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*Translated from the original in spanish*

**Original article**

## **Methodological procedure for the determination of the motor skill invariants of the long jump in sport initiation**

**Procedimiento metodológico para la determinación de las invariantes de habilidades motrices del salto de longitud en la iniciación deportiva**

**Procedimento metodológico para a determinação das invariantes das habilidades motoras do salto em distância na iniciação ao desporto**

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### **ABSTRACT**

Studies carried out in different countries show that internal-biological and external-social characteristics determine the pace of learner development. However, after an evaluation of the *Athletics Education Program*, it was found that the selection of tasks, the growth and development of the athlete, his/her participation in social life as a citizen and the changes in knowledge, skills, feelings and convictions have not been taken into account. That is why the present study was developed, with a view to determine the invariants of motor skills in correspondence with the development of the external and internal



characteristics of long jumpers in sports initiation. For this study, methods such as documentary review, interview, survey and the criteria of specialists and users, as well as interactive techniques were used, which made possible to conform the methodological procedure, which gives a different vision to the way in which the abilities are selected for the teaching-learning process of the Long Jump at present.

**Keywords:** Invariants; Sports Initiation; Skills.

## RESUMEN

Los estudios realizados en diferentes países demuestran que las características internas-biológicas y externas-sociales, determinan en el ritmo de desarrollo de los educandos. Sin embargo, luego de un análisis valorativo del "Programa de Enseñanza de atletismo", se constató que no se ha tenido en cuenta en la selección de las tareas, el crecimiento y desarrollo del atleta, su participación en la vida social como ciudadano y los cambios en los conocimientos, habilidades, sentimientos y las convicciones, lo cual demandó de los entrenadores, adecuaciones en el contenido de lo que se va a desarrollar en el entrenamiento deportivo, considerando la experiencia del atleta y su nivel de maduración. Es por ello que, se desarrolló el presente estudio con vista a determinar las invariantes de habilidades motrices en correspondencia con el desarrollo de las características externas e internas de los saltadores de longitud en la iniciación deportiva. Para dicho estudio se diagnosticaron a los entrenadores, especialistas y directivos del deporte atletismo en la provincia de Villa Clara mediante la aplicación de métodos como la revisión documental, entrevista, encuesta y el criterio de especialistas y usuarios, así como técnicas interactivas, que posibilitaron conformar el procedimiento metodológico, el cual le da una visión diferente a la manera en que se seleccionan las habilidades para el proceso de enseñanza-aprendizaje del salto de longitud en la actualidad.

**Palabras clave:** Invariantes; Iniciación deportiva; Habilidades.

## RESUMO

Estudos realizados em diferentes países mostram que as características internas-biológicas e externas-sociais determinam o ritmo de desenvolvimento dos estudantes. Contudo, após uma análise avaliativa do "Programa de Ensino de Atletismo", verificou-se que este não foi tido em conta na seleção de tarefas, no crescimento e desenvolvimento do atleta, na sua participação na vida social como cidadão e nas mudanças de conhecimentos, capacidades, sentimentos e convicções, o que exigiu dos treinadores, ajustamentos no conteúdo do que será desenvolvido no treino desportivo, considerando a experiência do atleta e o seu nível de amadurecimento. É por isso que o presente estudo foi desenvolvido a fim de determinar as invariantes das capacidades motoras em correspondência com o desenvolvimento das características externas e internas dos saltadores de longa distância na iniciação ao desporto. Para este estudo, técnicos, especialistas e gestores do desporto do atletismo na província de Villa Clara foram diagnosticados através da aplicação de métodos como a revisão documental, entrevista, inquérito e os critérios de especialistas e utilizadores, bem como técnicas interativas, que permitiram formar o procedimento metodológico, que dá uma visão diferente à forma como as competências são atualmente selecionadas para o processo de ensino-aprendizagem do salto em distância.

**Palavras-chave:** Invariantes; Iniciação desportiva; Habilidades.



## INTRODUCTION

The development of sports skills in athletics is the starting point in the initiation of its practitioners, based on the development of physical, technical and psychological preparation, which allows them to withstand the heavy loads they will receive during their future sports life, confirming that it is necessary to pay special attention to it as the main link in the sports training process.

One aspect to consider in sports initiation is the training capacity, which reflects the degree of adaptation to training loads. It is a dynamic magnitude, which depends on a series of endogenous factors (body constitution, age, etc.) and exogenous factors (nutrition, environmental conditions, etc.). Hence, within the same person it can vary in the different organic and functional systems. Likewise, it is necessary to bear in mind the "sensitive phases" understood as the periods of development especially favorable for the establishment of certain factors of sport-motor performance; that is, the stages in which the training capacity is especially high (Weineck, 2005).

From all this it follows that in the programming of tasks and exercises in training with children these are two elements that must be taken into account, considering the real possibilities of these and their level of maturation.

In the pedagogical process carried out both in Physical Education and in sports training, the dialectic relationship between internal biological factors and external pedagogical factors acquire a special significance, since the development and improvement of physical capacities and motor skills, fundamental objectives of this process, depend, on the one hand, on the internal conditions that the developing organism itself possesses, that is, in its physiological structure, in its psychic qualities. Although the sequence of the development of locomotion, for example, is determined genotypically, physical exercises are introduced into the process as an indispensable condition for it, as an important factor in muscular development, in the coordination of the child's movements. At the same time, the effectiveness of the exercises depends on the degree of maturity of the child's organism (Ruiz, 2007).

It should also be pointed out that the subject's capacities are shaped as the mastery of skills increases, while at the same time making possible the performance of his actions, constituting one of his conditions and the result of them. They are a set of fundamental movements and motor actions that arise in the human evolution of motor patterns, having their foundation in the hereditary (genetic) endowment. Basic motor skills are supported for their development and improvement in perceptual motor skills, evolving with them, these are decisive for the development of human motor skills, justifying the interest in them and their presence in basic Physical Education (Prieto, 2010).

For these reasons, in an Athletics training with children, the age, sex and maturation of the children cannot be disregarded when programming each of the tasks.

First of all, it is necessary to explain that, at this age, the child should not be subjected to a training plan, with periodization and peak moments of emergence of the form, with the rigorousness with which it is carried out by athletes of higher ages and categories, so it is necessary to involve children in various activities and not expose them prematurely to learn a particular skill or specialized in a sport, before they are fully developed. Early specialization can indeed lead to failure and discourage future participation (Cancio and Calderín, 2010).



Each child is a world with different motor skills and degree of maturation, so that not everyone can be assessed and judged equally (López and López, 2012).

Arteaga (2016), provides a classification on motor skills, where he points out that any classification used has to offer the possibility of:

- Work in and with different levels of difficulty (from easy to difficult).
- To become aware of the similarities and differences among motor skills, establishing relationships among them, taking into account their learning difficulties.

The evolution in the development of motor skills confirms the criterion that both these and habits are complementary phenomena, not exclusive and essential to any motor action, from which parallels can be deduced that explain how as the practical exercise is developed under certain conditions, morpho-functional and psychological changes of an internal and reflex nature occur, capable in turn of explaining their external, observable manifestations (López & Juanes, 2020).

The teaching of athletic sports skills is the starting point in the initiation of its practitioners, thus ensuring, as well as with the development of physical abilities, their future specialization.

The "Athletics teaching program" provides teachers and trainers with methods and means adaptable to any material condition, being feasible its development by teachers working in these areas. It also proposes recommendations that serve as a working tool for a better planning, control and evaluation of the pedagogical process in these age groups. However, some of the exercises for the development of jumping technique in horizontal jumps do not respond to the maturity levels of athletes of these ages.

The previously analyzed topics reveal that it is necessary to teach the long jump at the ages of 9-12 years old, using motor skill invariants that allow bringing the level of complexity of the exercises closer to the maturity levels of the practitioners.

Among the authors who have addressed the issue of invariant skills are: (Arce & Azahares, 2009; Oviedo & González, 2016; Hernández & Pérez, 2016). There are also other authors who have researched on the subject, but all from the perspective of pedagogy, especially cognitive skills.

All of the above leads to formulate the objective of the present research: to establish a methodological procedure to determine the invariant motor skills for the long jump, in the 9-10 years old category.

## **MATERIAL AND METHODS**

The approach of this study was the historical-dialectical-materialist one, since it allowed the use of both theoretical and empirical methods, depending on the nature of the object of study.

Among the methods used were:

Documentary analysis: this method made possible the study of methodological documents that regulate the teaching-learning process in sports initiation, among which is the "Athletics teaching program".



Units of analysis used:

- Orientations of the athletics teaching program in terms of teaching the technique of the long jump.
- The complex of exercises for the development of the technique of horizontal jumps.
- The components of the teaching-learning process of the long jump at the age of 9-10 years.

Survey: it was applied to the 14 base coaches who train athletics in sports initiation, so that we could gather information about the way in which they develop the long jump technique and if they knew the term invariant motor skills and some procedure to determine them.

Interview: it was applied to 12 officials of Athletics in Villa Clara, in order to know their valuation criteria about how coaches teach the long jump in the 9-10 years old category and if they know the invariant term of motor skills and some procedure to determine them. They also acted as introductory specialists.

Users' criteria: it was applied to 15 members of the Provincial Athletics Commission of Villa Clara to assess their opinion on the result.

The IADOV technique was used to evaluate user satisfaction, taking into account the theoretical postulates of Campistrous and Rizo (2006) cited in Fernández and López (2014).

A questionnaire was used with a total of five closed questions and two open questions, the relationship between which is unknown to the subject.

The number resulting from the interrelation of the five closed questions indicated the position of each subject on the satisfaction scale, that is, his or her individual satisfaction. The satisfaction scale used is as follows:

1. Clear satisfaction.
2. More satisfied than dissatisfied.
3. Not defined.
4. More dissatisfied than satisfied.
5. Clear dissatisfaction.
6. Contradictory.



This technique also made it possible to obtain the group satisfaction index (ISG in Spanish), for which we worked with the different levels of satisfaction expressed on a numerical scale ranging from +1 to - 1 as follows (Table 1).

**Table 1.** - Numerical scale

Scale	Results
+ 1	Maximum satisfaction
0.5	More satisfied than dissatisfied
0	Undefined and contradictory
- 0.5	Satisfied
-1	Maximum dissatisfaction

Group satisfaction is calculated by the following formula (Equation 1).

$$ISG = \frac{A (+1) + B (+0.5) + C (0) + D (-0.5) + E (-1)}{N}$$

In this formula A, B, C, D, E, represent the number of subjects with individual index and where N represents the total number of subjects in the group.

The group index yields values between + 1 and - 1. Values between - 1 and - 0.5 indicate dissatisfaction; those between - 0.49 and + 0.49 indicate contradiction and those between 0.5 and 1 indicate satisfaction.

The IADOV technique also contemplates two complementary open-ended questions. These are:

- What importance do you attach to the methodological procedure for the determination of the motor skill invariants of the long jump?
- What aspects in your opinion enhance or limit the use of this procedure?

Interactive techniques: it was applied to 14 specialists of the Faculty of Physical Culture of Villa Clara to socialize the proposal and to know their points of view for its improvement.

Different techniques for the biomechanical study: such as filming, editing and processing of videos, the use of software, which were used to verify weaknesses in the technical execution during the take-off of the children studied and thus show that they are not physically mature enough to execute certain technical exercises.

The biomechanical procedure used in the research was the following (Collective of authors of biomechanics and students of the Faculty of Physical Culture of Villa Clara):

- Step 1: filming using the cameras, positioned frontally and laterally to the jumping action.



- Step 2: digitization of the images frame by frame.
- Step 3: synchronization of the data obtained from each of the cameras.
- Step 4: phase: obtaining results.
- Step 5: processing and statistical analysis.

### **Instrument and techniques for data collection and analysis**

Two Panasonic digital cameras were used to record the images, using a computer for the subsequent analysis through the biomechanical software KINOVEA.

The recorded images collected a set of actions performed by the two jumpers under study during the training session.

Eight take-off actions were selected, ranging from the preparation to the take-off of the leg from the surface. The study variables are specified in the following kinematic parameters:

- a) Distance of the last step.
- b) Take-off leg placement and cushioning.
- c) Extension of the take-off leg.
- d) Contact time.
- e) Center of gravity position.
- f) Position of the trunk at take-off.
- g) Position of the pendulum leg.
- h) Speed of the movement.

### **Population and sample**

A population of 35 base coaches working in sports initiation was used, of which 21 were randomly selected, representing 35 % of the total, as well as five directors of the Technical Commission of Athletics in Villa Clara, who participated as introductory users and who provided information on how the coaches taught the long jump in the 9-10 years old category and what methodological orientations they received in the Teaching Program. We also worked with six specialists of the Faculty of Physical Culture of Villa Clara, with more than ten years of experience in athletics and with domain on the subject of skills, to whom we presented the proposed procedure to determine the invariants of motor skills, an activity that was carried out in the form of a workshop. In addition, they were asked for their opinion on the similarity or not of the complex of exercises offered by the Teaching Program and those of the "Integral program of preparation of the athlete in the area of jumping".

We also worked with two athletes out of nine that integrated the Vila Clara pioneer pre-selection in 2019, which represent 22 % of that population, also using a random sampling.





## RESULTS AND DISCUSSION

The applied survey allowed corroborating that 90 % of the coaches do not contemplate the internal and external aspects related to the maturation of the athletes, for the development of motor skills in the long jump, assuming the exercises offered by the teaching program, 100 % of them affirm that they did not know the term invariant motor skills, nor had they seen it in the specialized literature and the same percentage did not know of any procedure that allows determining them to use them in the teaching-learning process. In addition, they recognized that the exercises for teaching the long jump offered by the teaching program should correspond more to the conditions, maturity and motor experience of those ages.

In the interview with the directors of the Provincial Technical Commission of athletics, it was possible to corroborate these statements given by the coaches (Table 2).

**Table 2.** - Evaluation of the exercises and their correspondence with the maturity levels of the subjects in the 11-12 years old, carried out by the specialists of Athletics of the Faculty of Physical Culture of Villa Clara



Complex of exercises for the Long Jump technique in the 11-12 category	Complex of exercises for the Long Jump technique in the 13-14 category
1. Imitation of the take-off leg placement from the place.	1. Imitation of the take-off leg placement from the site.
2. Imitation of the take-off leg placement with one step.	2. Imitation of the take-off leg placement with one step.
3. Imitation of the take-off with one step.	3. Imitation of the take-off with one step.
4. Imitation with 1, 2 and 3 steps, walking with a fall on the take-off leg.	4. Take-off with one, two and three steps walking and running, with a fall on the take-off leg.
5. Imitation with 1, 2 and 3 steps, running with a fall on the take-off leg.	5. Take-off every three steps with drop on the take-off leg.
6. Take-off every 3 steps with fall in pendulum leg.	6. One, two and three step take-off with walking and running, with a pendulum leg drop.
7. Take-off with 3 steps for rhythm with fall on take-off leg.	7. Take-off every three steps with a pendulum leg drop.
8. Take-off with 3 steps for rhythm with drop on take-off leg, but directing the movement with clapping or the sound of a whistle.	8. Teach him to specify the 5-step impulse stroke.
9. Take-off with 5 steps, with marks on the floor for the last 3 steps.	9. Impulse race with 7 steps.
10. Take-off with 5 steps, with marks on the floor for the last 3 steps, with an obstacle of 20 - 50 cm high, placed 1.00 to 1.50 m from the take-off place.	10. Natural long jump with an impulse running step
11. Take-off with 5 steps.	11. Hanging, imitate take-off- legs up and "L" position of the legs
12. Impulse run with 5 steps for precision and continue running.	12. Repeat No.1 combined with No.2
13. Impulse run with 7 steps for precision and continue running.	12. Repeat No.1 combined with No.2
14. Natural long jump with one step of impulse running.	13. Natural long jump with 2 and 3 steps of impulse running and correct fall.
15. Hanging, imitating the take-off - legs up and leg position.	14. Hip leaning on a wall, as close as possible to the floor, with legs extended, move forward and do a variant with a lateral turn.
16. Natural long jump with 2 and 3 steps of impulse running and correct fall.	
17. Natural long jump with 3 steps of impulse running, taking off with gymnastic wedge, executing correct fall. It can be combined with an obstacle of 40 - 50 cm.	
18. Complete jumps with 4, 5, 6 and 7 steps of impulse running.	
19. Jumps from the place with signals and without signals.	
Total of exercises 19	Total of exercises 14

It is important to clarify that the same exercises contained in the teaching program for the 11-12 years old category are the same as those used by the trainers in the 9-10 years old category, since it is the only complex that exists for both categories.



When evaluating the complex of exercises for the categories 11-12 and 13-14 years old by the specialists, it is important to emphasize that there is coincidence of exercises in spite of the difference of ages in the categories, in this sense they coincide in 10 of the 19 exercises and it is supposed that the gradient of complexity of the complex of exercises of the category 13-14 should be greater.

There is a group of exercises of the complex for 11-12 years that present a greater complexity than the exercises for the complex for 13-14 years, such as exercises 4, 5, 8, with fall on the take-off leg, as well as 10 and 17 where obstacles are used to overcome at the time of take-off, which are not even in the complex of exercises of the 13-14 category.

In this sense, it is important to say that the teaching program has not taken into account the maturation levels of the athletes of the 9-10 years old category.

### **Biomechanical study of the long jump of two of the athletes of the 9-10 years old category who were part of the Pioneer pre-selection**

The biomechanical study made it possible to assess the errors in the technique that may be conditioned by the motor maturation to perform the task, and which in turn are movements associated with the tasks of teaching the long jump take-off (Figure 1).



**Fig. 1.** - Leg positioning stage

When assessing the take-off technique of athlete 1 by the selected specialists, they agree that in figure 1, in which the leg placement phase is appreciated, the angle related to the surface of the rail and the take-off leg is 73 degrees. This indicates that the foot implant is performed passively and not in the form of a paw, which requires strength and coordination, since the take-off leg must take a contact time with the take-off board in milliseconds, so the flexion cannot be so sharp as to make this a slow action, a movement that starts from the leg that is in the form of a forward step down. In summary, if this phase is to be taught it is necessary that the athlete has adequate strength levels as well as good coordination and speed, so this movement should be taught in the category 9-10 years in the form of imitation in place, and walking, until the motor maturation required to perform the movement with running steps is reached.



In figure 2, the damping phase can be seen and in this phase the flexion continues to become acute, which limits the take-off time, and in turn, causes a brake in the movement; that is why it is considered that the take-off begins with imitation movements in this category and is introduced from recreational activities to form the motor habit in this phase.

In the last phase or active extension phase, the pendulum is low with respect to the imaginary horizontal line that passes through the hip, because with an adequate level of strength it should be around 90 degrees, however, this athlete presents an angle of 119, which indicates that she does not have strengthened back and quadriceps femoris muscles. Finally, the fourth moment in Figure 2 presents the extension of the take-off leg, which according to the biomechanical model should be around 180 degrees, however, this has a value of 144 degrees, which indicates that there is no strengthening of the take-off leg to make a good execution of this movement, so the exercises to teach the take-off should be in correspondence with the age and physical maturity (Figure 2).

In general, it can be stated that the take-off, although the long jump is the most natural of the jumps, is a complex movement because it requires levels of strength, coordination and speed, which children in the 11-12 years old category do not have, so the coach must be careful when selecting the exercises for its teaching.



**Fig. 2.** - Amortization phase

According to specialists, the take-off technique in figure 2, the athlete, presents similar results to the athlete in figure 1, which indicates that there are low levels of strength, so it is recommended to teach the take-off with imitation exercises and playful tasks, until they have the adequate maturity to face more complex tasks (Figure 2).

The above arguments indicate that it is necessary to determine a methodological procedure for the determination of motor skill invariants.

### **Methodological procedure for the determination of motor skill invariants**

The consultation of the specialized bibliography, documents and other sources, allowed to know that the term invariant skills is used in the field of pedagogy but not in Sports Training as special didactics, so it was necessary to determine a procedure to determine the invariant motor skills for the teaching of the long jump in the 9-10 years old category, because so far it is taught through exercises, without taking into account the maturity



levels of the athlete. There is also no known definition of motor skill invariants, which is confirmed by the techniques and methods applied.

### **The methodological procedure to determine the invariants answers the following question**

In order to start the procedure to determine the motor skill invariants, it is essential to answer the following question: what is the importance of establishing the motor skill invariant?

The consultation with specialists of Athletics of the Faculty of Physical Culture of Villa Clara, as well as the bibliography consulted, allowed giving the following answer to the formulated question:

Its value consisted not only in providing a didactic procedure to the sports trainer in order to raise the quality in the development of skills, but also in facilitating the athlete the process of appropriation of the content in the technical preparation, since it allows him to face and solve in a conscious way the complex problems related to the development of the skill, taking into account the experiences and knowledge that he brings, the types of habits and skills that he may be able to achieve, since it will depend, on the one hand, on the internal conditions that the developing organism itself possesses.

To define the term invariant motor skills, the model of **Valle (2007)** was used to obtain a conception. Hence, motor skill invariant was defined as: the unification of knowledge, skills and varied motor experiences, which stand as invariants of the motor skills of a discipline, whose dynamics support the relationship between what the sports teacher requires to develop and the opportunities of the athlete from his diversity to be able to master it. In this way, one of the purposes of this study was fulfilled.

For all of the above, the technological procedure for determining motor skill invariants was also defined as the way to establish the nuclei or content of the selected motor skill, which corresponds to the experiences and knowledge that the athlete brings, the types of skills that he/she may be able to achieve according to the level of maturation of the organic and functional capacities corresponding to the initiation stage.

Once this term was defined, it was considered that the technological procedure to determine motor skill invariants is specified in three phases, based on the procedure used by Hernandez and **Pérez, (2019)**, which was contextualized according to the demands of the sport activity.

First phase: criteria for the determination of the tasks of the technical progression of the long jump for the 9-10 years old category.

1. The correspondence between the logic of the technical progression for the teaching of this discipline, with the content of the complex of exercises that guides the Teaching Program.
2. Logic and order of the tasks and exercises of the technical progression for the long jump in sport initiation.
3. Level of technical complexity of each of the exercises of the technical progression.



Second phase: didactic criteria for the selection of the contents for the development of long jump skills.

1. Level of knowledge and previous experiences of the athletes about the long jump discipline.
2. Analysis of the organic and functional possibilities of the athlete to perform the exercises of the Teaching Program for the long jump.
3. Correspondence of the motor skills of the long jump with the objectives, methods, organizational procedures and forms of evaluation.
4. Selection of the invariant skills for the long jump in the 9-10 years old category.

Third phase: Evaluation of the motor skill invariants determined for athletes practicing long jump in the 9-10 years old category.

1. Evaluation of the motor skills invariants determined for the athletes who practice long jump in the 9-10 years old category.
2. Definition of exercises to minimize the deficiencies found in the development of the invariant skills.

### **Expert opinion on the proposal of the term invariants and the procedure to determine them**

Once the proposal was presented to the specialists in the different workshops, they considered that the term defined on invariants is adequate to the characteristics of special didactics or sports training, and that the methodological procedure proposed to determine the invariants of motor skills is useful and pertinent.

### **Users' criterion**

After applying the ISG formula, the following index is reached:

ISG = 0.70 (between 0.5 and 1 indicates that there is satisfaction).

This index indicates that the introductory users are satisfied with the methodological procedure proposed for the development of skill invariants, despite the fact that they make several reflections when answering the open questions, which are taken into account in their improvement.

The IADOV technique also contemplates two complementary open-ended questions. These are:

- What importance do you attach to defining the proposed motor skill invariant term and the procedure for its determination?
- What aspects in your opinion enhance or limit the use of the proposal?



## CONCLUSIONS

The study carried out, based on the bibliography and documents consulted, as well as the criteria of specialists and users, allowed us to propose the term invariant motor skills, which is a new vision for the development of skills, as well as the methodological procedure to determine them in the long jump in the 9-10 years old category, with which the users are highly satisfied.

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**Conflict of interests:**

The authors declare not to have any interest conflicts.

**Authors' contribution:**

**Hiramnia Mabel Sánchez Acosta:** Concepción de la idea, búsqueda y revisión de literatura, confección de instrumentos, aplicación de instrumentos, recopilación de la información resultado de los instrumentos aplicados, análisis estadístico, confección de tablas, gráficos e imágenes, confección de base de datos, asesoramiento general por la temática abordada, redacción del original (primera versión), revisión y versión final del artículo, corrección del artículo, coordinador de la autoría, traducción de términos o información obtenida, revisión de la aplicación de la norma bibliográfica aplicada.

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