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Original article

Procedure for biomechanical analysis of motion variability in discus throw

Procedimiento para el análisis biomecánico de la variabilidad del movimiento en el lanzamiento de disco

Procedimento para a análise biomecânica da variabilidade do movimento no lançamento do disco

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ABSTRACT

The analysis on the technique of the sports movements from the study of the variability of the movement is a new approach to the evaluation, diagnosis and control of the sports techniques. It was known of the existence of diverse researches on the technique of the discus throw, nevertheless, these have not focused their analyses from the variability neither have offered procedures to make the analysis from this perspective. The objective of this research is to establish a procedure for the study of the variability of the technique in discus throw. The study was centered in a case of 15-year-old male who trains discus throw in the Sport Initiation School of Villa Clara, Cuba. In the research, there were used methods of the theoretical and empirical levels such as the study of cases, the biomechanical study and the statistical-mathematical analysis. It is possible to confirm that only two parameters showed high variability in the nine throws carried out, while the rest achieved a minor standard deviation and, therefore, little variability in the movements. Besides, there was a high satisfaction of users with the procedure used. The index obtained when

applying the IADOV technique indicates that there is satisfaction of the introductory users with the determined indicators.

Keywords: Variability; Procedure; Gesture; Technique; Movement.

RESUMEN

El análisis sobre la técnica de los movimientos deportivos desde el estudio de la variabilidad del movimiento es un nuevo acercamiento a la evaluación, diagnóstico y control de las técnicas deportivas. Se conoció de la existencia de diversas investigaciones sobre la técnica del lanzamiento del disco, sin embargo, estas no han enfocado sus análisis desde la variabilidad ni han ofrecido procedimientos para hacer el análisis desde esta perspectiva. El objetivo de esta investigación es establecer un procedimiento para el estudio de la variabilidad de la técnica en el lanzamiento de disco. El estudio se centró en un caso del sexo masculino que cuenta con 15 años y que entrena lanzamiento del disco en la Escuela de Iniciación Deportiva Escolar de Villa Clara, Cuba. En la investigación, se utilizaron métodos del nivel teórico y empírico tales como el estudio de casos, el estudio biomecánico y el análisis estadístico-matemático. Se logra constatar que solo dos parámetros mostraron alta variabilidad en los nueve lanzamientos efectuados, mientras que el resto sí logra una desviación estándar menor y, por tanto, poca variabilidad en los movimientos, además, existió una alta satisfacción de los usuarios con el procedimiento utilizado. El índice obtenido al aplicar la técnica IADOV indica que existe satisfacción de los usuarios introductores con los indicadores determinados.

Palabras clave: Variabilidad; Procedimiento; Gesto; Técnica; Movimiento.

RESUMO

A análise da técnica dos movimentos esportivos a partir do estudo da variabilidade do movimento é uma nova abordagem para a avaliação, diagnóstico e controle das técnicas esportivas. Sabia-se da existência de várias investigações sobre a técnica do lançamento de disco, porém, estas não focalizaram sua análise a partir da variabilidade, nem ofereceram procedimentos para fazer a análise nesta perspectiva. O objetivo desta pesquisa é estabelecer um procedimento para o estudo da variabilidade da técnica de Lançamento de Disco. O estudo teve como foco um jovem de 15 anos que treina lançamento de disco na Escola de Iniciação ao Esporte Escolar (Eide), em Villa Clara. Cuba. A pesquisa utilizou métodos de nível teórico e empírico como o estudo de caso, o estudo biomecânico e a análise estatística-matemática. É possível verificar que apenas dois parâmetros apresentaram alta variabilidade nos 9 arremessos realizados, enquanto os demais obtiveram menor desvio padrão e, portanto, pouca variabilidade nos movimentos, além disso, houve alta satisfação dos usuários com o procedimento utilizado. O índice obtido pela aplicação da técnica IADOV indica que há satisfação dos usuários introdutores com os indicadores determinados.

Palavras-chave: Gesto; Movimento; Processo; Técnica; Variabilidade.

INTRODUCTION

Biomechanics is a discipline located among the sciences derived from the natural sciences, which deals with the physical analysis of biological systems, consequently, the physical analysis of the movements of the human body. These movements are studied through mechanical laws and patterns according to the specific characteristics

of the human biological system, including anatomical and physiological knowledge (Kharmanda & El Hami, 2017; León, Calero, & Chávez, 2016).

Each athlete, taking into account their individual differences, both in their body structure and in the execution of sports gestures, has variability in their patterns and their relationship with those of other athletes. Thus, researching the variability of movement in an intra- and inter-individual way is a new approach to the evaluation, diagnosis and control of sports techniques (Ramon, 2009; González-Catalá & Calero-Morales, 2017; Andrade, Villarroya-Aparicio, & Morales, 2017; Criollo Romero, Espinoza Saltos, Calero Morales, Chávez Cevallos, & Fleitas Díaz, 2018).

Variability far from being interpreted as detrimental to performance, the new approaches suggest that when variability appears in motor execution, it can be beneficial to the organization and execution of the movement, even representing an index of the capacity of resistance to the conditions related to such execution (Ramon, 2009).

This variability is transferred to the field of motor behavior to explain the differences in such behavior between various individuals and even in the motor actions performed by the same person. From the knowledge of the kinetic and neurophysiological parameters that produce and regulate human movement, it has been possible to demonstrate the non-existence of two exactly identical movements, with interindividual differences in the execution of the same motor task (Slifkin & Newell, 2000).

Another way of interpreting this phenomenon of variability is that biological systems are self-organized in terms of environment and biomechanical and morphological constraints (Leon, Calero, & Chavez, 2016) in order to find the most stable solution in the production of a specific movement (Thelen & Smith, 1996).

Under the previous concept, an increase in the variability of a movement pattern means a lesser cooperation of the three components of the referential system mentioned above. A decrease in the variability of the pattern of movement would indicate a highly stable and cooperative behavior of the system. This line of thought would indicate in the sports plane, that to carry out the throwing it is necessary to take into account the environment or external state of the moment of the gesture and the kinetic, kinematic and neurophysiological limitations of the thrower (Newell, Slifkin, & Piek, 1998).

Variability in human movement can be conceptualized as the normal variations that occur in motor execution through multiple repetitions of a gesture (Stergiou, Buzzi, Kurz, & Heidel, 2004; Cali, 2009).

In the literature on motor control, there are a variety of scientific guidelines on the variability of human movement. According to Schmidt (2003), Schmidt (2005), the variation of a motion pattern, at a given time, can be considered as the consequence of errors in the ability to predict the parameters necessary to use a motor program and, with the practice of specific tasks, the prediction of errors can be gradually eliminated and thus optimize the accuracy and efficiency of the motor pattern, applying, for example, the method of repetition.

Some researches have found that there are other causes of variability than the traditional ones, such as the result of adjustments, compensations and coordination. On the other hand, Kudo, & Ohtsuki, (2008) reported that human movement is

produced in variable external and internal environments and that, because of this variability, the same motor command can result in quite different movement patterns. Therefore, to produce complex or highly skilled movements, such as sports gestures, humans have to regulate variability and not try to exclude it.

Each athlete, taking into account his or her individuality, makes his or her movements dependent on the functional adaptation to new and different patterns of restrictors that occur at the time of execution of the same pattern of movement, which emerge from a cooperative behavior of multiple degrees of freedom. For the coaches, the goal is to optimize the sport gesture of each individual, knowing their characteristics and their serial behaviors in time and space (Lasluisa, Rodríguez, & O'Farril, 2019; Viscarra & Frómeta, 2020).

To these aspects of variability, it does not escape the discus throw, (Frutos, Palao, & Elvira, 2012) which is an athletic specialty in which they are executed, to high speed, complicated combined movements of translation and rotation, affected by the external or environmental conditions, especially to the sustenance and resistance of the air, all of which makes this gesture highly demanding physically and technically, which is a determining factor in achieving high performance, as well as the athlete's ability to adapt to external conditions, enhance their internal conditions in terms of variability and control movement.

Several authors have applied the biomechanics in function of the analysis of the technique in function of the performance, among them: Grande (2000); Floria (2006); Navelo (2011); Rubio (2017) and Romero (2019), among others.

Several authors have given biomechanical treatment to the analysis of the discus throw technique, (Rodríguez, 2000; Floría-Martín, 2006; Rubio-Rodríguez, 2017; Navelo, Cutzal, & Santeliz, 2011 and Frómeta, Irúa, & Pillajo, 2019) from the categorization of variables of the technique's effectiveness, from the biomechanical evaluation of thethrow, from a methodology that can be applied in the analysis and performance support programs, the analysis of the influence of the disc's trajectory during the last two phases of thethrow on its release speed, biomechanical analysis of the lower limbs during the discus throw, the technical performance in the discus throw phase and the discus throw technique, however, these have not focused their analysis from the study of the variability of movement.

It is important to consider what is meant by emerging behaviors. In this sense, Newell, Slifkin, & Piek (1998) propose that it is the coordination that emerges in the executing system-environment and relates three elements: organism, environment and task. The organism includes the subsystems of the human body (postural, hormonal, cognitive and emotional subsystems). The medium is the effect of gravity, reaction forces and energy flows surrounding the performer (also socio-cultural influences). The task is specific to the context of the performance and includes the norms, limits and instruments involved.

These elements, from the dynamic point of view, have the same influence on the behavior of the individual, so that no single construct dominates the rest. A coordinated pattern is the successful product derived from this process, taking into account that the influence of a particular subsystem can vary the organization of the whole system.

The Integral Program of Preparation of the Athlete of throwing is the methodological document that guides the coaches of the Sport Initiation School "Héctor Ruiz Pérez", of Villa Clara, Cuba (Eide in Spanish), however, only indications are given for the teaching in the throwing of the disc.

As it can be appreciated, in spite of the importance of the analysis of technique from the variability in movements, it has not been found in the bibliographic searches carried out a procedure that allows carrying out this study from this vision, for this reason, this research has as an objective; to establish a biomechanical procedure for the adjustment, compensations and control of the variability of the technical execution of discus throw, of the athletes of the 15-16 years old category of Eide "Héctor Ruiz Pérez".

MATERIAL AND METHODS

The context of study was the Eide of Villa Clara. Among the subjects of the research, there was an athlete belonging to the category 14-15 years old (case study), the throwing coach of the Eide, four members of the Provincial Athletics Commission, intentionally selected under the criteria of having more than ten years of experience in the activity, being specialists of postgraduate or master's degree and the two members of the Biomechanics collective of the Faculty of Physical Culture of the Central University "Marta Abreu" of Las Villas (U.C.L.V in Spanish).

A semi-structured interview was applied, which allowed to know the criteria of coaches and members of the Provincial Technical Commission about the way in which the technique of the athletes is currently analyzed and whether or not the study of variability is used. The interactive techniques made it possible to structure the procedure proposed for the analysis of variability. In this, the group of researchers and Biomechanics of the Faculty of Physical Culture of the U.C.L.V. participated jointly.

Used methodology

Two Panasonic digital cameras were used to record the images, with the support of a computer through the biomechanical program KINOVEA. The recorded images collected a set of actions performed by the thrower under study during the training session.

Nine actions of the complete throw were selected, from the side and front position, guaranteeing the possibilities of comparison they offer. In this communication, the focus was on the period from the swinging to the release of the implement.

The kinematic parameters used in the research for the analysis of variability were:

a) Abduction angle of the shoulder on the executing side at the moment of release.
b) Disc release height.
c) Initial acceleration of the implement.
d) Lateral bending angle of the trunk at the instant of release.
e) Horizontal distance between the disc and the center of mass.
f) Rotation time.
g) Attack angle at the instant of release.
h) Initial speed of attack of the implement.
i) Initial attack speed of the implement.

Indicator system user criteria

The IADOV technique was used to evaluate user satisfaction, taking into account the theoretical postulates cited in López & González (2002). A questionnaire was used with a total of five closed questions and two open questions, whose relationship is not known by the subject. The resulting number of the interrelation of the five closed questions indicates the position of each subject in the satisfaction scale, that is, his individual satisfaction. The satisfaction scale used is the following:

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

This technique also allows us to obtain the group satisfaction index (ISG in Spanish), for which we work with the different levels of satisfaction expressed in the numerical scale that ranges from 1 to -1 as follows (Table 1).

Table 1. - Numerical scale ranging from 1 to 1

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

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

$$ISG = \frac{A\,(+1) + B\,(+0.5) + C\,(0) + D\,(-5) + E\,(-1)}{N} \quad (1)$$

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 gives values between + 1 and - 1. Values between - 1 and - 0.5 indicate dissatisfaction; those between - 0.49 and + 0.49 show contradiction and those between 0.5 and 1 indicate satisfaction.

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

a) What importance do you attach to the system of indicators?
b) What aspects, in your opinion, strengthen or limit the use of this system of indicators?

The statistical software SPSS in its version 25.0 was used to calculate the different measures of position and dispersion such as mean, median, variance and standard deviation, among others, for the analysis of variability.

RESULTS AND DISCUSSION

When evaluating the Integral Program of Preparation of the Athlete in Throwing, which is the methodological document that guides the coaches in the process of sports training, it was found that it does not offer any procedure to make analysis of the technique, it only deals with a group of aspects related to the technical direction to which the sports coach must pay attention and that are directed, rather, to the teaching. Among these aspects are:

b) Technical direction: Teaching methodology.

This content is aimed at developing the methodology for teaching throwing, running and weightlifting techniques. It is recommended that attention be directed towards the teaching methodology of the following components, which are very important in the process of learning the technique:

Priority No. l:

- Teaching methodology of shot put technique.
- Methodology of teaching the technique of discus throw.
- Teaching methodology of javelin throw.
- Methodology of teaching the technique of hammer throw.

In the four throws it is necessary to insist on the following contents:

- Magnus reflexes or tonic neck reflexes.
- Accumulation of elastic energy.
- Implement delay and increase of the energy application path on the implement.
- Whiplash mechanism.
- Continuity of movements, acceleration and speed.
- Balance.
- Direction of the movements and fall zone of the implement.
- Stability of the technique.

These aspects are of great importance; but, for this, it is necessary the biomechanical study and the procedure to carry out the evaluation of each content is not considered, among which, in spite of its importance, the variability of the movement is not found.

b) The trainer must place his attention on the fact that, after the impulse, the athlete has to go through the phase of preparation of strength and unloading or also called preparation for the final effort and final strain, without destroying it.

When throwing the discus, from the beginning, emphasis must be placed on placing the right foot in the center of the circle, with the puck as far back as possible, so that, at the end of the sprint step, the foot descends to position itself with the heel towards the throwing area to avoid breaking the throwing rhythm. Similarly, a procedure for biomechanical analysis is needed, from the perspective that the program is proposing and the variability is obviated as a study.

When evaluating the results of the interview with the coach and the members of the Technical Commission of athletics selected, we were able to confirm that the analysis of the technique carried out is of an empirical nature, since it follows traditional procedures without the use of biomechanics or computers.

They also propose that the analysis of the technique, based on the variability of movement, is new for them and they do not have the procedure to make a biomechanical study.

Presentation of the proposal, biomechanical procedure for the analysis of the variability of the technical performance of the discus throw

Criteria used to determine the steps for the analysis of the variability of the technical execution of the discus throw.

To determine the steps for the analysis of the variability of the technical execution of the discus throw, a workshop was held with the participation of professors from the Biomechanics collective of the Faculty of Physical Culture, at the Central University "Marta Abreu" in Las Villas.

In the workshop, the objectives of the same one are announced and a first version of the steps of the methodological procedure is presented, which are submitted to discussion; later, consensus was reached and the definitive proposal of the analysis of the variability of the technical execution is made.

The procedure is specified in the following steps:

Step 1: filming by means of the cameras, located front and side to the action of the thrower.

Step 2: scanning images frame by frame.

Step 3: synchronization of the data obtained in each of the cameras.

Step 4: phase: obtaining results.

Step 5: processing and statistical analysis.

The study variables are specified in the following kinematic parameters:

a) Abduction angle of the shoulder on the executing side at the moment of release.
b) Discus release height.
c) Initial implement acceleration.
d) Lateral bending angle of the trunk at the moment of release.
e) Horizontal distance between the disc and the center of mass.
f) Rotation time.

g) Angle of attack at the moment of release.
h) Initial attack speed of the implement.

Implementation of the procedure proposed in the analysis of the case study technique

After applying the different steps of the procedure used for the analysis of movement variability, the following results are achieved.

The variability in the behavior of the human movement system is not seen as typically seen, as a factor of noise or error in the execution, on the contrary, it is indicated in Davids, Shuttleworth, Button, Renshaw, & Glazier, (2004) that the systems of the human movement need to access to this information to contextualize the movements in presence of error or noise, in the form of variability of the structure of the motor result, factor that constitutes an imperative for the functional adaptations to the dynamic environments. In other words, variability in human movement should not be conceived as a negative factor, but rather as a functional factor that contributes to sports performance.

From that perspective, the variability of the different shipments of the athlete under study is analyzed below, where angles, heights, speeds and accelerations are analyzed (Table 2).

Table 2. - Presentation of the results of the variability of the parameters studied

Abduction angle of the shoulder on the executing side at the moment of release	Discus release height	Initial implement acceleration	Lateral bending angle of the trunk at the moment of release	Horizontal distance between the disc and the center of mass	Rotation time	Angle of attack at the moment of release	Initial attack speed of the implement	
83	1.78	21.71	84.5	1.08	1.25	33.2	25.76	
100	2.07	61.13	84.4	0.95	1.4	54.4	27.53	
103	1.94	61.75	86	0.99	1.2	38.1	23.49	
105	2.15	41.28	79.5	0.9	1.22	29.1	28.75	
79	1.7	34.48	79.5	1.1	1.4	59.1	28.67	
67	1.42	58.51	80.4	1.12	1.3	49.8	27.49	
98	2.09	74.32	77.1	1.1	1.26	52.2	25.62	
99	1.09	47.34	82.3	0.96	1.35	54.1	27.93	
75	1.55	65.47	71	0.88	1.2	47.8	28.8	
105	**2.15**	**74.32**	**86**	**1.12**	**1.4**	**59.1**	**28.8**	maximum
67	**1.09**	**21.71**	**71**	**0.88**	**1.2**	**29.1**	**23.49**	minimum
89.89	**1.75**	**51.78**	**80.52**	**1.01**	**1.29**	**46.42**	**27.12**	**Media**
98	**1.78**	**58.51**	**80.4**	**0.99**	**1.26**	**49.8**	**27.53**	Median
195.361	**0.125**	**282.630**	**21.064**	**0.009**	**0.006**	**109.269**	**3.265**	Variance
13.977	**0.35388**	**16.81161**	**4.5896**	**0.09266**	**0.08016**	**10.4532**	**1.8069**	Deviation

Statistically, variability can be defined as the variance of the data, related to its mean and usually quantified by the size of the standard deviation (Riley & Turvey, 2002). The standard deviation informs about the degree of variability of a given system parameter. That is why the analysis is focused on the standard deviation of each of the biomechanical parameters.

In the case of the height of release of the implement, which is one of the determining factors of the result, it is appreciated that both the mean and the median oscillate between 1.75 and 178 m. and a smaller deviation than one is obtained, which indicates that this parameter is stable, that is, there is not a great variability in the execution of the nine shots.

The horizontal distance between the disc and the center of mass, although it is not a determining factor of the result, has a similar behavior to the previous one as far as the variability, counts on a median and average that oscillate between .99 cm. and 1.00 m., reason why the athlete in study manages to regulate its movements of suitable way.

On the other hand, the rotation time, which is one of the parameters that affect the output speed of the implement, is another of the values that do not present a great variability, since the values of the mean and median range between 1.26 and 1.29 m/s, as well as a standard deviation below one.

The speed of attack of the implement can be said to be the factor that most affects the achievement of the sports result, and as can be seen in the table, this ranges between 27.12 and 27.53 m/s, with a deviation of around one, so it can be said that there is little variability of this parameter in the nine shots.

Similarly occurs in the lateral flexion of the trunk that, although it is not a determining factor of the result, affects other factors that are. In this case, the deviation is around four and values in the mean and median ranging from 80, 4 and 80, 52 degrees; however, here there is greater variability than in the previous parameters.

The angle of attack at the moment of release, being a determining factor in the performance, presents a greater deviation, which is around ten and the average and median range between 46.4 and 49.8 degrees.

The initial acceleration of the implement is also dispersed, as its deviations are around 16 and the average varies between 51.78 and 58.5 m/s2. This factor is not decisive in the result as it is the initial speed.

Table 3. - Summary of the results of the parameters studied

	N	Mínimum	Maximum	Mean	Typical deviation.
Abduction angle of the shoulder on the executing side at the moment of release	9	67	105	89.89	13.977
Discus release height	9	1.09	2.15	1.7544	.35388
Initial implement acceleration	9	21.71	74.32	51.7767	16.81161
Lateral bending angle of the trunk at the moment of release	9	71.0	86.0	80.522	4.5896
Horizontal distance between the disc and the center of mass	9	.88	1.12	1.0089	.09266
Rotation time	9	1.20	1.40	1.2867	.08016
Angle of attack at the moment of release	9	29.1	59.1	46.422	10.4532
Initial attack speed of the implement	9	23.49	28.80	27.1156	1.80690
N valid (according to list)	9				

The previous table reflects, in a general way, the variability in the studied parameters, which is considered low, since only two parameters, which are not determinants in the competitive performance, the variability is higher, so it is considered that this decrease in the variability of the movement pattern indicates a cooperative and highly stable behavior of the system because the higher the variability operated by the standard deviation, the higher the noise in the system. From this perspective, researchers in biomechanics and motor control have typically sought parameters of low variability or "lower noise" within human movement, although the role that parameters with variability or "higher noise" can play, in this case, is an important role in the regulation of movement against external factors, seeking an adaptation of the organism-environment, hence in the case at hand can justify the parameters of greater variability to the above (Table 3).

In summary, these traditional perspectives are complementary and have a common denominator: a) variability is equivalent to "noise", b) they recognize that decreased variability results from efficient execution of a given movement pattern, and c) that

changes in motor behavior states can be signaled, increasing variability until a more stable movement pattern is adopted. This proposal implies that the lack of variability in movement, in the presence of demands of changing motor tasks or environmental conditions, may indicate rigid and inflexible motor behaviors with limited adaptation, which may also justify the greater variability of these two parameters.

The variability of the patterns, that gave discharges, diminishes with the acquisition of the technique, process that is denominated "paradigm of the motor learning" and in another nontraditional sense, the variability increases with the acquisition of the technique, denominated "the development of the motor repertoire", to which the pitcher is submitted, that occupies this case, for being in a category where the technical work is a priority (Stergiou, Buzzi, Kurz, & Heidel, 2004).

This is also based on the literature of motor control because according to Schmidt (2003); Schmidt (2005), the variation of a motion pattern, at a given time, can be considered as the consequence of errors in the ability to predict the parameters necessary to use a motor program and, with the practice of specific tasks, the prediction of errors can be gradually eliminated and thus optimize the accuracy and efficiency of the motor pattern. In practical terms, this trend of thought would imply that, with more practice of a specific task, it is possible to obtain a level of little variability in the sports gesture of the pitcher under study.

From the above, it is inferred that the subject under study is a young athlete, needs to accumulate higher volumes in the tasks related to the technique and its improvement.

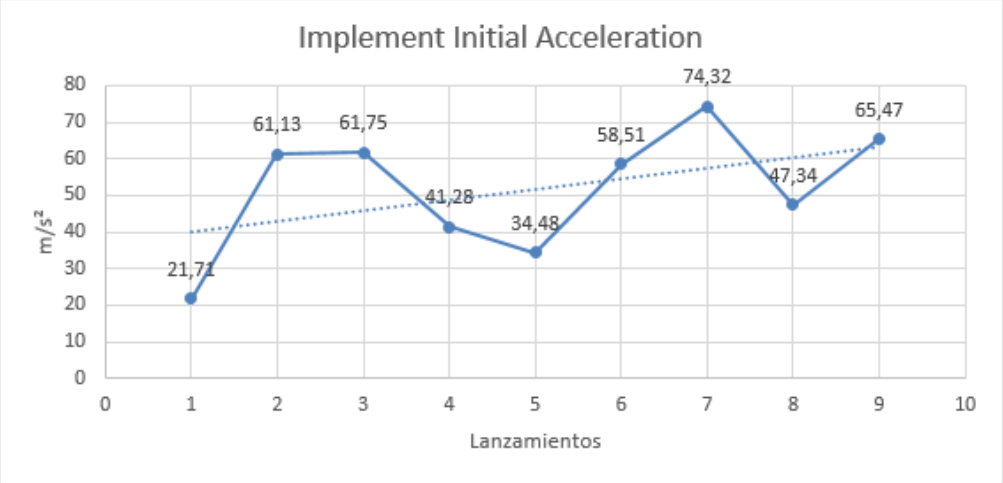

Fig. 1- Behavior of variability in the acceleration parameter

The researchers who have studied the timing of the body segments in the throws mention consecutive accelerations and decelerations, which is corroborated in the graph that shows the nine throws of the subject under study (Figure 1), where there are consecutive ups and downs in the acceleration, especially in the throws one, four, five and eight. Zatsiorsky's (1994) research in shot put, using a two-dimensional photographic system, confirms a consecutive upward acceleration and deceleration of the body segments, which could have been occurring in the case under study.

Another element that can justify the variability in this parameter is the fact that there are adjustments, compensations and coordination in the movement. For example, Kudo & Ohtsuki (2008) reported that human movement is produced in variable external and internal environments and that, because of this variability, the same motor command can result in quite different movement patterns. So, in order to produce complex or highly skilled movements, like sports gestures, humans have to coordinate (regulate) the variability and not try to exclude it (Figure 2).

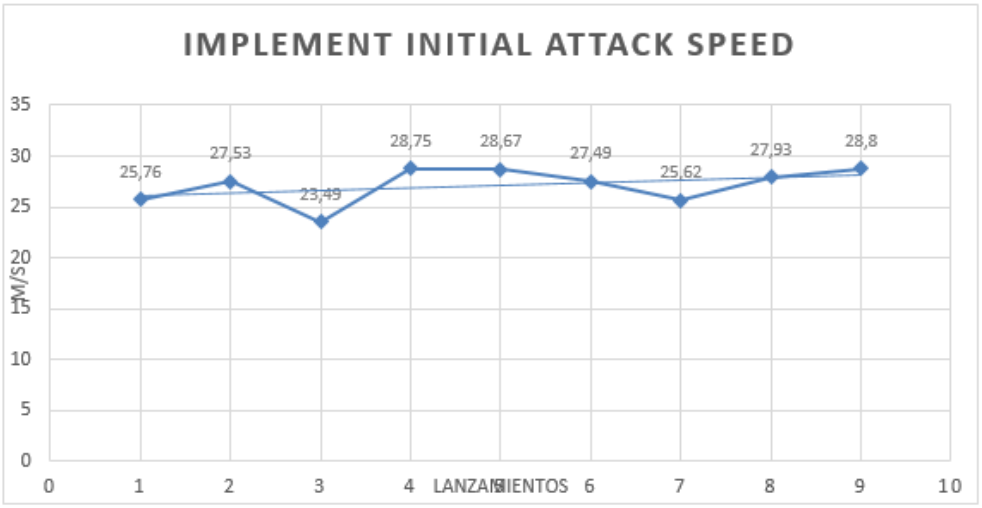

Fig. 2 - Behavior of variability in the speed parameter

It is agreed that the achievement of speeds is the most important, in this case the actions of the segments are consecutive. Each segment starts its action at the moment when the segment previously involved reaches its maximum speed. The horizontal and vertical forces must be properly timed. This results in that the maximum speed is reached just previously, at the moment of release (Redding, 1988).

Each athlete, taking into account his or her individuality, makes his or her movements dependent on the functional adaptation to new and different patterns of restrictors that occur at the time of execution of the same pattern of movement, which emerge from a cooperative behavior of multiple degrees of freedom. The more richness the athlete finds in the repertoire of the sports gesture, the greater the chances of success and adaptation. As shown in Figure 2, speed has a low variability, only the three and seven shots are slightly below average, but in general it can be considered that it has been possible to regulate the variability in this important parameter.

The results of the group satisfaction index (ISG), applied to the introductory users who were made up of four members of the Technical Athletics Commission and the main throwing coach, who, in turn, serves as head of the athletics department (Table 4).

Table 4. - User satisfaction when using the IADOV technique

Name	Function	Values assigned to the proposal	Answering open-ended questions
Mario A. Guerra (doing master's studies)	Provincial Commissioner of Athletics	Maximum satisfaction + 1	The proposed biomechanical procedure is of great importance for the analysis of the technique in an objective manner, although I suggest that courses be implemented for EIDE trainers
Nelson Millares	Methodologist	More satisfied than dissatisfied + 1	The proposed procedure allows to improve the preparation of the coaching athletes in the analysis of the technique, but I recommend that it be used in other throws and other areas.
MS.c Alberto Morales Fábrega (candidate)	Technical Manager	More satisfied than dissatisfied 0.8	I think it is a very good proposal, although it requires preparation by the coaches to apply it.
Dr.C Nieves Acosta Guibert	Professional upgrading manager	Maximum satisfaction + 1	The proposal, not only allows to prepare the coaches, but finally will result in the technical preparation of the athletes and their performance.
MS.c Luis Alberto Argudin Gómez	Throwing Coach	More satisfied than dissatisfied + 1	I am very happy with the proposal because making evaluations of the technique using simple observation does not allow to obtain great information so this can help to improve the performance of the athletes. In addition, this should be extended to other areas of Athletics.

Group satisfaction is calculated by the following formula (Equation 2).

$$ISG = \frac{A\,(+1) + B\,(+1) + C\,(0.8) + D\,(+1) + E\,(+1)}{N} \quad (2)$$

After applying the ISG formula the following index is reached:

ISG = 0.96 (0.5 to 1 indicates satisfaction)

This index indicates that there is satisfaction of the introductory users with the determined indicators, in spite of the fact that they make several reflections when answering the open questions that are taken into account in their improvement.

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

- What importance do you attach to the proposed manual?
- What aspects in your opinion enhance or limit the use of the proposed manual?

The answers to these questions are relegated to the table above and are taken as suggestions to improve the final determination of the proposal.

It was possible to confirm that the analysis of the technique of discus throw is carried out in an empirical way by the Eide's throwing trainers, without the use of new technologies, that the consulted bibliography allowed knowing the foundations of the variability of the performance of the movement in the discus throw, hence it was necessary a biomechanical procedure for the analysis of the variability of the technical execution of the, in this discipline.

In a general way, it was verified that the variability in the studied parameters is not high, only two parameters, which are not determinants in the competitive performance, present the biggest variability, for what it is considered that this decrease in the variability of the movement pattern indicates a cooperative and highly stable behavior of the thrower system in the case under study, because the smaller the variability operated by the standard deviation, the smaller the noise in the system and vice versa. The IADOV index indicates that there is satisfaction of the introductory users with the determined indicators, in spite of the fact that they make several reflections when answering the open questions, which are taken into account in their improvement.

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