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Original article

Sports Biomechanics applied to volleyball with the STEAM approach

[*Biomecánica Deportiva aplicada al voleibol con el enfoque STEAM*]

[*Biomecânica esportiva aplicada ao voleibol com uma abordagem STEAM*]

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ABSTRACT

Introduction: This research addresses the study of movement in physical activity, particularly volleyball, through biomechanics with a STEAM approach, integrating science, technology, engineering, mathematics, and the arts.

Objective: To analyze the blocking technique in Volleyball from the ages of 11 to 12 years in the Luis Pérez Lozano secondary school in Cienfuegos using the tools of the STEAM approach, in particular the LongoMatch software.

Materials and methods: Methods such as historical-logical, analytical-synthetic, inductive-deductive, document analysis, and surveys were used.

Results: The simultaneous application of tools in this approach links new information and communication technologies with biotechnology, motion simulators, software, robotics, and artistic manifestations that represent the movement of this biomechanical study.

Conclusions: In the analysis of human movement, the methods employed depend on the subject matter being studied. STEAM tools can be used individually or collectively to understand the movements performed in Physical Education classes. Specifically, the LongoMatch software is a tool to facilitate the analysis and improvement of volleyball performance within the framework of Sport for All for 11- to 12-year-olds at the Luis Pérez Lozano Secondary School in Cienfuegos. This is a fundamental connection for the research-based work practice, linking the situations inherent in sports with the realities of second-year Physical Culture and Sports students in the Sports Biomechanics course, so that their experiences contribute to the acquisition of knowledge.

Keywords: STEAM approach, biomechanics, volleyball, LongoMatch software.

RESUMEN

Introducción: La investigación aborda el estudio del movimiento en la actividad física, en particular voleibol mediante la biomecánica con el enfoque STEAM, al integrar las ciencias, las tecnologías, las ingenierías, la matemática y las artes.

Objetivo: analizar la técnica de bloqueo en el Voleibol desde en las edades de 11 a 12 años en la secundaria Luis Pérez Lozano de Cienfuegos mediante las herramientas del enfoque STEAM, en particular el software LongoMatch.

Materiales y métodos: se emplearon métodos cómo el histórico-lógico, el analítico-sintético, el inductivo-deductivo, análisis de documentos, encuesta.

Resultados: La aplicación simultánea de herramientas de este enfoque relaciona las nuevas tecnologías de la información y las comunicaciones con la biotecnología, los simuladores de movimiento, software, la robótica y las manifestaciones del arte que representan el movimiento de este estudio biomecánico.

Conclusiones: En el análisis del movimiento humano, los métodos empleados, dependen del tema estudiado, siendo posible su utilización de manera individual o colectiva las herramientas del STEAM para comprender dichos movimientos que se realizan en la Educación Física Escolar, en particular el software LongoMatch es una herramienta para facilitar el análisis y mejora del rendimiento en el Voleibol desde el Deporte para Todos en las edades de 11 a 12 años en la secundaria Luis Pérez Lozano de Cienfuegos. Relación fundamental para la práctica laboral investigativa vincular las situaciones propias del deporte con la realidad de los estudiantes de segundo año de la carrera de la Cultura Física y el Deporte desde la asignatura Biomecánica Deportiva, de forma que sus vivencias favorezcan la adquisición de conocimientos.

Palabras clave: enfoque STEAM, biomecánica, voleibol, software LongoMatch.

RESUMO

Introdução: Esta pesquisa aborda o estudo do movimento na atividade física, especificamente no voleibol, através da biomecânica, utilizando uma abordagem STEAM, que integra ciência, tecnologia, engenharia, matemática e artes.
Objetivo: Analisar a técnica de bloqueio no voleibol em alunos de 11 a 12 anos da Escola Secundária Luis Pérez Lozano, em Cienfuegos, utilizando ferramentas STEAM, em particular o software LongoMatch.
Materiais e métodos: Foram empregados métodos como o histórico-lógico, o analítico-sintético, o indutivo-dedutivo, a análise documental e um questionário.
Resultados: A aplicação simultânea de ferramentas desta abordagem conecta as novas tecnologias de informação e comunicação com a biotecnologia, simuladores de movimento, software, robótica e expressões artísticas que representam o movimento neste estudo biomecânico. Conclusões: Na análise do movimento humano, os métodos empregados dependem do tema estudado. As ferramentas STEAM podem ser utilizadas individualmente ou em conjunto para compreender os movimentos realizados nas aulas de Educação Física. Em particular, o software LongoMatch é uma ferramenta para facilitar a análise e o aprimoramento do desempenho no voleibol no âmbito do programa

Esporte para Todos, para alunos de 11 a 12 anos da Escola Secundária Luis Pérez Lozano, em Cienfuegos. Uma conexão fundamental para a prática de pesquisa é vincular as situações inerentes ao esporte com as realidades dos alunos do segundo ano da disciplina de Biomecânica do Esporte, de modo que suas experiências contribuam para a aquisição de conhecimento.

Palavras-chave: Abordagem STEAM, Biomecânica, Voleibol, Software LongoMatch.

INTRODUCTION

In recent years, sports have undergone significant changes, with a focus on spectacle to attract larger audiences and, crucially, greater profits for professionals in the field. This has spurred research into new studies on training, performance, and competition, applying biomechanics as a science to improve performance in specific sports techniques and reduce the risk of injury.

Hernández (2016), citing directors of the National Institute of Sports, Physical Education and Recreation (INDER) in Cuba and the Improvement of Physical Education and Sport for All program, asserts that it is necessary for Cuban sport to link physical and sporting activities to improve the quality of life of children, adolescents, and young people within a school context. This principle is the guarantee of Sport for All. In this regard, the incorporation of science, technology, engineering, mathematics, and the arts can positively influence the understanding of sporting movements and gestures, specifically in volleyball, and help prevent the risk of injuries.

In this regard, Physical Education promotes Sport for All starting in Secondary Education. At this level, students will find projects approved by National Sports Federations, such as " *Volleyball for All* " for both sexes. This project aims to encourage girls to participate in this sport.

Furthermore, reviews were conducted on research results published by thesis authors. Thus, based on the authors' practical experience, the results of research conducted on the topic, theoretical reflections, and the empirical study developed in the exploratory stage, it was confirmed that: There is evidence of insufficient theoretical research on guiding the process of introducing volleyball to school sports within Physical Education activities. Professionals working in this area with 11-12 year olds do not apply methodologies that foster creativity, independence, and active participation in their own learning. Therefore, to strengthen this learning, science teaching approaches with a comprehensive and interdisciplinary perspective are needed.

Coello et al. (2018), Santillán *et al.* (2019), Higuera *et al.* (2019), Alsina (2020), Celis and González (2021), Contreras (2021), Castro (2022), and Macurí (2023) assert that the STEAM approach is an integrative method for the disciplines that comprise the acronym: S (Science), T (Technology), E (Engineering), A (Art), and M (Mathematics), thereby generating theoretical foundations that can contribute to a shift in the educational paradigm. These are key contributions to this research, as they connect with the curriculum content across various sciences.

The research is based on another reference of greater relevance as defined by Contreras (2021) and Castro (2022), as STEM education that "can be interpreted as an approach to teaching science, technology and engineering in an interdisciplinary way" (p.160).

The interest of professionals in Physical Culture and Sports in Higher Education suggests that their graduates should master basic content in an interdisciplinary manner as an indispensable cognitive resource in physical activity and sports. The authors Estrada (2018), Perdomo *et al.* (2018), and Hernández (2020), the latter using new technologies for the three-dimensional analysis of the blocking landing in volleyball and its possible implications for lower limb injuries, argue that acquiring prior knowledge in an integrated way is beneficial for understanding the sciences applied in Physical Education and Sports. However, they do not direct the sciences, engineering, technology, mathematics, and the arts to guarantee the comprehension of new knowledge, nor the critical and scientific learning that is essential.

Biomechanics is a comprehensive science that studies the application of the laws of mechanics to the structures and organs of living beings. It allows the application of mathematical and physical knowledge to understand the behavior of a living organism, in our case, in the execution of techniques in Physical Education. It offers broad possibilities for application in solving practical problems within sports-related learning situations. In our case, it can be applied to the analysis of human movement to improve the efficiency of movements and skills in a specific sport within Physical Education, thereby transforming it into a motor skill.

Oliveira (2018, p. 363) refers to the fact that physical activity needs specialized equipment or laboratories, in an integrated way, giving the need to include other areas of knowledge for a broader and more holistic analysis of data and results, in addition to solving the possible emerging challenges during the development of the investigations. The challenge in Physical Education is the collection of data for which interventions have been planned, such as small, pre-sports, and sports games. This contribution impacts physical activity from the initial stages of sports initiation. This guarantees the development of motor skills and motivates students to choose sports as a foundation for sports initiation. However, they do not delve into how to integrate the STEAM approach into the sports initiation process in Volleyball, a sport for all, within School Physical Education. Based on the literature review conducted and the limitations found in biomechanical studies of the sport under study, the objective is to analyze the blocking technique in Volleyball among 11- to 12-year-olds at the Luis Pérez Lozano Secondary School in Cienfuegos using STEAM tools, specifically the LongoMatch software.

MATERIALS AND METHODS

The methodological design corresponds to a descriptive study that seeks to establish the existence of a phenomenon through its explicit description. It is a non-experimental, cross-sectional study, where data collection occurs at a single point in time. For the development of the research, different scientific methods were used at the theoretical

level: analytical-synthetic, inductive-deductive, and historical-logical, which provided a theoretical foundation. Empirical methods included document review, measurement, and surveys for data collection. Descriptive statistics were used with the LongoMatch software.

The implementation was organized with a purposive sample of six students from Luis Pérez Lozano High School, selected based on the criteria of student-athletes who practice volleyball. In addition, three students from the student research group of the Physical Culture and Sports program participated.

In identifying the problem, the diagnosis and measurement using LongoMatch software demonstrated the need to study the physical activity of volleyball from a biomechanical perspective within secondary school physical education. Empirical methods were employed: document analysis was used to verify the content of biomechanical studies of techniques in school physical education as an introduction to volleyball within the framework of Sport for All with a STEAM approach; a survey of the same sample was administered to determine their perception of the benefits of the STEAM approach through interdisciplinary relationships between science, engineering, technology, mathematics, and the arts in secondary school physical education.

Biomechanics and the tools of the STEAM approach

LongoMatch software is a tool for specialists, coaches, analysts, physical trainers, etc., whose objective is to facilitate the analysis and improvement of your team's performance, regardless of the sport you play. According to Hernández (2020), any motion analysis software is helpful in preparing your own team and in analyzing the opposing teams you play against. It allows for detailed analysis of game situations through video.

In the case of the LongoMatch software , it originated as a final year project. According to Mercado (2020), one of the pioneers in this type of research was Andoni Morales, who at the time was a professional field hockey player. Andoni wanted to offer a powerful

video analysis tool for amateur clubs that did not have the same financial resources as first division clubs, and that is how the project was born.

In 2014, the software was acquired by Fluendo , which has been responsible for its development and marketing ever since. Based on these concepts, the students in the Physical Culture student research group use it to understand the movements of sports equipment and the human body in the practice of indoor volleyball for girls aged 11-12.

Similarly, to achieve a sociocultural approach, it would be appropriate, as Lóriga (2020) and (2024) reflect in their historical research on sport, to examine all processes related to sport from within their own historical context. Therefore, biomechanical studies can also be approached from this perspective.

One of the biggest advantages is that we have subscription plans that make LongoMatch accessible to all types of users. For daily use, the video conversion tool, which allows you to combine multiple videos into a single file without needing any other software, is incredibly useful. The presentations section, which has recently been improved, is also great for keeping all the match highlights organized and editing them; you can also add external images and videos to create the final video you want to show your team, without needing external video editors. In addition, LongoMatch can be configured for a wide variety of sports through customizable dashboards . Another plus is that LongoMatch is available for both Windows and Mac, a feature that other tools lack.

LongoMatch software exemplifies the STEAM approach, as it analyzes and connects science, technology, engineering, mathematics, and the arts. Furthermore, LongoMatch is compatible with Windows and other operating systems.

Study of blocking technique in volleyball with a STEAM approach

Venek *et al.* (2022) state that the use of sensor technology in sports is necessary to facilitate data-driven evaluation of human movement. From this perspective, the movement of the human body during athletic activity is described. Another example, Olivera *et al.* (2016) define blocking as a product of the evolution of modern volleyball.

It is an action performed after a vertical jump, with the upper limbs extended over the net, with the aim of intercepting the opponent's attack. Furthermore, blocking in volleyball is a defensive method against attacks executed by the opponent; the defensive team jumps to intercept the ball with the aim of sending it back into the opponent's court.

The evolution of volleyball and the refinement of the attack have led to modifications in the rules of the game. The most important change is allowing the hands to pass over the net during a block. Based on this, several elements are needed to develop technical mastery, such as: consistent instruction and practice; a thorough understanding of the theory; excellent physical conditioning; and the experience gained through competition. To achieve this, a kinematic analysis was conducted on various athletes from the elite men's volleyball team. This analysis demonstrated that the vertical takeoff speed must be 3.59 m/s for the execution of the sporting skill to be effective.

These studies offer insights that highlight the importance of using tools such as software, motion simulators, and robotics to evaluate specific techniques. These contributions, particularly the analysis of the basic blocking technique in volleyball, establish that the correct final knee flexion angle is crucial for the final jump. This angle is between 100 and 115 degrees for players with significant lower limb muscle strength. However, biomechanical indicators that would allow for measuring the coordination of steps at the end of the movement to ensure they are adequate, and therefore, that players will be more successful in executing the technique, have not yet been demonstrated.

It is worth noting that Zapata and Suárez (2010), cited by Hernández, E. (2020), establish that the angle of both the right and left shoulders at the moment of contact with the ball should be 150º, and the angle of the right knee at takeoff corresponds to a value of 166º, compared to the left knee, whose angle at takeoff is 160º. These angles allow the athlete to adopt a key and decisive position upon which the effective execution of the technical movement largely depends. Block with displacement: particularities of the movement structure. Among the spatial kinematic characteristics of the block with displacement technique in the second phase of the movement, the following stand out: the maximum

flexion angle in the knees; the angle of the right knee at takeoff; the angle of the left knee at takeoff; and the takeoff speed of the center of gravity.

Similarly, the spatial kinematic characteristics of the blocking technique with displacement in the third phase of the movement are analyzed, such as: maximum hand height relative to the floor at contact with the ball; and the angle of the right shoulder at the moment of contact with the ball. Finally, the biomechanical spatio-temporal characteristics of blocking with displacement in the fourth phase of landing are examined, such as: landing on the toes, knee flexion, and preparation for the next action.

Several authors have conducted biomechanical studies of indoor volleyball. In this analysis, we focus on the takeoff phase, which influences the outcome of the block. The takeoff is performed by jumping and extending the upper limbs above the net to reach the height of the ball. The hands should be 15 cm apart, with the fingers fully extended and spread to cover the largest possible area and thus prevent the opposing team's spike from having a positive effect.

For the jump, the blocker makes a displacement that can be perpendicular to the net or parallel, depending on his previous position, lowers the center of gravity by flexing the legs, feet parallel somewhat separated, supported on their soles, the arms close to the body make a sudden extension upwards, hands very firm with the fingers separated; the eye follows the path of the ball.

The player who blocks cannot be in a passive position, but must be prepared to change position quickly.

There are two ways to achieve this:

- The player jumps with his arms bent and, at the moment of the attack, makes a violent extension of his arms.
- Jump with your arms outstretched and if the attacker touches the ball softly, quickly lower your arms to be ready to set up a new attack play.

To perform the analysis of the height of the body's center of gravity at the moment of contact with the ball and the maximum height of contact with the ball.

- He makes a counter-pendulum movement of his arms backwards in the form of an attack.
- He does not perform the turn in the last step to face the net.
- He does not extend his arms to the height necessary for contact with the ball.
- Little knee flexion for takeoff.

By using the tools and resources of the STEAM approach, biomechanical studies are complemented, and junior high school students in Physical Education class are able to understand sports gestures and techniques, in particular, the technique of blocking with displacement in volleyball from the perspective of sport for all.

These activities in Physical Education classes for 11-12 year old students culminated in a drawing activity where participants simply represented the movement description. Afterward, a survey was conducted to gauge student satisfaction with these activities. Eighty percent of the students rated them as positive and interesting, stating that the activities introduced them to new knowledge and fostered an understanding of the blocking technique in volleyball within the context of the sport being accessible to all. Many students were interested in volleyball, and these activities encouraged teamwork. Twenty percent rated them negatively because they did not understand volleyball and were not motivated by the sport.

Field study order. Takeoff to block the ball in volleyball

LongoMatch software analyzes the takeoff phase for blocking the ball in volleyball. The following describes the athletic movement of 12 volleyball players who, upon taking off from a standing position, reach a height of 1.22 m above the ground, while gravity remains constant.

a) Analyze the filming of the takeoff phase of the block in volleyball.

b) Using the LongoMatch software, determine the takeoff height of the blocking phase in volleyball for three male volleyball players in the junior category.

c) Explain the relationship between the height reached and the weight at the takeoff of the volleyball blocking technique and the effectiveness of the ball block. An effective shot at the basket. This task aims to determine the range of the ball throw in the shooting technique using a motion simulator, measurements, and the selection of the most effective positions. Furthermore, it relates the physical and biomechanical aspects, the range of the throw, and the angle of inclination of the parabolic motion, and, as a specific aspect of the sport, the basic basketball shooting technique. It is used as a laboratory exercise. It can be completed as independent work within the class system or as a research assignment. The task can be evaluated in different ways, either orally or in writing. The resources used to complete the task are the textbook, measuring tape, camera, computer, and GeoGebra motion simulator .

RESULTS AND DISCUSSION

LongoMatch software is one of the tools of the STEAM approach; it can analyze the effectiveness of the ball blocking technique and displays statistics on the correctness or failure of said technique.

The STEAM approach by Torres *et al.* (2024) connects the possible manifestations, expressions, and representations in other sciences and in the arts. These include motion simulators, software, models, and drawings. First, parabolic motion is analyzed independently through simulation. Then, the specific situation of the sport—the shooting technique—is analyzed. Next, the relationship between range and angle of inclination is determined using parabolic motion. Subsequently, the direct and inverse links (one or both approaches can be used) are determined. Direct relationships are established using physical equations and can be applied to the sport. Inverse relationships are determined based on the main kinematic release parameters (release

height, angle of inclination) in the phases of the technique that guarantee greater range. Finally, the relationships are explained through the answers to sections c and d, and the drawings.

The results of implementing a kinematic study of ball blocking in volleyball are presented. A diagnostic assessment was conducted to select the sample, taking into account the development of basic volleyball skills. Following the implementation of the LongoMatch software , which supported the understanding of the technique, the actions facilitated an understanding of Physics and Sports Biomechanics among the students participating in the student research group, within the framework of Sport for All in School Physical Education. From this perspective, student-student and student-teacher relationships are strengthened; deep learning is achieved with scientific rigor, yielding superior results. The impact on the kinematics of ball blocking was observed through analysis using the mediating instruments of the STEAM approach, supporting Vygotsky 's sociocultural theory. This is presented in Figure 1.

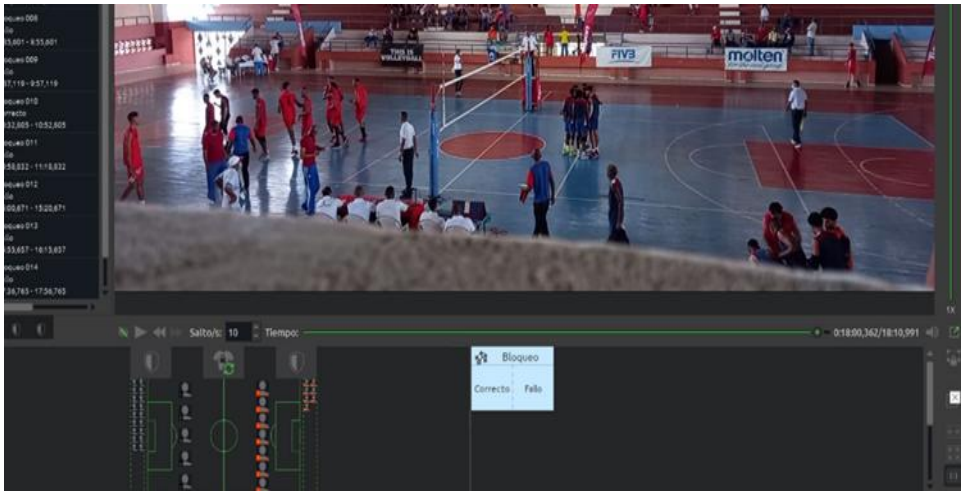

Fig. 1.- *Capture of the LongoMatch software , in a match of the first category of men's volleyball in Cienfuegos*

Below presents the statistical database for evaluating the kinematic characteristics of the ball blocking technique.

CATEGORY: Bloqueo							
Name	Time	Start	Stop	Team	Player	Correcto	Fallo
Bloqueo 001	00:17,3	00:07,3	00:27,3	ADV 15's	1-Player 1	0	1
Bloqueo 002	01:25,5	01:15,5	01:35,5	ADV 15's	1-Player 1	0	1
Bloqueo 003	02:30,1	02:20,1	02:40,1	ADV 15's	1-Player 1 |	0	1
Bloqueo 004	03:01,6	02:51,6	03:11,6	ADV 15's	1-Player 1 |	1	0
Bloqueo 005	05:49,6	05:39,6	05:59,6	ADV 15's	1-Player 1 |	1	0
Bloqueo 006	06:32,4	06:22,4	06:42,4	ADV 15's	1-Player 1 |	1	0
Bloqueo 007	06:58,8	06:48,8	07:08,8	ADV 15's	1-Player 1 |	0	1
Bloqueo 008	08:45,6	08:35,6	08:55,6	ADV 15's	1-Player 1	0	1
Bloqueo 009	09:47,1	09:37,1	09:57,1	ADV 15's	1-Player 1 |	0	1
Bloqueo 010	10:42,8	10:32,8	10:52,8	ADV 15's	1-Player 1	1	0
Bloqueo 011	11:08,8	10:58,8	11:18,8	ADV 15's	1-Player 1 |	0	1
Bloqueo 012	15:10,7	15:00,7	15:20,7	ADV 15's	1-Player 1 |	0	1
Bloqueo 013	16:05,7	15:55,7	16:15,7	ADV 15's	2-Player 2	0	1
Bloqueo 014	17:46,8	17:36,8	17:56,8	ADV 15's	1-Player 1	0	1
CATEGORY: Sustituciones							
Name	Time	Start	Stop	Team	Player		
AlineaciÃ³n	00:00,0	00:00,0	00:00,0				

Fig. 2. *- Statistical database for evaluating the kinematic characteristics of the ball blocking technique*

In the survey of the student research group, they were able to focus their study on Physical Education in schools and the sporting contexts of society. They considered teamwork to be positive, as together they achieved the proposed objective: the kinematic characteristics of ball blocking were evaluated, there was a good understanding of the movement of the equipment and the human body in sports performance, and the values of responsibility and collectivism were strengthened. They stated that the STEAM approach is an essential contribution to continuing education.

CONCLUSIONS

The study of the kinematic characteristics of ball blocking in indoor volleyball with displacement allowed the biomechanical model to be made with the support of the LongoMatch software for the analysis of its movements.

The diagnostic assessment revealed the current state of the relationship between the content of the Sports Biomechanics course and the teaching methods used by students

in the Physical Culture and Sports program. It confirmed deficiencies in the didactic approach and the way the content is presented within the STEAM framework.

The relationship of Sports Biomechanics with the STEAM approach can strengthen new scientific knowledge for the determination and analysis of the kinematic characteristics of motor action that influences the understanding of technical execution in volleyball as a sport for all.

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Conflict of interest:

The authors declare no conflicts of interest.

Authors' contribution:

The authors have participated in the writing of the work and analysis of the documents.