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Comparative analysis of the I and IV class springboard dives' final phase of the kinematic parameters fulfillment from 10 meters platform among the strongest athletes

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Abstract: Information concerning the kinematic parameters of the diving-entry phase is very limited in current information sources. There are publications of the group of authors, including the authors of the present article [1;2; 3; 4], concerning the problem of splashes formation in competitive dives. They don't reflect all theoretical and practical questions of this kind of sport. Kinematic parameters of the dives fulfillment from 10-metres platform were not previously studied and may differ significantly from 3-metres springboard dives. In this connection the presented article is dedicated to kinematic parameters of springboard diving analysis among the participants of the Olympic Games 2020. **Research methods:** video materials analysis, measuring the angles of the athletes' body positions by means of a special computer program "Screen protractor", methods of statistical data processing (calculation of X mean values and root-mean-square deviations). **Material.** The article describes kinematical analysis of the dive final phase fulfillment by the World's strongest athletes on the basis of video material of the Olympic Games 2020 final competition in Tokyo. **Results and novelty of the research work.** We defined kinematic parameters of the I and IV class dives' final phase fulfillment by high-class athletes. It was revealed that rotation stop in the I and IV class dives is fulfilled by the athletes in two ways: opening through the angle with considerable flexion in pelvis and straightening at a big angle relative to water and smaller angle in hip joints. It was revealed that the angle in shoulder joints significantly influences the quality of water entry. "Amortized" water entry in springboard dives is the key evaluation criterion for the success of a dive. **Conclusion.** During the I class dives fulfillment athletes have less time (twice less) for entry hands position, than during the IV class dives fulfillment. That is why an athlete has to fulfill the final movements with higher speed and it decreases the possibility of splashes formation and as a result, influences the quality of water entry estimation.

Keywords: diving, water entry, kinematic parameters of a dive.

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Introduction

Information concerning the kinematic parameters of the diving-entry phase is very limited in current information sources. There are publications by Gorokhovskiy L.Z. [1], Raspopova E.A. [2], by the authors of the present article [3], concerning the problem of splashes formation in competitive dives. They don't reflect all theoretical and practical questions of this kind of sport.

In the previous article [4] we considered kinematic parameters of the dive final phase fulfillment by the athletes from 3-metres springboard. We stated the main parameters of body parts position relative to water surface during different moments of diving. It was revealed that the time since opening till

touching water surface with hands in the I and IV class dives was equal, the differences were mainly connected with the difficulty of the fulfilled dive. The greatest differences in this phase fulfillment in the I and IV class dives are connected with body position in the air. The angle in hip joints in the I class dives was $152^{\circ} \pm 10^{\circ}$, in IV class dives – $154,8^{\circ} \pm 17,2^{\circ}$. At the same time, the angle in shoulder joints in this moment was the same.

The body angle in relation to water surface in the I and IV class dives was significantly different. In the IV class dives it was closer to vertical, than in the I class dives. We supposed that these differences were connected with the altitude of rotation ending. In the IV class dives rotation ends at smaller

altitude relative to water surface, so the athletes had less time to prepare for a dive. During the dives fulfillment from 10-meters springboard these kinematic parameters were not studied earlier and can significantly differ from the parameters of the dives from 3-meters springboard.

Materials and methods

We analyzed kinematic parameters of the dives final phase technique – water entry. For the analysis organization we used video of the final competitions from 10-meters springboard during the Olympic Games 2020 in Tokyo. 12 strongest athletes, who present different countries took part in the final competitions. With the help of a special computer program “Screen protractor”, which helps to measure any angle on the screen, we received the parameters of diving since the moment of touching water with hands till the complete entry.

We analyzed the fulfillment technique of the final phase of the flight in dives with forward rotation from the front and back stand (I and IV class). We defined kinematic parameters of the athletes' movements over the water, during the moment of opening (end of rotation), in particular hands, legs, body movements before and during diving. We defined the angles in shoulder, hip joints and the angles of body position relative to water surface during the moment of diving. Measurements were carried out: 1) during the moment of touching water with hands; 2) diving till shoulders level; 3) till pelvis level and 4) during the moment of complete diving, when legs of an athlete go under water.

We registered the judges' mark for the dive during the competitions.

Apart from the judges' mark, the quality of water entry was estimated by the experts according to the created by us system: no splashes, entry is amortized – 9-10 points; few splashes (airbag) – 7-8 points; there are splashes– 5-6 points; there are significant splashes- 3-4 points, high splashes – 1-2 points, high spray fountain – 0.

The results of the research works were handled with the help of mathematical statistics methods. We calculated the following: \bar{X} – mean values, σ – standard error of the mean.

Results and discussion

10-meters platform dives competitions among men at the Olympic Games in Tokyo were organized during the final day. 12 strongest athletes of the World took part in the competitions, including two representatives of the national team of Russia. The athletes demonstrated high class and the difficulty of the dives.

Let's consider kinematic parameters of the dives' final phase after rotations fulfillment from the I and IV classes.

The dives from the front stand analysis showed that almost all divers fulfilled the dive of 4,5 forward turns. Only the youngest athlete did 3,5 turns in the piked position. It should be noted that one of the representatives of PRC national team fulfilled 4,5 forward turns in the piked position. It is the most difficult dive, which was fulfilled from 10-meters platform during the whole history of diving, the degree of difficulty was 4,1 points.

The technique of 4,5 turns dive fulfillment doesn't differ among many athletes. Owing to the fact that after rotation there remains not much height till water surface, athletes have less time for the correct position taking before diving. For the coming out of the rotation, in order to stop it and start preparing for water entry, athletes open with a big angle in hip joints and then try to straighten as quickly as possible. Several athletes tried to open with a small angle in a hip, but they didn't manage to hold the legs in body line. They relaxed the spine and it led to “the transfer” and splashes formation.

For the front stand dives with forward rotation the angle of diving at the first stage in the average is $77,08^{\circ} \pm 2,87^{\circ}$. The angle in hip joints is $159,17^{\circ} \pm 7,89^{\circ}$, in shoulder joints – $163,4^{\circ} \pm 4,07^{\circ}$.

At the seconds stage of diving we see considerable extension in hip joints, the angle is $166,5^{\circ} \pm 8,3^{\circ}$ and straightening in shoulders, the angle is $169,9^{\circ} \pm 4,6^{\circ}$, the athletes submerge with the angle $80,67^{\circ} \pm 3,42^{\circ}$.

Pictures 1-4 show the parameters of water entry after forward rotations from the front stand during different moments of diving among three the best divers by superposition method.

We can underline that the parameters of water entry in different moments of diving don't differ, the angles in all joints are almost equal.

At the moment when the athletes entered the water till waist, the angle in pelvis decreases till $172,4^{\circ} \pm 7,3^{\circ}$, some athletes have excessive unbending. The angle at the third stage of diving is $85,08^{\circ} \pm 1,6^{\circ}$. By the final stage the angel is $88,58^{\circ} \pm 2,8^{\circ}$ and only three divers showed insignificant “transfer”.

The results of angles measurement during different moments of diving after I class dives fulfillment among 12 finalists of the Olympic Games in Tokyo are presented in table 1.

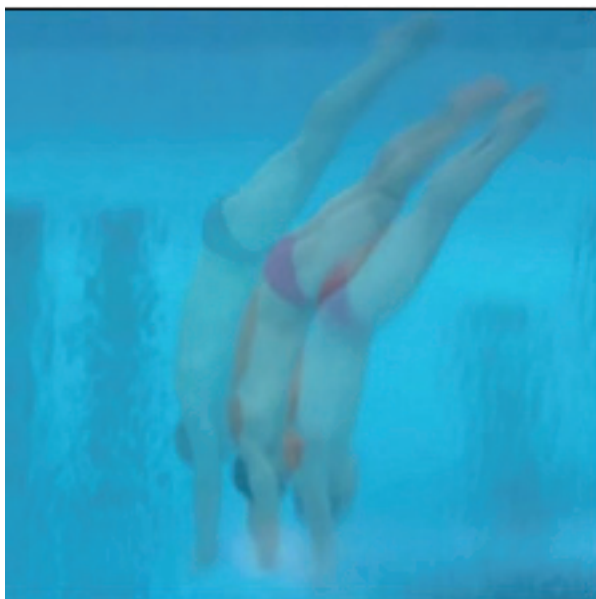


Fig. 1. Variations of athletes' body positions during submersion at the moment of touching water with hands in I class dives

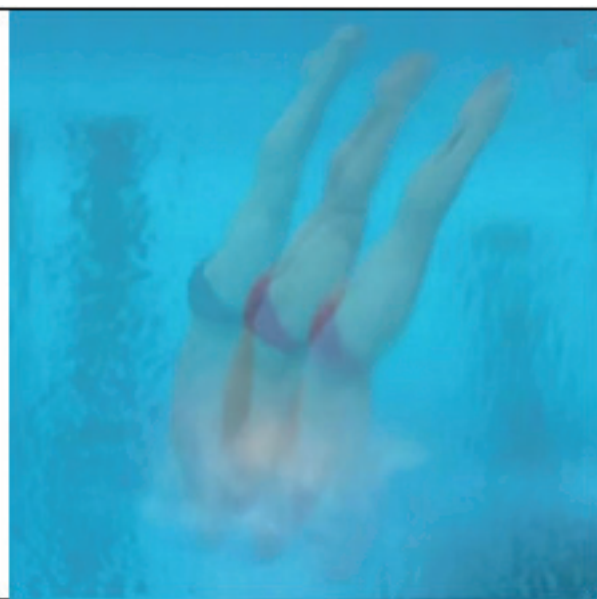


Fig. 2. Variations of athletes' body positions during submersion at the moment of water entry till shoulder level in I class dives



Fig. 3. Variations of athletes' body positions during submersion at the moment of water entry till pelvis level in I class dives

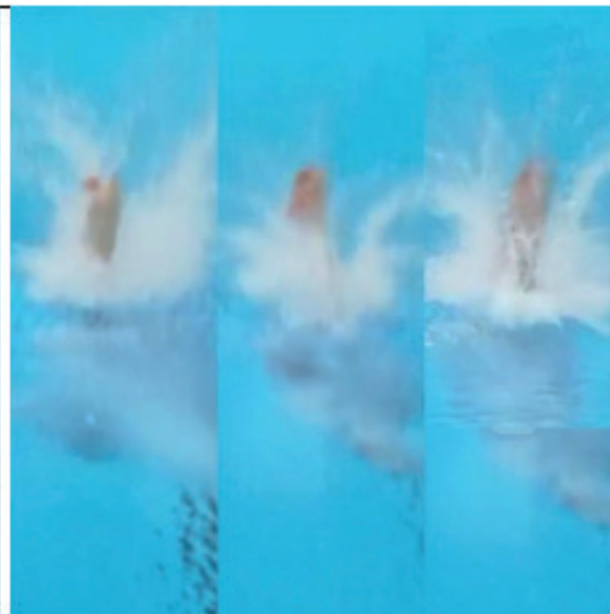


Fig. 4. Variations of athletes' body positions during submersion at the moment of water entry ending in I class dives

Analyzing the technique of dives' final phase fulfillment after front rotations, we noticed that the athletes fulfill opening in two ways. The first way was described above. It was opening through the angle with considerable bending in pelvis. It provides body rotation about transverse axis. The second way is characterized by the fact that an athlete tries to stop rotation abruptly, opening in almost straight position (with the minimal angle in hip joints). The difference is in the fact that during the opening through the big angle an athlete has an opportunity to control speed of rotation while flying and he has

only to straighten into the line for the entry. In the second case athletes don't have an opportunity to control the speed of rotation for an accurate body position in order to realize water entry. In this case it is more difficult to hold correct position and then divers bend the spine and make "transfer".

We revealed that the angle in shoulder joints influences the quality of water entry: the bigger is the bend in shoulder joints, the more splashes are formed. It influences the final mark of judges.

Table 1

Kinematic parameters of the flight phase final part fulfillment in I class dives among the finalists of the Olympic Games 2020

Name, surname of an athlete	During the moment of touching water with hands			Diving till shoulders level			Diving till pelvis level		Water entry angle	Mark	Expert mark
	Water entry angle	Angle in shoulder joint	Angle in hip joint	Water entry angle	Angle in shoulder joint	Angle in hip joint	Diving angle	Angle in hip joint			
Yuan CAO	80	167	156	85	175	158	86	164	88	9	9
Jian YANG	80	167	148	83	171	157	87	176	92	9	8,5
Thomas DALEY	79	168	159	83	175	168	87	174	89	8,5	8,5
Aleksandr BONDAR	78	168	157	80	170	172	86	176	89	8,5	9
Viktor MINIBAEV	74	159	165	76	164	173	83	178	86	7,5	6,5
Oleksii SEREDA	77	163	162	84	175	170	85	172	86	8,5	8,5
Rikuto TAMAI	80	163	144	84	172	149	86	155	86	7	7
Cassiel ROUSSEAU	79	168	156	81	174	163	84	169	90	8	9
Jordan WINDLE	78	164	165	82	172	175	87	179	92	8	9
Kawan FIGUEREDO	71	159	160	75	165	168	82	174	85	7	6,5
Brandon LOSCHIAVO	76	158	162	80	162	165	84	168	86	6,5	5
Andres Isaac VILLARREAL	73	157	176	75	164	180	84	184	94	6,5	5,5
X	77,08	163,42	159,17	80,67	169,92	166,50	85,08	172,42	88,58	7,83	7,67
σ	2,87	4,07	7,89	3,42	4,66	8,30	1,61	7,33	2,81	0,87	1,42

During water entry analysis after forward rotations from the back stand we revealed that all athletes, except one athlete, fulfilled 3,5 turns in grouping position. Only one athlete from China fulfilled the same dive in piking position. It is more difficult.

Mean values of body position analysis at the moment of water entry showed that at the first stage of the final phase of the dive deviation from the vertical line was $84,1^{\circ} \pm 2,7^{\circ}$. During the second stage the angle relative to water increased till

$87,6^{\circ} \pm 3,14^{\circ}$. During the third stage athletes are in a vertical position, the angle is $90,5^{\circ} \pm 2,7^{\circ}$, and for the final stage of diving “transfer” is typical, the angle of deviation is $97,5^{\circ} \pm 9,7^{\circ}$. 8 out of 12 athletes of the final competitions fulfilled the dive with “transfer”, 4 of them had considerable deviation from the vertical line, more than 10° . It is a bad mistake.

Fig. 5 and 6 present the parameters of the first two stages of diving fulfillment after IV class dives by the example of 3 strongest athletes of the competitions.



Fig. 5. Variations of athletes' body positions during submersion at the moment of touching water with hands in IV class dives



Fig. 6. Variations of athletes' body positions during submersion at the moment of water entry till shoulders level in IV class dives

At the first stage of diving, at the moment of touching water with the palms, the angle in hip joints is $170,5^{\circ} \pm 10,7^{\circ}$. During water entry till shoulders level the angle in a hip is $175,6^{\circ} \pm 7,4^{\circ}$, and by the final stage (when an athlete enters water till waist level) the angle in the average is $180,2^{\circ} \pm 5,4^{\circ}$. Mentioned above results show that it is typical for the athletes to bend in spine during diving, half of the athletes had the angle in hip joints more than 180° .

Fig. 7 and 8 present the parameters of the final stages of diving fulfillment after IV class dives by the example of 3 athletes, the winners of the competitions.

The angle in shoulder joints at the first stage in the average is $165,9^{\circ} \pm 5,27^{\circ}$, by the second stage it decreases till $173,4^{\circ} \pm 3,7^{\circ}$. It is better result than in I class dives. We can suppose that the higher quality of water entry in IV class dives is conditioned by the difference in time of athletes' preparation for the final phase of the dive, as in IV class dives athletes fulfill one turn more, than in I class dives and complete the dives at a high altitude relative to water surface.

Table 2 presents body position results at different stages of diving after the IV class dives fulfillment.



Fig. 7. Variations of athletes' body positions during submersion at the moment of water entry till pelvis level in IV class dives

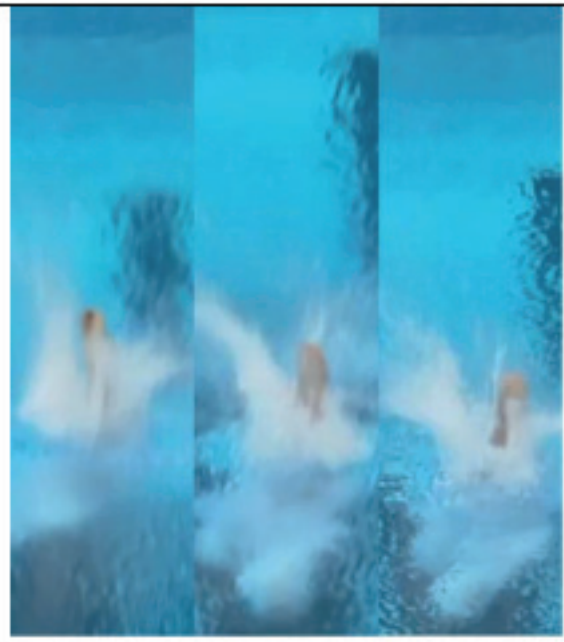


Fig. 8. Variations of athletes' body positions during submersion at the moment of water entry end in IV class dives

Table 2

Kinematic parameters of the flight phase final part fulfillment in IV class dives among the finalists of the Olympic Games 2020

Name, surname of an athlete	During the moment of touching water with hands			Diving till shoulders level			Diving till pelvis level		Water entry angle	Mark	Expert mark
	Diving angle	Angle in shoulder joint	Angle in hip joint	Diving angle	Angle in shoulder joint	Angle in hip joint	Diving angle	Angle in hip joint			
Yuan CAO	81	160	176	84	168	179	90	181	96	8,5	8,5
Jian YANG	88	167	139	90	175	155	91	170	93	9	8,5
Thomas DALEY	82	161	173	86	170	176	89	179	92	9,5	9,5
Aleksandr BONDAR	81	159	170	83	167	174	87	175	89	8	8,5
Viktor MINIBAEV	80	163	168	84	172	175	87	177	88	7	7,5
Oleksii SEREDA	84	173	178	89	179	179	92	183	95	8,5	9,5
Rikuto TAMAI	87	169	175	91	177	178	94	185	103	7,5	8
Cassiel ROUSSEAU	85	171	180	91	176	185	93	190	120	6	5,5
Jordan WINDLE	83	159	170	84	170	173	88	178	89	7	6,5
Kawan FIGUEREDO	88	170	178	92	175	182	95	186	111	6,5	3
Brandon LOSCHIAVO	87	174	162	88	176	170	88	175	89	7	6,5
Andres Isaac VILLARREAL	84	165	178	90	176	182	93	184	105	7	7,5
X	84,17	165,92	170,58	87,67	173,42	175,67	90,58	180,25	97,50	7,63	7,42
σ	2,73	5,27	10,75	3,14	3,71	7,44	2,69	5,40	9,75	1,02	1,77

We compared expert marks for the quality of water entry with the marks of judges for the dive fulfillment in general. The average mark of the judges for the I class dives is 7,83 points. It is almost the same as the experts' mark – 7,67. In the IV class dives the difference is more considerable, but also not much for 7,63 and 7,42. It means that water entry in springboard dives is the key evaluation criterion and the success of the dive mainly depends on this phase.

In our previous article we underlined that the mark for the dive included many factors, such as height of repulsion, easiness and cleanliness of rotations fulfillment, the technique and beauty of movements. This statement is mainly correct in terms of 3-meters springboard dives. In diving-board dives, as the practice shows, one of the main evaluation criteria is an “amortized” water entry.

In diving-board dives there is a considerable difference between the rotations of the I and the IV class in time since the beginning of opening till the beginning of water entry. In order to get ready for water entry during the I class dives fulfillment an athlete in the average needs 0,37 seconds, after the rotations of the IV class – 0,61 seconds. The greatest time period in the I class dives needed the athlete from the Ukraine – 0,53 seconds, as he fulfilled 3,5 forward turns. The rest of the athletes fulfilled 4,5 turns. The athlete from China needed the shortest time period for opening and preparation for the entry, as he fulfilled the dives in the piked position. It made his objective more difficult.

We can suppose that time decrease for the hand placing for the entry makes athletes fulfill the final movements with bigger speed. It means that the initial cavity formation in the I class dives happens quicker and it decreases the possibility of splashes formation and influences the mark for water entry quality.

Conclusion

1. The research showed that after front rotations athletes fulfill opening in two ways. The first, which is more effective, is opening through the angle with considerable bending in pelvis. The second way is characterized by the fact that athletes straighten at bigger angle relative to water and smaller angle in hip joints. In this case it is more difficult to hold correct position and then the athletes bend the spine and have “transfer”.

2. It is revealed that the angle in shoulder joints is important for the volume of the splashes: the bigger is the bend in shoulder joints, the greater volume of splashes an athlete has. It influences the quality of the dive and the final mark of the judges for the dive.

3. “Amortized” water entry in springboard

dives is the key evaluation criterion and the success of a dive depends on this phase.

During the I class dives fulfillment an athlete has less time for hands placing for the entry. That is why an athlete has to fulfill the final movements with greater speed. It means that the initial cavity formation happens quicker and it decreases the possibility of splashes formation and influences the mark for water entry quality.

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