Biomechanical analysis of the technical execution of the ballet figure in athletes of the Artistic Swimming team of the EIDE school of Villa Clara.

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Abstract

Artistic swimming is a competitive and elite aquatic sport worldwide. Its regulations emphasize the use of innovative techniques, skills, and beauty in its execution. In recent years, the results of the Villa Clara school team during their participation in provincial and national competitions have not been satisfactory, presenting difficulties in the execution of compulsory figures and free routines—important aspects that currently require improvement. Therefore, this research was directed at: conducting a biomechanical analysis of the technical execution of the compulsory ballet figure in athletes from the team. After applying different research methods and techniques for conducting biomechanical studies, and with the help of motion analysis software, it was possible to determine some kinematic characteristics present in the behavior of this execution. The results showed that the athletes' main deficiencies lie in a lack of body control in relation to the horizontal position in the water, failing to fully extend their legs and demonstrating the need to exert greater force at the hip point to prevent sinking. aspects that the coaches valuedof great use and viability for improving the competitive results feasible for youruse as a basic element in the reorientation of training, preparation and improvement of technique in the Villa Clara school team.

Keywords:Artistic swimming, technical execution, ballet

Introduction

Artistic Swimming (called Synchronized Swimming in the last four years) is a competitive aquatic art sport that combines different techniques and involves harmony and synchronization of movements with music, developing physical, flexibility, and coordination skills such as strength, coordination, rhythm, perception, acrobatics, and body awareness. It is a complete expressive component of the body that unites all the technical and artistic aspects in an aquatic environment.

It is considered the most modern expression of aquatic sports, regarded by many as an art requiring great skill, in which movements are performed with aesthetic appeal, demonstrating a strong sense of balance and rhythm. Precision and clean execution are essential, as is absolute control of the body in the water.

The control of movements is characterized by great complexity, variety and delicacy, manifests great physical capacity and muscular strength, strength that is inextricably linked to flexibility, requires a high stability of the vestibular apparatus for the performance of rapid and prolonged turns, orientation in space is also of great importance, and it also requires an exact dosage of muscular effort and respiratory capacity.

A current deficiency is the decrease in the quality of execution of the different figures to be performed by the athletes due to the lack of work regarding the types of movements contemplated in them from the training.

The results of Artistic Swimming in recent years in provincial and national competitions have not been satisfactory for the school team of Villa Clara province, presenting difficulties in the execution of figures and free routines.

The general objective is the biomechanical analysis of the behavior of the technical execution of the ballet figure in the athletes of the school team of Artistic Swimming of Villa Clara.

Methodology

Methods:

*Documentary analysis:*Its application aimed to determine the methodological and legal conception established by normative documents, as well as in articles, research carried out and other documents related to the topic under study; the following were considered as documentary sources:

- ✓ Rule Book of the International Swimming Federation (FINA),
- ✓ Artistic Swimming Athlete Preparation Program in Cuba,
- ✓ The call for the school category.
- ✓ Previous research addressing Artistic Swimming and the application of biomechanics.

From their analysis it is possible to suggest that there are no specific patterns for performing ballet; this is why the coaches do not have a uniform guide for training, nor in the explanation of that figure.

Within this method, an additional step was taken*Literature Review*and the following were consulted:

- ✓ Texts on Biomechanics,
- ✓ References in Research Methodology,
- ✓ Investigations carried out. (Postgraduate specialization thesis in high-performance synchronized swimming. - Montiel, D.; 2010).
- ✓ Articles and digital publications on websites specializing in sports.

The observation: was used at various points in the investigationduring several training sessions (2 sessions), with the purpose of verifying the execution of the technical performance of the ballet figure, to determine the subjects that would be selected as a sample, and during the filming sessions.

It allows us to understand reality, it is used in diagnosis and in the evaluation of performance, and the observations carried out were structured and participatory.

*Interview:*Interviews were conducted with the coaches and the national commissioner to understand their needs and interests, allowing the collection of information and the selection of athletes for study and processing.

*The evidence:*The selected technical execution for the work was applied equally to all athletes.

The procedure proposed by Perdomo was applied for the biomechanical study. et al., (2021) which consists of five steps

Step 1: Filming using cameras positioned in front of and to the side of the jumping action

Step 2: Digitizing the images frame by frame

Step 3: Synchronization of the data obtained from each of the cameras

Step 4: Phase: Obtaining results.

Step 5: Statistical processing and analysis.

Where:

*Biomechanical filming:*It was carried out in compliance with the requirements of biomechanical research, in order to perform the analysis of the technical execution of the ballet figure with the use of computer software, which is adjusted to the analysis of movements and sports actions; its application made it possible to calculate different physical magnitudes that intervene in the execution.

The filming used a camera, positioned to the side of the swimmers under investigation, to capture the execution of the ballet figure in all phases of the action and trajectory.

*Film processing:*It allowed the selection of the best sequences of the execution of the technique performed by the athletes for the application of the software, the determination of the variables and the comparison with the selected pattern.

*Software for motion analysis:*It made it possible to determine the magnitudes: angle of the ballet, speed and acceleration of the flapping and hip movements, as well as the trajectories followed by the athletes during the execution of the technique.

The following proposal was used as a pattern to obtain the results:

- ✓ Call for entries for the Artistic Swimming School Games (2016-2020). Organized by the National Artistic Swimming Commission and the Cuban Swimming Federation. (Havana).
- ✓ Official video delivered by the National Artistic Swimming Commission and the Cuban Swimming Federation, at a national meeting of coaches and judges on the performance carried out by the Mexican team.

*Methodological triangulation of the data:*Its basic principle consisted of collecting and analyzing data obtained from the application of different methods, in order to compare and

interpret them. This allowed for verifying the correspondence between the data obtained during diagnosis and implementation; furthermore, it enabled the evaluation of results to establish patterns. It is primarily applied in the study of information derived from the reference model, video analysis and processing, software application, and the athletes' actual performance.

Results and Discussion

Reference pattern for biomechanical characterization.

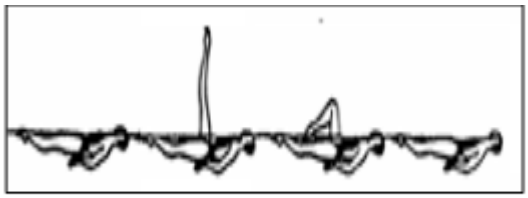


Ilustración 1:Natación Artística 2016 - 2020

According to the Artistic Swimming School Games call for entries (2016-2020), issued by the National Artistic Swimming Commission and the Cuban Swimming Federation, the Ballet Characterization is given by: “from the stretched back position, one leg is raised straight to the underwater ballet leg position. The ballet leg is then lowered.” (GD 1.6)

In addition, the official video sent as an observation guide of the figures by FINA, at the approval congress when the cycle begins, is used for the comparison of the execution; it was delivered to the province by the National Commission of Artistic Swimming and the Cuban Swimming Federation, at the national meeting of coaches and judges; it is based on the execution carried out by the Mexican team.

The comparison between the video and the performances allowed us to determine variables and observe their level.

Sequence of positions to be analyzed from the video:

Foto 1: Posición supina en la superficie del agua.

Foto 4: Ejecución de la posición de tub

Foto 2: Ejecución del ballet por encima del agua.

Foto 5: Ejecución de los aleteos en el momento del tub.

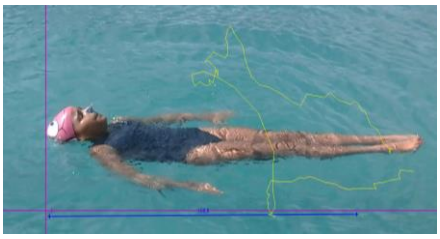
Foto 3: Ejecución del ballet por debajo del agua.

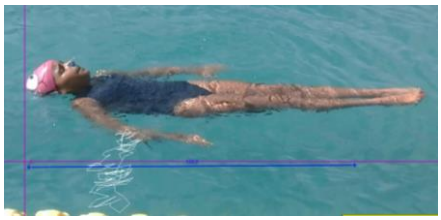
Foto 6: Ejecución de los aleteos en el momento de la supina.

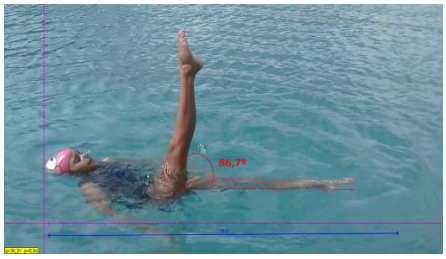
- ✓ The swimmer's position upon entering the water is correct because she is positioned horizontally and the head, torso, and legs are in proper alignment with the water's surface.
- ✓ In the execution of the ballet entrance, no sinking occurs and it exerts a 90-degree angle, which is correct.
- ✓ In the execution of the ballet underwater, it is observed that the frequency of the flapping increases when maintaining that position.
- ✓ In the execution of the tub up to the supine position, it is performed on the surface of the water without sinking the body.

Biomechanical analysis and results obtained.

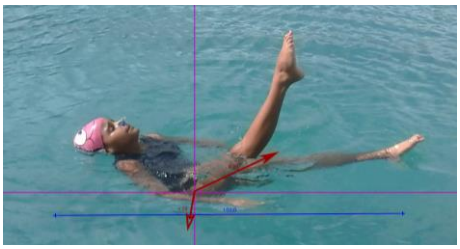
<u>Athlete 1:</u>Trajectory of the hip, right elbow, and right ankle:







Angle achieved 86.7º

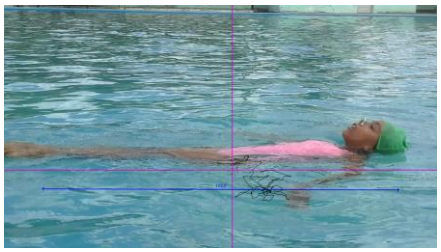


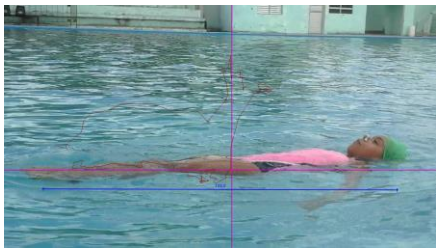
Moment of greatest force (at the hip point).

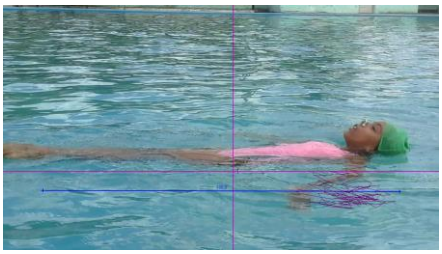
The sequential analysis of the execution shows that:

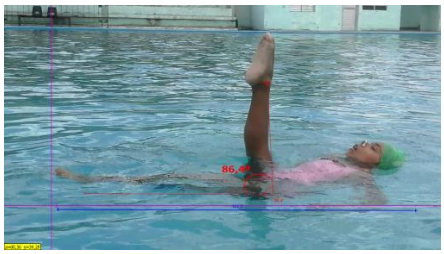
- ✓ The swimmer's initial position upon entering the water is incorrect because she is not positioned horizontally on the water's surface.
- ✓ The moment when the greatest force is exerted on the hip is while raising the leg to the ballet position.
- ✓ The kinematic analysis of the motion reveals the presence of braking, which is clearly determined by the opposition between the velocity and acceleration vectors (V- and a+) at this point (the hip).
- ✓ the need to increase the speed and force of the flapping, for which he had to hold his breath to raise his leg,
- ✓ The ballet position is reached, achieving an angle of 86.7º. (The thigh should not exceed an angle of 90º).
- ✓ It is not achieved in accordance with the model; keeping the chin above the water is not possible.

<u>Athlete 2:</u> Trajectory of the hip, right elbow and right ankle.

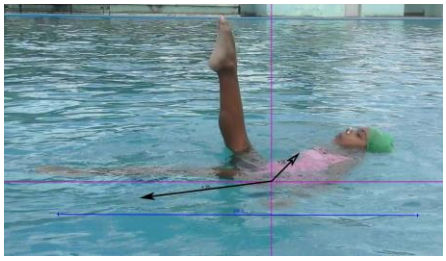








Angle achieved 86.4º



Moment of greatest force (at the hip point).

The sequential analysis of the execution shows that it is very similar to athlete 1, since:

- ✓ The swimmer's initial position upon entering the water is incorrect because she is not positioned horizontally on its surface.
- ✓ She lowers her hips too much, causing the rest of her body to sink during the ballet entrance.
- ✓ The leg is very low when performing the tubing towards the supine position.
- ✓ The moment when the greatest force is exerted on the hip is while raising the leg to the ballet position.
- ✓ The kinematic analysis of the motion reveals the presence of braking, which is clearly determined by the opposition between the velocity and acceleration vectors (V- and a+) at this point (the hip).
- ✓ need to apply greater force at the hip point to maintain the position,
- ✓ It only achieves an angle of 86.4º when the ideal angle is 90º.
- ✓ the chin submerged when, according to the model, it should be above the water.

Both athletes underwent ballet figure tests, both at the initial stage of the study and after discussions with their coaches regarding the deficiencies identified in each athlete. Based on these deficiencies, the training plan was adjusted accordingly. A reference profile was then developed to assess the development of ballet execution skills in the under-12 age category. This profile used a scale to assign scores by comparing skill development with the proposed profile. The procedure outlined by Zatsiorski (1989) in

section 5.3, Norms, was employed, which defines a norm as the limiting magnitude used to classify an athlete into one of the classification groups.

It is taken into account (according to the author himself) that among the types of norms that are proposed, the comparative norm should be used, which is based on the comparison of people who belong to the same universe and can be developed from the data of the averages and standards.

In evaluating the results obtained from the application of the biomechanical procedure, the results obtained are first compared with the reference pattern explained above for the biomechanical study, since no references to previous biomechanical studies were found, and then the results obtained are compared with the prototype or reference profile determined in the research.

Table 1.

Evaluation of indicators based on results in athletes

Athletes / Indicators	Body placement in relation to body surface area (cm)	Distance from the hip to the water surface at takeoff (cm)	Hip position during movement (cm)	Ballet angle (degrees)
Pattern	0	5	8	90
Athlete 1	4	10	12	80.5
Athlete 2	1	7	9	89
Athlete 3	2	9	12	87.3
Athlete 4	3	6	13	85
Athlete 5	2	8	10	87.4
Athlete 6	1	6	9	91.5
Athlete 7	2	7	10	89.5
Athlete 8	4	11	13	80
Minimum value	1	6	9	80
Average	2	8	11	86
Maximum value	4	11	13	92
Median	2.0	7.5	11.0	87.4
Standard Deviation	1.19	1.85	1.69	4.17

Note: My own inspiration

For the development of the standards to evaluate the results of the application of the reference profile for the mastery of the body posture of the ballet figure in the school

category of artistic swimming, Zatsiorski VM (1989) is assumed, and the procedure is based on adding to the mean 1/2, 1/4 and 1/6 of the Standard Deviation and the high, medium and low values were determined which will be compared individually with the subjects of study of the research

Table 2.

Standards for evaluating the results of applying the reference profile for mastering body posture in the technical execution of ballet figures

Indicators	N	Mean	SD	High + 1/2 SD	Medium + 1/4 SD	Bass + 1/6 SD
Body placement in relation to body surface area (cm)	8	2	1.19	1.6	2.8	4.2
Distance from the hip to the water surface at takeoff (cm)	8	8	1.85	6.9	8.5	11.4
Hip position during movement (cm)	8	11	1.69	9.8	11.4	13.3
Ballet angle (degrees)	8	86	4.17	93.6	87.3	80.8

Note: My own inspiration

Table 3.

Results of the implementation of the reference profile to assess the development of skills for mastering body posture in the technical execution of the ballet figure in the school category of artistic swimming

Athletes	Sex	Body placement in relation to body surface area (cm)	Qualification	Distance from the hip to the water surface at takeoff (cm)	Qualification	Hip position during movement (cm)	Qualification	Ballet angle (degrees)	Qualification
1	F	4	M	10	R	12	R	80.5	M
2	F	1	B	7	R	9	B	89	B
3	F	2	B	9	R	12	R	87.3	R
4	F	3	R	6	B	13	M	85	R
5	F	2	B	8	R	10	R	87.4	R
6	F	1	B	6	B	9	B	91.5	B
7	M	2	B	7	R	10	R	89.5	B

8	M	4	M	11	M	13	M	80	M
Average result		3	R	8	R	11	R	86	R

Source: own elaboration

By implementing the reference profile, it is possible to assess the development of each athlete's skills in terms of mastering body posture in the technical execution of ballet figures, such as:

- Athlete 1, in body placement in relation to body surface (cm) 4, has a rating of M; distance from hip to water surface at takeoff (cm) 10, has a rating of R.hip position during movement (cm)12 has an R rating, ballet angle 80.5 has an M rating.
- Athlete 2 in body placement in relation to body surface (cm) 1 has a rating of B, distance from hip to water surface at takeoff (cm) 7 has a rating of R,hip position during movement (cm)9 has a grade of B, ballet angle 89 has a grade of B.

And successively the rest of the team, which benefits the coachTo have a real understanding of the current situation of the artistic swimming team of the provincial EIDE “Héctor Ruiz Pérez” of Villa Clara, and to be able to readjust the training plans for it.

Conclusions

1. The biomechanical analysis showed that the regulations in the reference model are not met; deficiencies persist in the height of the body relative to the horizontal with the water, there is a lack of body control during execution, the legs are not extended correctly, and there is a need to apply greater force at the hip point to prevent pronounced sinking.
2. The methodological procedure created allowed the formation of the reference profile of the body posture domain of the ballet figure in the sport discipline of Artistic Swimming, and its implementation revealed, by comparing the average results derived from the biomechanical analysis, with the prototype or reference profile created for this purpose, the current situation of the team of this sport of the provincial EIDE “Héctor Ruiz Pérez” of Villa Clara.

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