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Original Article

Cliff diving: water impact and video-analysis

SALVATORE NAPOLITANO
Department Physical Education and wellness, University of Naples "Parthenope", ITALY

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Abstract:
Purpose. The sport of cliff diving was born fifteen years ago, and has gained enormous success. Barcellona in 2013, in light of the World Swimming Championships, the International Swimming Federation (FINA) has added this sport among the official swimming disciplines present in the competition. This highly spectacular sport complies particular motary and psychological abilities, which are not possible to train for lack of specific sports facilities. In competitions, the starting platforms are at a height of 25-28 meters, and the impact with the water is at a high velocity that stimulates the entire body in little time . The goal is to calculate the impact with the water, its form and the hypothetical consequences on the body using video training
Methods. This study uses three distinct approaches: a case study of single performances, the descriptive research for the contribution of the evaluation of the analyst, and the constitution and elaboration of the data for the contribution of the physics expert.
The model consists in the total of three performances of three international competitions:
•2 Red Bull Cliff Diving World Series competitions
•1 World Championship competition
The single dives were analyzed, compared with overlapping displays of the performances, the analysis and decoding of the video given by the analyst and the technical expert in the field on water entry with Kinovea software. This specific software was used for simulations…data of coefficient of water impact and entry.
Results. For each dive impact incidence and eventual consequences on the athlete were calculated. For each athlete both the positive and the negative aspects of their performances were located. The evaluation of the data collected (each single dive for each single athlete, total nine dives each) allowed an individual hypothetical model to use pre-competition.
Conclusions. The results can be used by the athletes themselves, using the video education method, and by technical trainers for training, for the analysis and specific evaluation during competitions. Furthermore, a more in depth study will be able to demonstrate the danger and the consequences on the athletic organism in Olympic competition.
Key words: video evaluation, Kinovea, video education, video didactics.

Introduction

In high diving competitions the platforms are placed at a height that measures from 28 meters: it can imagine the impact with the water at such velocity (24 m/s) that exposes the muscles and the articulations and all the soft parts of the whole organism to abnormal solicitations that must be absorbed in tenths of a second.

This pilot work has calculated the influence of the impact with water in high divers and the eventual consequences.

High diving, or cliff diving, is a sport that has become very popular in the last fifteen years, and beginning in 2013, in light of the World Swimming Championships, FINA has added it to the official list of swimming disciplines.

This highly spectacular discipline complies a series of motor and psychological abilities which imply constant and meticulous preparation on the athlete's part.

According to technical trainers and athletes, a growing need to analyze athletic preparation has occurred. If it considers that divers can practice only the day before the competition and not have the possibility to practice on a daily basis, as in other sports. (Poul-Erik Paulev, ed. Al. 2007)

Due to this , we've come to need as many elements as possible to support their performance. The aim of the study is to analyze the various segments of technical execution of each single dive executed by the athlete during the competition in order to better prepare and individualize the strengths and weaknesses of the athlete in each single execution. (Yuan Xiong, ed al. 2004)

In modern sports the trainer's need to have useful data to analyze the skills of their athletes is growing.

Corresponding Author: NAPOLITANO SALVATORE, E-mail: : salvatorenapolitano1@alice.it

When considering high diving, it comes to miss the technical analysis of coded methodological performance for the individualization of errors, which is usually left to the discretion of the singular athletes.

The goal of this study is to create a methodological model that will fill, through video analysis, acquiring and elaborating a certain amount of data collected relative to each performance.

The impact coefficient was calculated using pre existing data found in literature and a series of parameters that we will see later on. Wanting to evaluate the weight that the diver's body takes on, we've also referred to studies in the aeronautical fields on water impact on objects. (Isard M, ed. Al. 1996)

Consider the diver as a cylinder, long and slim (1.71 m in height) and weighing 80 kg and a fall from a height of 28 meters.

In the "in air" phase, consider "g" (gravitational acceleration) for which the impact velocity is given by $v0=\sqrt{(2*g*h)}$ m/s.

In the "water phase" consider the phenomenon of water being put into motion, ignoring any other phenomena that this actions might trigger (friction, etc.). The evaluation of charges is based on the momentum theorem (Von Karman, 1929). From the moment of impact short intervals of time are considered (dt= 0.001 s), for each interval we've considered how far the object penetrated into the water and what water mass was being moved (in the interval "dt", impulse is equal to the quantity of motion) to then calculate force. (Von Karman, T. 1929)

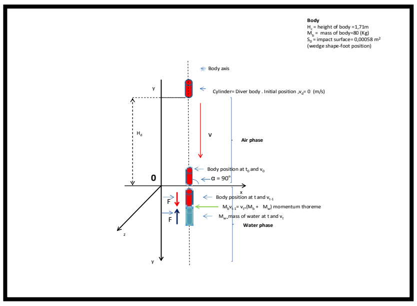


Figure 1 - Diver body as a cylind

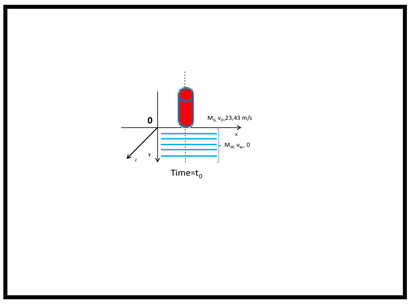


Figure 2 - water impact

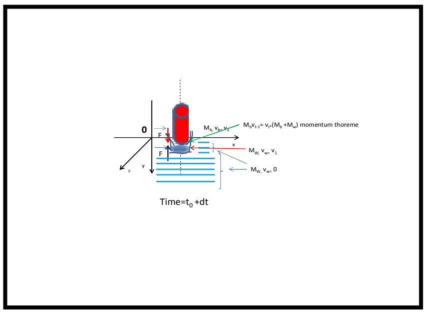


Figure 3 - post-impact

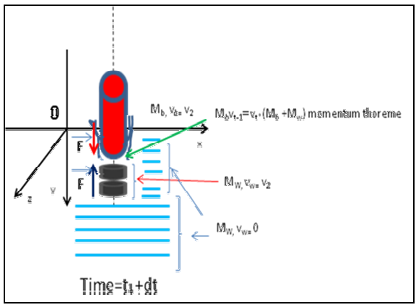


Figure 4 - momentum theorem

Picture frame 1

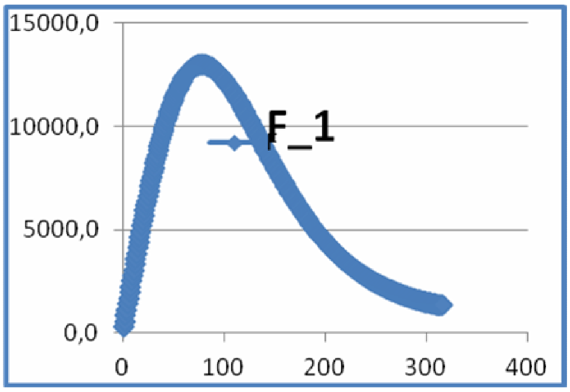
Another approximation considered was that the masses of water being put into motion in the following "dt" behaved in the same manner as masses moving at the same speed. The results obtained were compared to those obtained using the formula from Von Karman for the calculation of the pressure of a "Flat Bottomed Float" and with experimental data taken for an impact at a speed of 9. 14 m/s.

The results obtained show that based on the surface impact, a body takes the maximum charge when it is partially submerged. This is verified with the following numbers: 12994,525 [N] in a “dt” of 0,001s (at 9,14 m/s , 4,25 m in height, maximum force 3661,86 [N]).

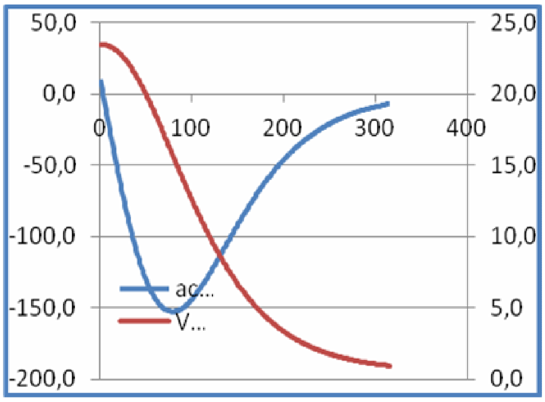
Now we must evaluate G (vs. “dt”) that the body takes on and its possible consequences. (Table 1)

The graphic (Graph 1) shows that a diver of 80 kg with a surface impact equal to 0,000508 m2 (foot in hyperextension) jumping from a height of 28m finds its highest stimuli at 12994,525 N at 1.64 mt of water penetration. The duration of the maximum stimuli is equal to 0.001 seconds.

As is easily understood, the diver’s body, even for a short time, is subject to notable stimuli.(Napolitano ed al. 2013)



Graph 1 - highest stimuli



Graph 2 - speed/acceleration

Material & methods

1. The approach is integrated and composed by three methods: case study for the analysis of the single performance, action research for the contribution of the specialist (aerospace engineer) and the elaboration of data with theoretical deduction discussions. The study is based on a series of dives with different situations regarding water impact. The analysis instrument is the decoded video on behalf of the analyst, the researcher and the specialist in that category, previously divided, of the independent and the dependent variables of the data gathered with Kinovea software: having previously calculated an impact coefficient based on surface contact.

2. Furthermore a questionnaire was administered to six high level divers (the study is based on ten divers who perform this discipline) in order to gain ulterior data regarding the study.

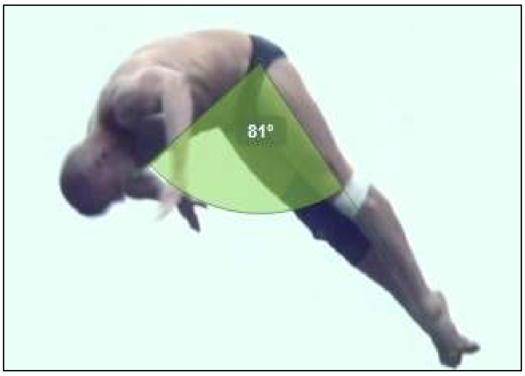
Results

For each athlete, as we have already stated, based on the results obtained from the analysis of the collected data, we’ve individualized the strengths and weaknesses in the comparison of the execution of each single dive in the three competitions taken into consideration.

Given the data collected (for each single dive of each single athlete- in total nine dives for athlete), it has been possible to elaborate a coded and personalized methodological model of technical training.

Table 1. "keyframe

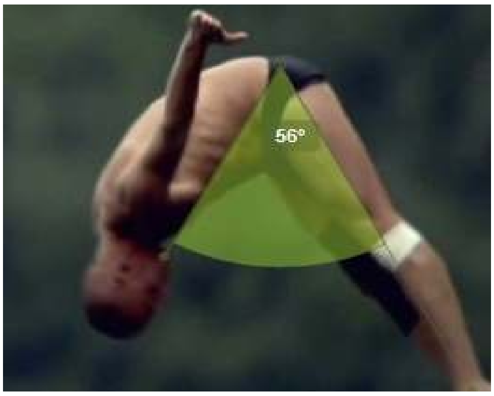
									Mbody	So	Dt	pi	**gi**	roH2O			Press
									[kg]	[m²]	[s]	3,1415927	**[m/s²]**	[kg/m³]			[N/m²]
									80	0,000508	0,001		9,80665	998,21			67838192
Vol_iniz	Ho	Vo	Eo														
[m³]	[m]	[m/s]	[J]								F_max	i_Fmax	X_Fmax				Lav_Fmax
0,0	28	23,43	21966,9								[N]	[-]	[m]				[N*m]
											12994,525	79	1,64				13298,32
	acc_Inerz	acc_gall	acc_Corpo	V_corpo	X_spost.	Vol H2O	Massa H2O	Quantità di Moto	Masse in moto	V1	F_1	F_2	F_somma	Press	n_press	Lavoro	Integrale del lavoro
#	[m/s²]	[m/s²]	[m/s²]	[m/s]	[m]	[m³]	[kg]	[N*s]	[kg]	[m/s]	[N]	[N]	[N]	[N/m²]	[-]	[N*m]	[N*m]
1	9,80665	0,0000	9,8	23,4344	0,023434	1,19E-05	0,01188	1874,75	80,012	23,4309	278,439	278,439	556,9	1096216	0,016	6,53	0,0
25	-70,1462	0,0346	-70,2	22,6468	0,579857	0,000295	0,29404	1811,74	80,294	22,5638	6634,679	6634,679	13269,4	26120782	0,385	150,25	1959,73
50	-129,335	0,0681	-129,4	20,0514	1,115341	0,000567	0,56558	1604,11	80,566	19,9106	11261,034	11261,034	22522,1	44334781	0,654	225,80	6849,14
78	**-152,568**	**0,0997**	**-152,7**	**15,9870**	**1,619301**	**0,000823**	**0,82113**	**1278,96**	**80,821**	**15,8246**	**12994,096**	**12994,096**	**25988,2**	**51157860**	**0,754**	**207,74**	**13092,57**
150	-92,1452	0,1490	-92,3	6,7197	2,403754	0,001221	1,21892	537,58	81,219	6,6189	8067,858	8067,858	16135,7	31763220	0,468	54,21	22044,23



Picture frame 2

Picture frame 3

Picture frame 4



Picture frame 5

Picture frame 6

Picture frame 7

Dicussion

The results of this study will supply a series of sufficient data and elements, able to supply athletes and their trainers a series of elements that will favor the elaboration of a coded methodology for teaching high diving techniques and will shed light on the organism's water impact.

Conclusions

It is possible to develop a model that, given height, weight and anthropometric values :

1 - Calculate the body segment that will suffer the most stress on impact.

2 - Calculate the changes in the coefficient of impact based on the exposed surface.

A so constructed model may help athletes to develop a type of training that protects privileged way in the body segments most vulnerable to and including and prevent the consequences of any errors.

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