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Original article

Study of the biological age in male athletes of the school category

Estudio de la edad biológica en atletas del sexo masculino de la categoría escolar

Estudo da idade biológica em atletas do sexo masculino da categoria escolar

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ABSTRACT

A study of the biological age of male school athletes was carried out. It was declared as an objective to characterize the behavior of the biological age of male school athletes, 13-14 years of age in tennis, handball, athletics, judo and weightlifting sports, at the EIDE (Sports Initiation School) *Julio Díaz Gonzalez* from Artemisa. In this non-experimental design some methods of investigation were used as well Empiric and Theoretical methods. The Empiric ones are: document review, observation, interview

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and measurement which allowed verifying information related to the biological age of the athletes and their integration to the planning of the sport training process that is developed to long term. The application of the method of Tanner Whitehouse, adjusted by Jordan of the radiograph of the left hand, total hand, was essential in this study. As a result is identified the athletes' bone maturation behavior that participated in this investigation.

Keywords: Bone maturation, Biological age, Sport training.

RESUMEN

Se realizó un estudio de la edad biológica de los deportistas escolares del sexo masculino. Como objetivo de este trabajo se declaró caracterizar el comportamiento de la edad biológica de los atletas escolares del sexo masculino, de 13 y 14 años de los deportes de tenis, balonmano, atletismo, judo y levantamiento de pesas en la Eide (Escuela de Iniciación Deportiva) "Julio Díaz González" de la provincia Artemisa, Cuba. En este diseño no experimental, se emplearon métodos de investigación, tanto de carácter teórico como del nivel empírico. Entre los empíricos, se encuentran la revisión de documentos, la observación, la entrevista y la medición. Estos permitieron constatar información relacionada con la edad biológica de los atletas y su integración a la planificación del proceso de entrenamiento deportivo que se desarrolla a largo plazo. Fue esencial en este estudio la aplicación del método de Tanner y Whitehouse, ajustado por Jordán, de la radiografía de la mano izquierda (mano total). Como resultado se identifica el comportamiento de la maduración ósea de los atletas escolares participantes en la investigación.

Palabras clave: Maduración ósea; Edad biológica; Entrenamiento deportivo.

RESUMO

Foi realizado um estudo sobre a idade biológica dos atletas da escola masculina. O objetivo deste trabalho era caracterizar o comportamento da idade biológica dos atletas escolares masculinos, de 13 e 14 anos, nos desportos de ténis, handebol, atletismo, judô e halterofilismo, na Eide (Escola de Iniciação ao Desporto) "Julio Díaz González", na província de Artemisa, Cuba. Neste desenho não experimental, foram utilizados métodos de investigação tanto teóricos como empíricos. Entre os empíricos, há a revisão de documentos, observação, entrevista e medição. Estes permitiram apurar informações relacionadas com a idade biológica dos atletas e a sua integração no planeamento do processo de treino desportivo que é desenvolvido a longo prazo. Foi essencial neste estudo a aplicação do método de Tanner e Whitehouse, ajustado por Jordán, da radiografia da mão esquerda (mão total). Como resultado, é identificado o comportamento da maturação óssea dos atletas escolares que participam na investigação.

Palavras-chave: Maturação óssea; Idade biológica; Treinamento desportivo.

INTRODUCTION

The practice of sport, as part of human behavior, is a physical activity that involves voluntary body movements with supplementary energy expenditure, involving biological, pedagogical, psychosocial and cultural components, which is subject to the regulations generated by the process of adaptation in the subjects who perform it systematically.



The benefits of sport, throughout life, are unquestionable; they can considerably influence the proper functioning of the organism. In this sense, the structuring and organization of sports programs determine the development that can be achieved under the direction of coaches and with the help of specialized doctors.

In school sport for high performance, it is necessary that coaches and sports physicians assume, in a particular way, the biological particularities of the organism of the child and/or adolescent athlete and its importance in the development, both of the motor qualities and in the formation process of habits and skills related to the sport in question.

Male school athletes of 13 and 14 years of age are adolescents who show biological and psychosocial characteristics that influence learning in its broadest expression.

When taking into account these aspects, which punctually characterize adolescents, it is considered that: "Between the ages of 12-15 years, the so-called transit age is located, which encloses a complex process of readjustment of somatic and vegetative functions linked to the changes that accompany the process of sexual maturation" (Zaldívar, 2018, p. 544). This same author adds that,

"accelerations in the increase of body size, body disproportions, instability of vegetative functions and emotional affectations appear, and marked sexual differences are consolidated. At this stage, males begin to surpass females in the indicators of strength, speed and endurance". (p. 544)

Assuming these elements makes it possible to adjust the biomedical control of sports training and the adequate integral preparation of the athlete. In this process, a system of influences intervenes that determine the functional possibilities of the human organism to the adaptive changes that occur in it. The results of works by Coelho *et al.*, (2002) allow us to consider that,

"when the enormous variation associated with maturation status and gender is not taken into account, and when sports programming is structured according to chronological age, the health and sporting life of young talent is at risk". (p. 14)

It turns out that ignorance of structural and functional transformations can lead to serious consequences for the health and sporting life of athletes.

In assessing these particularities of the systematic practice of sports at school age, Zaldívar (2011), states that:

(...) "a quantitative assessment and a qualitative characterization of the capacity of a given organism to assimilate the training with all the effects that this implies (...), can be made by means of methodological procedures designed for the evaluation of the functional capacity of adaptation, which depend on the level of training of the athlete, the specialty being trained, the sports qualification, the level reached in the preceding stage of preparation and many other factors". (p. 8)

Both references ratify that, in sports practice, biological age should be considered as an aspect that has an important influence on the level of the functional capacity of adaptation of the athlete's organism, that is, to take into account the biological potentialities that the athlete has, which trigger adaptive responses and, consequently, the achievement of the competitive result, an aspect of maximum aspiration in the sports training process.



Biological age is not a new element, much less unknown to the scientific community, it has been addressed since the first decades of the twentieth century and, of course, a concept with implications in the life of human beings and that requires deepening, especially in the field of sports.

Therefore, it is necessary to estimate the biological age of the young athlete, regardless of their chronological age, in order to define the state of biological maturation as a result of the processes of growth and development achieved.

Several authors have referred to biological age. Volkov and Filin (1988) consider biological age to be a complex concept that relates physical development, state of health, physical and mental work capacity, as well as the functional capacities of the organism.

Matsudo (1991) defines biological age as a process of morphological, physiological and psychological development of the individual that necessarily has genetic and environmental influences.

According to Restrepo *et al.*, (2001), biological age corresponds to the morphological and functional development reached by the individual and to the appearance of primary and secondary sexual characteristics.

Biological age is understood as the degree of maturation of an individual, determined by individual maturation processes and exogenous influences (Lopes and Barbanti, 2007).

León (2013) states that biological age corresponds to the level of maturation reached by the organism as a unit, as a single whole and, by extension, the degree of maturity of each of the systems that form it.

Biological age is the age of the organs that form the systems that make our organism function (Cardona, 2018). Related to this approach, Ramos (2018) adds that biological age is that which corresponds to the functional state of our organs compared to the standard patterns for an age. Both opinions evidence that biological age is a physiological concept.

In relation to biological age, there is the chronological age, Real (2019) defines it as:

"the measure of the time lived by a person from birth to the moment it is required. At present, it is considered as an administrative criterion that is the social, legal and penal referent of each individual and that does not always correspond to his or her biological circumstances". (p.17)

It is derived that the chronological age is based on the calendar, that is, the time that has passed from birth to the present moment, however, the biological age is the age of the organism, of the cells, it is the real age.

These criteria allow us to affirm that the biological age of an individual is the result of the processes of biological maturation, so it is directly related to this. In addition, the organic and physiological development of the organism is evidenced, in which genetic and environmental characters intervene, which determine the state of maturation of the individual. That is why the biological age of each individual must be taken into account in any activity of life that he/she performs and, in this case, in sports training.



The biological maturation processes have a particular connotation in the ages of 13 and 14 years and it is, precisely, when a point of maximum expression of growth and development of the individual occurs; the development of the reproductive, dental, skeletal and muscular organ systems is evidenced. Their integration and proper functioning makes possible the psychomotor progress of the athlete, which is a fundamental aspect in the integral preparation of the school athlete.

The components that integrate the biological age in relation to the biological maturation (Figure 1).



Fig. 1. - Components of biological age and its relationship to biological maturation
Source: Modified from Díaz (2012).

In sports, the biological age and maturity status of athletes can be predicted. According to Pancorbo (2002) ... "biological maturation is one of the many factors involved in athletic performance when maturity has not yet been reached." (p. 281)

Giving continuity to this line of thought, Carvajal (2013), states:

"The study of biological maturation is of vital importance for sports scientists, since it gives them the possibility of having a more realistic criterion than that of chronological age, when evaluating the reasons for the outstanding or mediocre results of a child who belongs to a competitive category in the pyramid of performance" (p.121).

Given the complexities of the biological maturation processes in adolescent athletes, all the elements analyzed above have a particular connotation at the ages of 13 and 14 years and it is precisely when a point of maximum expression of growth and development of the individual occurs, so that the development of the sexual, dental, skeletal and muscular organ systems is evidenced and, as a result of their integration, enables the psychomotor progress of the athlete, which is a fundamental aspect in the integral preparation of the athlete as a result of the development of the sports training process.



National research such as: Jordán (1972); León (1984, 2013); Román (2004); Pérez (2003); Miló (2007); Carvajal (2013) and international: Greulich and Pyle (1959); Tanner and Whitehouse (1959); Lapieza (1994); Navarro (1996); Malina (1994, 2006); Hernández (2012), Casanova and Gamardo (2017), reveal studies about biological age and the sports training process.

Generally speaking, the results of these and other researches constitute the objective basis for the improvement in the application of the principles of sports training to occur. This implies that the functional changes of the human organism, due to training in a set time, can lead to the search for solutions in the functional reserves of adaptation that it reaches, in its magnitude and in the effectiveness of the methods and practical procedures for its use and development.

The coach's mastery of aspects of biological maturation guarantees solutions to the differences in biological age as an indicator to adapt training loads to the individual characteristics of the athletes.

In correspondence with these criteria and in close relation to the biological age, the chronological age of the athletes of the Integral Sports Schools (Eide) is used as a reference to organize the training groups, to establish the competitive categories, as well as for the selection of subjects suitable for the practice of certain sports events. These aspects are indicated in the official documents that govern the sports system in Cuba.

León (2013) considers that chronological age is the time elapsed from birth to a given moment in the life of an individual, i.e., the temporal duration of the interrelation between organism and environment, expressed in years, months and days. Moreover, chronological age alone does not provide information on the measure of the real, individual variations of the organism and its adaptation to the organism-environment interrelationship; chronological age does not provide much information on individual differences in the time, rhythm or measure of development.

In the analysis of these concepts, it is deduced that both chronological age and biological age have a close relationship in influencing the sports training process. However, their differences can determine the adequate development of this and obtain satisfactory sports results. Taking into account these fundamentals, the work to be done will not only be by chronological age category, but also takes into consideration the biological age indicator. That is why attention should be directed to the treatment of biological age and its importance in school categories.

In Cuba, Pérez (2003) made comparisons between chronological and biological ages in relation to the development of physical capacities in school weightlifters and Miló (2007) incorporated the criterion of biological age in the planning of the physical preparation of child athletes in the sports of basketball, artistic gymnastics, swimming, fencing and volleyball.

In both researches, general methodological proposals are designed that take into account the biological age criterion in the sports training process.

The present study of biological age was developed in the Initiation Sport School (Eide in Spanish) "Julio Díaz González", of Artemisa. In the review of normative documents that govern the methodological work of the sports trainer and the systematic observation of the training sessions of male school athletes, aged 13 and 14 years in five sports: Tennis,



Handball, Athletics, Judo and Weightlifting, insufficient methodological indications were found for the treatment of the biological age of the athletes.

The situation shows that athletes receive similar training loads, regardless of their biological conditions, so that the assessment of chronological age predominates over biological age in the sports training process, which constitutes the problematic situation of this research work.

These insufficiencies limit an adequate development of this process, however, it is necessary that in the sports training process the biological age indicator should be taken into account, which as a consequence would contribute to the solution of situations in the integral preparation of the school athlete.

Therefore, the objective of this work is to characterize the behavior of the biological age of male school athletes, 13 and 14 years old, in the sports of Tennis, Handball, Athletics, Judo and Weightlifting, in the Eide "Julio Díaz Gonzalez" of Artemisa.

MATERIALS AND METHODS

The research was characterized by a non-experimental design, according to the analysis of the procedures carried out and the scope of the results. Specifically, it is a descriptive research with a quantitative-qualitative approach and it was organized on the basis of the scientific methods used, fundamentally, document analysis, observation, interview and measurement.

It was selected as population and sample 51 male school athletes of 13 and 14 years old of five sports, from the Eide "Julio Díaz González" of Artemisa. The sports under study represent the different sports groups organized in the sports institution: tennis, handball, athletics, judo and weightlifting. In addition, nine tennis, handball and judo coaches participated, one from each, two from weightlifting and four from athletics, and the five sports doctors responsible for each of the sports.

It was worked with the total sample of athletes, coaches and sports physicians, which coincides with one hundred percent of the population, thus constituting a purposive sample. Figure 2 shows a graph with the total sample of the research (Figure 2).



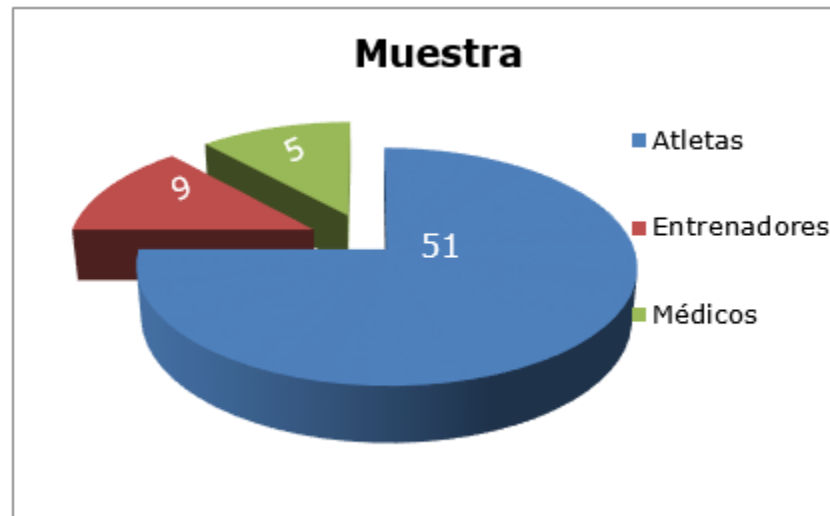


Fig. 2. - Graph of the composition of the research sample
Source: Own elaboration with information provided by Eide's sports subdirection.

In the analysis carried out, the results obtained with information corresponding to the 2018-2019 school year were evaluated. Male school athletes of 13 and 14 years old, who were in the seventh and eighth grades of junior high school, are characterized by being in the stage of adolescence, in which changes and transformations occur in their organism, as a result of the processes of biological growth and development, which can be determinant for later stages of life such as youth and adulthood, especially for the future life in the practice of sport.

School athletes manifest variability in intensity, in pubertal changes, so that, in this phase of human ontogeny, chronological age does not prescribe states of biological maturation. This indicates the importance for athletes of the same chronological age, because it can represent both an approaching and a considerable departure in somatic order and vegetative support.

Bone age is defined as,

"the measurement of the progress of ossification during development, estimated through the degree of growth that occurs in areas undergoing ossification and the level of calcium deposition in those areas, which follow from infancy to adolescence a timeline determined by a specific pattern." (Real, 2019, p.22)

Taking into account the characteristics of the sample of this study, the diagnosis of the biological age of school athletes was carried out. This was determined with the application of the method of **Tanner and Whitehouse (TW2) (1959)**, adjusted by **Jordán (1977)** of the radiography of the left hand, total hand, in which bone maturation is evaluated.

This consists of the study of the bones of the hand and carpus, with the abundant number of evolving epiphyses. This indicates the possibilities of growth and development that adolescents probably have until the culmination of this process, that is, a development that involves a highly somatic process and a maturation that contains the capacity to do, integrating the qualitative and quantitative.



With the radiographs of each athlete, comparisons are made, 20 bones are evaluated, seven of the carpus and thirteen epiphyses of the metacarpals and phalanges 1, 3 and 5, which are assigned a proportional value that appears in a predetermined way in the bone age table. Each bone shows different stages and its fundamental description of the different representations with the score according to the growth and development it shows. Subsequently, the values of each bone are noted down and the sum of the total is made, matching the score tables to obtain the bone age.

To state the final result, the bone age reached is compared with the chronological age expressed in decimal age, also predetermined, and the different levels of biological maturation are established, classified into late, normal and early maturers, as follows:

- If the subject has a bone age lower than the decimal age, he/she is most likely a late maturer.
- If the subject has a difference between bone age and decimal age of less than one year, he/she is considered a normal maturer because there is similarity between both ages.
- If the subject has a bone age greater than the decimal age, he/she is an early maturer.

This process was carried out in the months of March and April of the 2018-2019 school year, in the General Teaching Hospital "Ciro Redondo García", in the province of Artemisa, in the department of Radiology and Imaging, specifically, with the Digital K-Ray equipment for Diagnosis, model (VISARIS AVANSE DR), SN-AD 15 E-01001, V-230, Hz 50I and 3A, manufactured in 2015 in the Republic of Serbia. The use of this technology facilitates the evaluation of anatomical structures, reading with magnification, superior quality of the image and the one obtained in real time, discriminating the use of traditional materials and substances that impeded the sharpness of the radiographic image, which eliminates the chemical method of image production. These can be stored in databases for the sequential evolution of the subject.

1. The position that the athlete should adopt is separated from the X-Ray equipment, precisely away from the region of the male gonads so that the radiation received is as little harmful as possible to the growing and developing organism.
2. The hand in prone ulna position in contact with the body of the X-Ray equipment.
3. The axis of the middle finger in a straight line with the forearm axis, the fingers slightly apart and the thumb is placed in a comfortable position, with a natural degree of rotation of about 30° in relation to the index finger.
4. The athlete should make a slight pressure with the palm of the hand at the time of radiation exposure.
5. A radiographic image is obtained on electronic support in real time.

For the collection of the required complementary information, different methods were applied, such as measurement, documentary review and observation, as well as the interview technique, which guaranteed to cover the whole set of elements taken into consideration.



The obtaining, analysis, synthesis and evaluation of the information of the results of the applied instruments provide the criteria that allowed characterizing the current state of the regularities of the diagnosis of the biological age of male school athletes of 13 and 14 years old.

The normative documents that establish the methodological work for the development of the sports training process were reviewed: Integral Program for the Preparation of the Athlete (Pipd in Spanish) and Sports Training Plan (Ped in Spanish), for the five sports under study (tennis, handball, athletics, judo and weightlifting). Both documents are significant for the adequate performance of sports coaches.

Systematic observation allowed the collection of information in the months from September to January, in 32 training sessions of the five sports under study, distributed in 20 microcycles that covered four mesocycles of general physical preparation in the following order: incoming, basic developmental, basic stabilizing and basic or control, and one mesocycle of special incoming physical preparation.

The interview was applied with different questionnaires to coaches and sports physicians. In the case of the nine coaches, it is significant that 100% state that there are difficulties with respect to the biological age information of school athletes, their derivation from the X-ray for the determination of bone maturation and the insertion in the training process and particularly in the preparation of strength; they do work with the development of maximum intensity, power, strengthening of the musculature in athletes, among other elements, but it is insufficient to carry it out in an individualized way.

This shows deficiencies in the communication, coordination and socialization of information, as well as in the methodological work to be done regarding the treatment of biological age, which constitutes a limitation in the adequate performance of this process.

The use of measurement was relevant in the study carried out on biological age, focusing on bone maturation by the TW2 method.

The radiographs were evaluated by comparing the bones of the hand with the schematic representations and the description of the portion of each bone being evaluated. Each one is assigned a letter and its corresponding numerical value, so some bones show more variations than others. The letters and values obtained from the evaluation of the 20 bones (total hand), as well as the total sum, are recorded in the Model for the Evaluation of Bone Maturation, indicated by the Institute of Sports Medicine (IMD in Spanish).

RESULTS AND DISCUSSION

Based on the documentary review carried out, it is stated that:

In the Tennis Pipd (2016), the concepts of biological age and chronological age are mentioned. However, these are not defined or methodologically developed for their treatment in school categories. It appears, as a medical action, to establish the comparison between biological age with chronological age, but without indication of procedure for its realization.



The Pipd of handball (2016) is characterized by the developmental influence of the content of skills and capacities of this sport, emphasizing the maintenance of good health of the athlete. There is no mention of the concept of biological age, the raised lacks terms related to it, so it is deficient treatment of the fundamentals of biological sciences that explain the transformations that occur in the organism of adolescents who perform systematic physical activity.

In judo, Pipd (2016) orients the physical performance standards of the weight divisions with the training directions for the development of each of the physical capacities. Characteristics of adolescents are mentioned, in which bone growth issues and their implication in these ages are referenced.

In the case of weightlifting Pipd (2016), although it is outlined that, at these ages, the coach must take into account the biological effects of the training load on the athletes' organism, it is mentioned that the chronological age, the biological age and the age of initiation in this sport are aspects that are related to the physical load and determinants to raise the functional possibilities of adaptation of the organism being trained.

For weightlifters, it is mentioned that the physical and physiological bases that guarantee them should be explained from a theoretical point of view in the teaching of the technical elements, but there is no explicit link between the content and the biological age that relates it.

The link of the content with respect to the biological age that relates it is not made explicit.

In the different events of athletics, established in the Pipd (2016), there are no orientations of contents related to the human organism, with the transformations that occur at these ages or aspects related to the biological age of these athletes, precisely because of the physical activity they perform. In the 2018-2019 school year, new precisions are oriented that only refer to the reorganization for the sports preparation of school athletes of 13 and 14 years old by the exalts.

It turns out that the indications for the work by steps pursue the multilateral development for athletes of 13 and 14 years old with a view to guarantee future specialization.

In the analysis made of all the Pipd, the proposed objectives lack elements of scientific knowledge to be concretized in the theoretical component of the integral preparation of the athlete, of aspects concerning the biological age, that is, knowledge as a result of the development of the biological sciences, of the processes that occur in the organism that is trained in the ages of 13 and 14 years and their implications in the sports training process.

In the assesment of the PD, with respect to biological age, there are no manifestations of methodological treatment of this indicator, so that contents linked to biological maturation processes are not taken into account, elements of biological age are not conceived, particularly, the characteristics of bone maturation that can be determinant in the assimilation of training loads, aspects that coincide with the norm in the Pipd of each sport.



It is significant that in the tennis and weightlifting Ped it is recorded that some biological characteristics related to sexual maturation should be taken into account, but the emphasis is placed on age, as in the rest of the sports. This shows that it is planned taking into account the chronological age and there is no manifestation of treatment with respect to the biological age of the athletes.

In handball, athletics and judo, no delimitation is confirmed in the differentiated work required at these ages. Likewise, training loads are dosed in a similar way, without characterizing the athletes according to their biological potentialities. Specifically, for handball players, similar approaches are revealed with respect to physical loads; in athletics, they are adjusted to the characteristics of the exalon and in judo to the established weight divisions.

With these elements of the documentary review of the Pipd and Ped, it can be stated that the formation of school athletes is outlined from the criterion of chronological age and not with respect to the biological age, so it is necessary a methodological conception that integrates both indicators, especially in correspondence with the biological conditions of athletes during the training process.

In 100 % of the observations made in the five sports under study, information was obtained directly in the real context of the sports training process, at the same moment it was developed.

The predominance of the application of physical loads was observed, without taking into account the biological age as an indicator for the establishment of the differences between athletes, regardless of their chronological age; there was no evidence of the establishment of the biological age to identify the morphophysiological differences of the athletes or more precisely as the bone age. It is notorious that a very similar sports training process is performed for all athletes, so the treatment is not differentiated.

Particularly, in the sports of tennis, handball and weightlifting, which despite having small enrollments (three, seven and 13 athletes, respectively), it is deficient to carry out a study of the biological potential and monitoring of athletes from the biological age indicator, so that the work performed by coaches lacks effectiveness with respect to the performance and sporting result that is aspired.

According to the results of the interview, 100 % of the sports coaches recognize the importance of taking into account the biological age to avoid irreversible damages in the physical integrity of the organism that have repercussions in the biological, psychological and social development of the athletes.

In the case of the five doctors, all the interviewees stated that the treatment of the biological age indicator is insufficient, taking into account that only the X-ray is required for enrollment in this sports institution, so it becomes a requirement for admission and not for permanent analysis and monitoring in the complex process of sports training of school athletes.

This condition implies that, although it is considered that the realization of the radiography can be invasive for the organism in growth and development, its importance is based on the fact that it accurately reflects the stage of skeletal maturation of the athlete. In addition, it constitutes a necessity because it specifies the dimensions of the bones in evolution, ossification processes and, in a practical way, it contributes to avoid



injuries and affectations in the integral preparation in the long term in male school athletes of 13 and 14 years old.

One element to be taken into account in the adolescent stage is bone maturation. This is part of the biological age of adolescents and its study constitutes the fundamental cognitive core of this study. At this age, the changes in bone tissue, as a result of the processes of growth and development, vary not only in quantity, but fundamentally in chemical composition.

Precisely, the differences in the concentration of minerals such as calcium mark the bone chemical variability in the process called mineralization, a fundamental aspect that was evidenced with the application of measurements of the radiographs taken and evaluated for the determination of the biological age of the athletes.

Due to the complexity and extension of the results of the biological age study (bone age) of the 51 athletes, an example of a tennis athlete will be presented with its corresponding Biological Maturation Report, which allows understanding the diagnosis made. This is shown in figure 3, which represents the radiography of the left hand and in table 1, the data and anthropometric indexes of the athlete are recorded, constituting his growth and development examination sheet (Figure 3) and (Table 1).



Fig. 3.- Radiography of the left hand



Table 1. - Tennis athlete growth and development test sheet

Laboratorio de Cineantropometría	
Hoja de Examen de Crecimiento y Desarrollo	
Datos Generales	
Nombre y Apellidos:	XXXXXXXXXXXXXXXXXX
Edad Cronológica:	13 años
Actividad:	Tenis
FN:	30/06/2005
FE:	10/04/2019
Sexo:	Masculino
Datos para realizar cálculos de los parámetros	
Peso(Kg)	45
Talla (cm)	147
Edad Decimal (Años)	13,6
Percentil P/E	90-97
Percentil T/E	50-75
Edad Ósea (Años)	15,1
Talla Madre(cm)	157
Talla Padre(cm)	168
Pruebas aplicadas	
Los percentiles se determinaron por las Tablas de Jordán (1977).	
Método de TW2 se utilizó para determinar la Edad Ósea.	

Source: Own elaboration based on the model established by the IMD.

The contribution of all the previous information made it possible to carry out the study of Biological Maturation of the Tennis athlete, which classifies him as an early maturer. This is an athlete of 13 years of chronological age, being the decimal age 13.6 years. Using the TW2 method, the bone age was estimated to be 15.1 years. The analysis of the radiograph of the left hand showed a bone development corresponding to an individual of 15.1 years of bone age.

The results obtained showed the variation in the growth and bone development of this adolescent, being grouped in the same age category and with similar chronological ages as the athletes in the group. Tennis players one and three are classified as late, while tennis player two is precocious with respect to the biological maturation of his organism, as already characterized in the example discussed above.

As can be seen, biological maturation studies are very complex because they involve the assessment of different components contained in biological age, as explained above. In this sense, when carrying out the bone age study, it was considered to have a more comprehensive criterion of biological age, so anthropometric indices such as height and body weight were analyzed in a complementary way, since these can be related to the possibilities of growth and development that athletes have. In this way, the probability of growth can be predicted, for example, the prediction of the final size of the athletes.

The results obtained from the study of biological age by sport are shown in figure 4, which summarizes the classification of the biological maturation of school athletes (Figure 4).



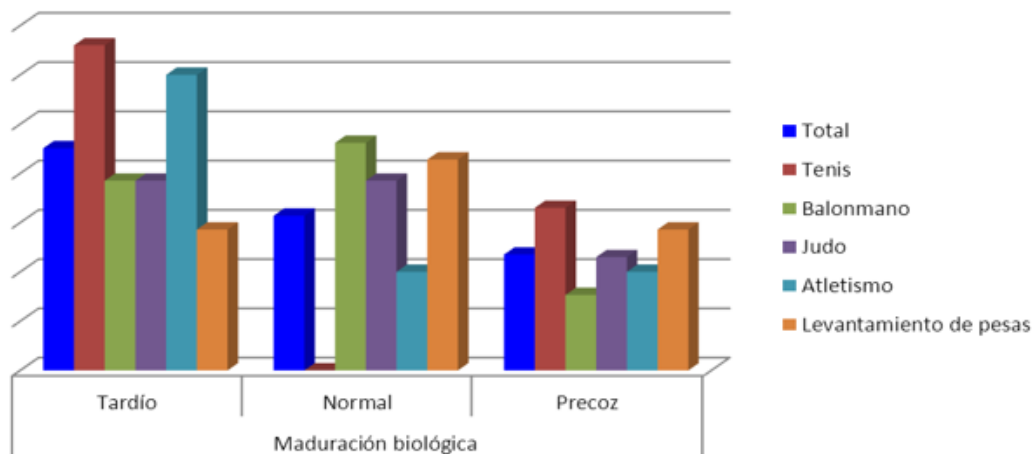


Fig. - 4. Relative composition of the biological maturation of school athletes by sport

In the analysis of the relative composition of the biological maturation of the 51 athletes, 45.1 % are classified as late maturers; 31.4 % as normal maturers and 23.5 % as early maturers, which is dominated by 23 late maturing athletes in the sample. It is evident that the sports of tennis (2) and athletics (9) have a higher proportion of late maturers, while handball (5), judo (5) and weightlifting (2) have late maturers below the overall average. Tennis players (1) and weightlifters (2) stand out as early maturers above the totality of the rest of the sports, with respect to the number of athletes in each.

With the application of the TW2 method for the evaluation of the radiography of the 51 male school athletes of 13 and 14 years of age, it was found that they were at different stages of biological maturation. Similar results were obtained in the study conducted by [Miló \(2007\)](#), with the difference that the group studied was female and other sports. In essence, what this means is that each subject has different biological characteristics that must be taken into account for their performance in sports practice.

They also agree with the results achieved by [Hernández \(2012\)](#) about the variability in the slow and accelerated growth rates of athletes, as a result of biological maturation, precisely determined by biological age, which should be known and considered in the sports training process. This ensures the proper application of the principle of individualization of the physical load and not only be governed by the chronological age at the time of organizing groups for the preparation of athletes, but the biological age.

Similarly, it agrees with the results obtained from the research conducted by [Casanova and Gamardo \(2017\)](#) about biological maturation, strength and power in swimmers between 10 and 13 years old, in that they present difference in terms of growth and development processes, predominantly late and normal maturers, so it recommends adjustments in training time as the ages increase in correspondence with the principle of individualization of physical loads, that is, taking into account the biological age.

From the analysis of the results obtained from the different sources of information, triangulation was used for their processing. This made it possible to compare and contrast them with each other, that is, to cross-check the different methods used, to understand the objectivity of the study and to gain a relatively greater credibility of the facts ([Ruiz, 1999, p. 73](#)).



The data triangulation showed a lack of knowledge of the biological age of male school athletes of 13 and 14 years of age. 100 % of the coaches interviewed do not consider the biological age indicator in the methodological conception of the sports training process in the different stages of the integral preparation of school athletes, an element that coincides with the opinions of the sports doctors. Both coaches and sports physicians considered it appropriate to integrate all those involved in the sports training process, as well as methodological actions for the adequate treatment of biological age.

Likewise, the methodological triangulation allowed contrasting the information offered by the analysis of the normative documents that govern the methodological work and the observations made during the training sessions; it is corroborated that in two of the five sports Pipd, objects of study (tennis and weightlifting), the concepts of biological age and chronological age are mentioned and in handball, athletics and judo there is no reference to these concepts. This process is not developed according to the biological characteristics and potentialities of the athletes, so the exact biological age of the athletes is not known.

CONCLUSIONS

Finally, there is no evidence of elements of individualized characterization taking into account the biological age, which coincides with the information obtained from the Pipd, the Ped and the observations made during the training sessions. This indicates that the biological age indicator and its direct relationship with the individualization of the training process is not contemplated.

It is concluded that the chronological age is the indicator that agglutinates the sports grouping, reaffirming the age categories as an element for the organization of the competitions, as well as for the definition of the categories. School athletes receive similar training loads, regardless of their biological conditions, so that the assessment of chronological age predominates over biological age in the sports training process.

The indicated inadequacies affect the effectiveness of the training process of the athletes participating in the research. It is necessary that the improvement of the integral preparation programs for school athletes, as an instrument of methodological orientation for the work of the coaches, contemplate in a wide and precise way the sections that should be dedicated to the biological age as an element of singular importance in the planning and implementation of the training plans directed to the school categories.

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Authors' contribution:

Ángel Lázaro Gil Suárez: Conception of the idea, literature search and review, instrument making, instrument application, compilation of information resulting from the instruments applied, statistic analysis, preparation of tables, graphs, and images, database preparation, general advice on the topic addressed, drafting of the original (first version), review and final version of the article, article correction, authorship coordinator, translation of terms or information obtained, review of the application of the applied bibliographic standard.

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