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Original article

BIOMECHANICAL CHARACTERISTICS OF THE START IN BACKSTROKE SWIMMING STYLE IN THE STUDENTS OF HIGHER EDUCATION OF OTHER PROFILES

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Abstract

Objective. The purpose of the paper is to highlight the kinematic and dynamic characteristics of sports technique key elements of the start in backstroke swimming style in the students of higher education of other profiles.

Methods. This scientific undertaking entailed the organization of an ascertaining experimental study, using the following research methods: bibliographic review of the specialized literature; video computerized literature, by means of Pinnacle Studio, Kinovea and Physics ToolKit programs; method of movement postural orientation for the analysis of sports technique; statistical-mathematical method using KyPlot program and the method of graphical representation of the results. The research was carried out throughout the period October 2017 – January 2018 and involved 12 students of second year, series 2 from the Faculty of General Medicine. The physical training level of the subjects of the study was evaluated with the help of the test events included in the university curriculum of the higher education of other profiles within the „Carol Davila" University of Medicine and Pharmacy of Bucharest.

Results. The study results point out the development level of arms, abdomen and legs muscle strength in the students under study. The use of the video computerized method revealed and identified the kinematic and dynamic characteristics of sports technique key elements of the start in backstroke swimming style in terms of initial posture, launching posture, multiplication of body posture (flight through the air) and concluding posture (entering the water). The work under water and the emerging out of the water prove the accuracy of the execution. The angular characteristics of the positions of sports technique key elements, the trajectory of GCG, the linear and angular velocity of body segments and the resultant of force were highlighted within the phasic structure.

Conclusions. The video computerized analysis method used in accordance with the method of movement postural orientation showed the kinematic and dynamic characteristics of the sports technique key elements and enabled. a more thorough knowledge of the phasic structure of the start in backstroke swimming style in the students of higher education of other profiles.

Key Words: swimming, biomechanics, key elements, physical training, performance.

Introduction

Swimming practice arouses a great interest, in academic environment too. Therefore an increasing number of students in the higher education of sporting profile (where the swimming is a binding discipline involving practical lessons, stages and applications) and in the higher education of other profiles (in which students have the opportunity to practice the swimming as subject included in the curriculum for two academic years) choose the swimming for their physical education classes. (Toma Urichianu, 2004; Sima, 2011).

At the present moment, 4 swimming styles are mainly practiced; they are characterized by the alternation of the work with arms and legs – front crawl and back crawl and by simultaneous work with arms and legs – breaststroke and butterfly (dolphin). The side swimming has currently lost its sporting importance and is used as an element of the utilitarian swimming (Ganchar, 2006).

The scientific-methodological literature pays attention to the learning of all swimming styles elements but especially the starts and turns. These ones are officially included in the competitive regulations of FINA (Gorlov et al., 1996) that are corrected, modified and supplemented periodically for objectivization purposes (Pavlenco, 1998).

During the training process meant to consolidate and improve the dominant motor skills and abilities of sports swimming styles accessible at school level, there are several elements to be monitored: methods to learn the technique, turns, start and finish;

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development of specific motor skills; knowledge of regulations; rescue from drowning and giving the first aid (Urichianu, 2004; Sima, 2011). The biomechanical studies related to swimming can be used as additional documentary materials for technique learning and improvement in elite sport and higher education sport as well (Sanders, et al., 2015; Toussaint, Beek, 1992; Kolmogorov , 1997; Vantorre et al., 2014; Seifert et al., 2004).

The objective of this study is to highlight the kinematic and dynamic characteristics of sports technique key elements of the start in backstroke swimming style in the students of higher education of other profiles.

Methods

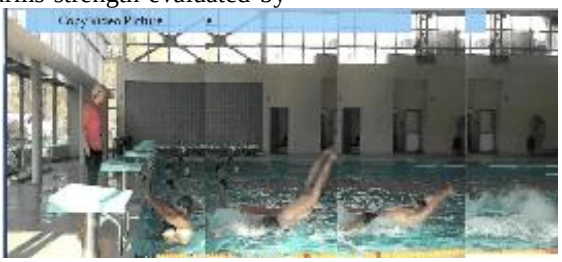
The study was conducted from October 2017 to January 2018, with a group of 12 students of 2nd year, series no 2 of the faculty of General Medicine, with the mean±SD of the size 1.78±0.06 m, weight – 69.50±8.13 kg.

A number of three test events were applied during the swimming lessons: test1 - abdominal strength evaluated by torso raises from supine position in 30 sec. (no of reps); test 2 - arms strength evaluated by push-ups executed continuously (no of reps) and test 3 - legs strength evaluated by jumping squats in 30 sec. (no of reps).

The biomechanical analysis of the start technique in backstroke style was performed by means of the movement postural orientation method (Boloban, 2013; Sima, Potop & 2018), regarding the initial posture (I.P.) – position on the starting block, launching posture (L.P.) –impetus, multiplication of body posture (M.P.) – flight, concluding posture (C.P.) and work under water – emerging out of the water; video computerized method, using Kinovea program for measurement of the segmentary angular characteristics and Physics ToolKit program for biomechanical analysis of the kinematic and dynamic characteristics of start technique in backstroke style.

Results

Figure no 1 shows the phases of the biomechanical analysis of the start in backstroke style, concerning the I. P., L.P., M.P. The C.P. and the "work underwater and emerging out of the water" phase were not studied because the positions of the segments are not visible.



I. P. **L.P.** **M.P.** **C.P.**

Figure no 1. Phases of start in backstroke (video stud.7)

In table no 1 are listed the results of students' test events in terms of abdominal strength, arms strength and legs strength. The analysis of the test events results of the subjects under study highlight the level of the their physical training (mean ±SD), concerning the abdominal strength with a value of 25.75 ±3.33 number of reps in 30 sec, arms strength – 22.08 ±3.94 number of reps in 30 sec, legs strength – 23.75 ±2.53 number of reps in 30 sec and performance achieved in freestyle – 42.80; ±1.96 sec, with a moderate homogeneity in all cases.

Table 1. Results of students' test events (n=12)

	Tests events		
Variables	Test 1, No	Test 2, No	Test 3, No
Mean ± SD	25.75±3.33	22.08±3.94	23.75±2.53

Test 1 - abdominal strength; Test 2 - arms strength; Test 3 - legs strength, No – reps number; S.D., standard deviation, Cv, coefficient of variation; n- number of subjects.

Table no 2 presents the results in terms of angular characteristics of the key elements of standing start technique on the standing block for the breaststroke style measured with Kinovea program, regarding the angles between segments in initial posture on the starting block (I.P.), launching posture (L.P.) at the impetus and multiplication of body posture (M.P.) during flight phase.

Table 2. Results of angular characteristics of the key elements of start technique in breaststroke style (n=12)

Variables	I. P., degrees		L.P., degrees		M.P., degrees	
	Cs-Tr	Tr-B	Hz.-U	Tr-B	Cs-Tr	Tr-B
Mean	35.67	103.58	35.17	147.58	191.92	166.58
S.E.M.	2.89	5.61	3.33	4.87	6.43	5.27
S.D.	10.03	19.45	11.53	16.88	22.26	18.25
Cv%	28.12	18.78	32.80	11.44	11.60	10.96

Note. S.E.M., standard error mean; S.D., standard deviation; Cv, coefficient of variation; n, number of subjects; I. P. – initial posture; L.P. – launching posture; M.P. – multiplication of body posture; Cs –Tr, thigh – torso; Tr-B, thigh – arms; Hz-U, water horizontal line – shoulder

The analysis of the angular characteristics of the key elements of start technique in backstroke style (mean ±SD), reveals the following values: I.P. – initial posture, angle between thigh – torso (Cs –Tr) 35.67±10.03 degrees and between thigh – arms (Tr-B) – 103.58±19.45 degrees; LP – launching posture, angle between water horizontal line – shoulder (Hz-U) – 35.17±11.53 degrees and between torso – arms (Tr-B) – 147.58±16.88 degrees; MP – multiplication of body posture, angle between thigh – torso (Cs –Tr) - 191.92±22.26 degrees (torso extension 11.92 degrees over body longitudinal axis) and between torso – arms (Tr-B) – 166.58±18.25 degrees with high homogeneity in L.P. (arms work – 11.44%) and M.P. (torso extension and arms work – 11.60% and 10.96%); the homogeneity is low in the other postures, which highlights the subjects' various ways of execution and even mistakes of execution.

Table no 3 shows the biomechanical indicators necessary for the analysis of the start technique in backstroke swimming style calculated with Physics ToolKit program, concerning the inertia of rotation (IR) and the radius of motion (RM) of shoulders and arms. The review of the results reveal the following values (mean ± SD) at IR – 27.68±4.75 kgm^2, at RM of the shoulders – 0.409±0.06 m and RM of the arms – 0.717±0.11 m, with moderate homogeneity in all cases between 14.51 – 17.15%. Also, these values demonstrate that there are execution differences between subjects and execution mistakes.

Table 3. Biomechanical indicators necessary for the analysis of the start technique in backstroke style (n= 12)

Statistical indicators	Variables		
	IR, kgm^2	Radius of the motion	
		shoulders	arms
Mean	27.68	0.409	0.717
S.E.D.	1.37	0.02	0.03
S.D.	4.75	0.06	0.11
C.V. %	17.15	14.51	15.58

IR – inertia of rotation; S.E.M., standard error mean, S.D., standard deviation, Cv, coefficient of variation; n, number of subjects.

In table 4 are listed the spatial-temporal characteristics of the key elements of start technique in backstroke swimming style regarding the trajectory of the hip, shoulders and arms in I. P., L.P. and M.P. The analysis of the spatial characteristics highlights the total duration of the motion 5.04±0.87 sec, calibration of the frames by 2 frames and by phases at I. P. – 0.0 sec, L.P. – 0.25±0.04 sec, M.P. – 0.34±0.04 sec. The reference point of the spatial characteristics was the height of the starting block, namely 0.35 m and the origin was at the swimming pool. Referring to hip trajectory (GCG) during motion phases, we notice that in I.P. this one has the value of -0.47±0.04 m from pool edge; in L.P. – 0.68±0.09 m in length and -0.21±0.09 m under pool

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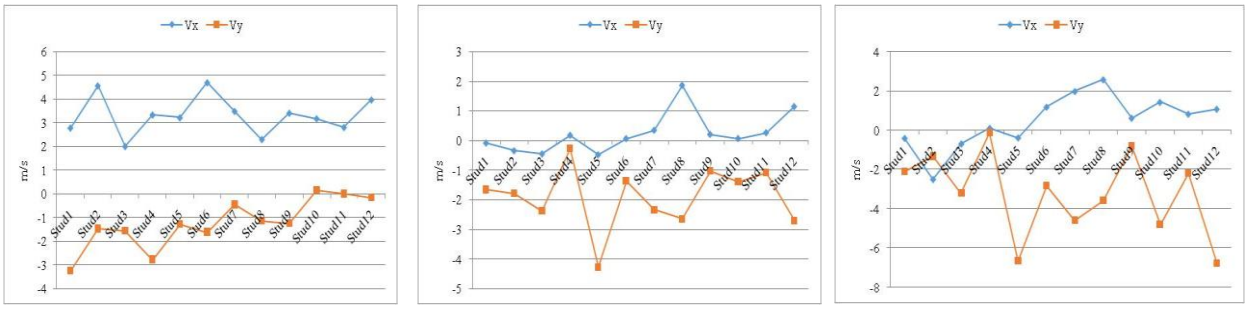
edge while in M.P. – hip we have 0.97±0.14 m length and -0.22±0.09 m.

Table 4. Spatial-temporal characteristics of the key elements of start technique in backstroke swimming style , n=12

Variables	Times, sec	Mean ± SD Hip, m x	Hip, m y	Shoulders, m x	Shoulders, m y	Arms, m x	Arms, m y
I. P.	0.00±0.00	0.34 ±0.05	-0.47±0.04	0.37±0.04	-0.17±0.07	0.18±0.096	0.05±0.15
L.P.	0.25±0.04	0.68±0.09	-0.21±0.09	1.03±0.10	0.06±0.16	1.22±0.21	0.46±0.18
M.P.	0.34±0.04	0.97±0.14	-0.22±0.09	1.39±0.14	-0.15±0.08	1.77±0.17	-0.002±0.20

I. P. – initial posture, L.P. – launching posture (impetus), M.P. – multiplication of body posture (flight)

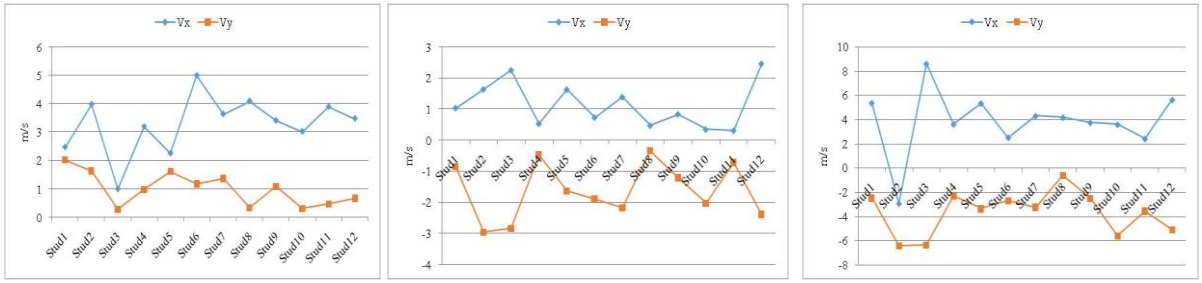
Figure no 2 shows the values of the linear velocity of the subjects' body segments during the impetus phase in the launching posture, namely the values of the horizontal and vertical travel of the hip, shoulders and arms. The analysis of the results (mean ±SD) reveals the following values: hip – 3.28±1.03 m/s (Vx) and 0.99±0.58 m/s (Vy), shoulders – 1.14±0.73 m/s (Vx) and -1.63±0.89 m/s (Vy) while arms – 3.85±2,71 m/s and -3.69±1.80 m/s. These values highlight the efficiency of the impetus, namely the preparation for taking off from pool edge; the values are higher for hip and shoulders on Vx and equal values ±Vx and Vy.



a) Hip b) Shoulders c) Arms

Figure 3. Characteristics of linear velocity of subjects' body segments during the flight phase in the multiplication of body posture during the execution of start in backstroke style.

In figure no 3 are listed the values of the linear velocity of subjects' body segments during the flight phase in the posture of multiplication (M.P.), regarding the values of the horizontal and vertical motion of hip, shoulders and arms. The analysis of the results (mean ±SD) highlights the following values: hip – 3.31±0.82 m/s (Vx) and -1.23±1.04m/s (Vy), shoulders – 0.23±0.67 m/s (Vx) and -1.91±1.04



a) Hip b) Shoulders c) Arms

Figure 2. Characteristics of the linear velocity of subjects' body segments during the impetus phase in the launching posture of the backstroke start execution.

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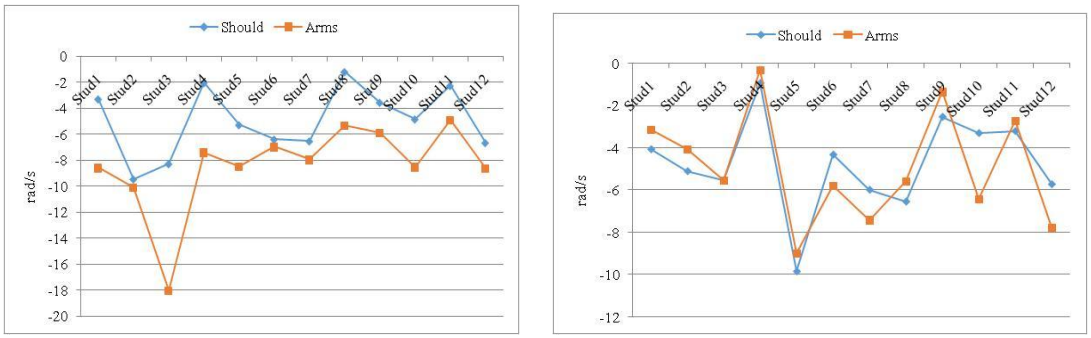
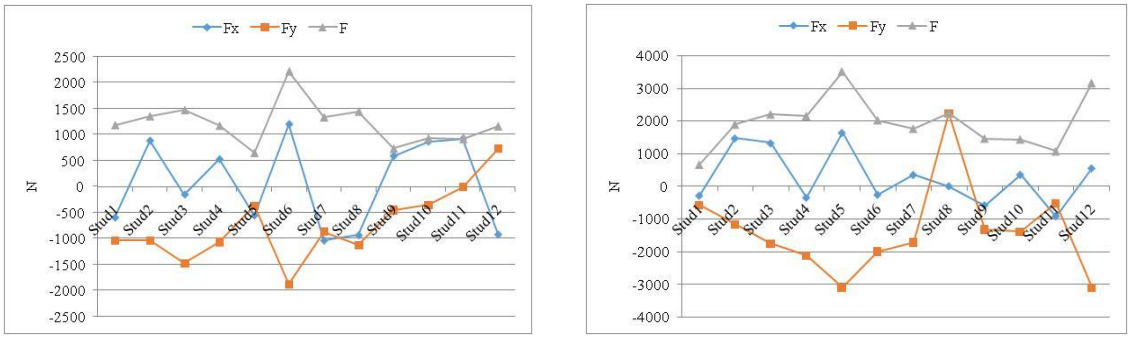
m/s (Vy) while arms – 0.48±1.37 m/s and -3.27±0.82 m/s. These values demonstrate the efficiency of the impetus as a result of the accumulation of a higher horizontal velocity of the hip and vertical velocity at shoulders and arms (torso extension and work of arms when diving into the water).



a) Impetus – launching posture (L.P.) b) Flight phase – multiplication of body posture (M.P.)

Figure 4. Results of the angular velocity if subjects' body segments during the execution of the start in the backstroke swimming style.

Figure no 4 presents the results of the angular velocity of subjects' body segments during the execution of the start in backstroke style in terms of values of the shoulders and arms motion during the impetus in launching posture and during the flight phase in the multiplication of body posture. The analysis of the results highlights the values (mean ±SD) as follows: in launching posture (L.P.), at the impetus, a value of -4.98±2.58 rad/s of the rotation movement of shoulders-hip and -8.39±3.38 rad/s at the level of arms – hip; during the multiplication of body posture (M.P.) in the flight phase - -4.74±2.27 rad/s rotation of shoulders-hip and 4.92±2.65 rad/s – arms – hip. These bigger values at arms level during the impetus (L.P.) allow ½ roll-over backward of the body (rotation) and the close values during the flight (M.P.) makes possible a more efficient diving into water.



a) Impetus – launching posture (L.P.) b) Flight phase – multiplication of body posture (M.P.)

Figure 5. Results of the strength at hip level in the subjects of the study during the execution of the start in backstroke swimming style.

In figure 5 are listed the results of subjects' hip strength while executing the tart in backstroke swimming procedure, regarding the values Fx - horizontal, Fy - vertical and F – impetus resultant (L.P.) and flight phase (M.P.). The review of the results highlights the following values (mean ±SD): at L.P. 70.05±843.97 N (Fx), -738.76±696.44 N (Fy) and 1220.69±412.75 N (F); at M.P., Fx – 269.97±839.19 N, Fy – (-1383.14±1400.27 N) and F – 1961.56±801.92 N.

Discussion

In order to highlight the kinematic and dynamic characteristics of the key elements of start technique in backstroke swimming style practiced by the students of higher education of other profiles, a study was organized from October 2017 to January 2018 in the Faculty of General Medicine, with a group of 12 students.

The results of the study prove the level of development of arms, abdomen and legs muscular strength in the students monitored during this

research. The use of the video computerized method helped to reveal and identify the kinematic and dynamic features of the most important elements of backstroke start technique in the students of higher education of other profiles regarding the I. P. on the starting block, L.P. - impetus, M.P. – flight and C.P. (diving into water). The work under water and the emerging out of the water will highlight the correctness of the execution. There were also pointed out, during the phasic structure, the spatial-temporal and angular characteristics of the positions of the key elements of start technique in terms of trajectory of the hip (GCG), shoulders and arms, the linear and angular velocity of body segments and the resultant of force.

According to V.A. Aikin (1983), when learning the start, the elements of this one are more easily learnt. Therefore it is recommended to observe the principle of progressive increase of exercises difficulty and to learn all variants of the start (Kochergin, 1992). In addition to that, we must take into account the particularities of students' age when building the technique of the start and we must use the proper means, methods and methodical procedures corresponding to the individualized learning, improvement and objective control (Parfenov et al., 1992).

Other studies focus on the characterization of the backstroke swimming technique of 11-13 year-old swimmers when performing at very high intensity (Silva et al., 2013); they examine the influence of the energy cost of swimming, body composition, and technical parameters on swimming performance in young swimmers (Jürimäe, et al., 2007); the specialists tried to determine whether a particular start technique leads to a short 15 m start time or whether several start profiles contribute equally well (Seifert et al., 2010).

Conclusion

The use of the video computerized analysis method consistent with the method of movement postural orientation highlighted the kinematic and dynamic characteristics of the sports technique key elements and enabled a more thorough knowledge of the phasic structure of the start in backstroke swimming style in the students of higher education of other profiles.

Acknowledgments

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