PODIUM
Journal of Science and Technology in Physical Culture

UNIVERSITY EDITORIAL

Volumen 17
Issue 1
2022

University of Pinar del Río "Hermanos Saíz Montes de Oca"

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ISSN: 1996–2452 RNPS: 2148
*PODIUM Journal*, January-April 2022; 17(1):141-161

*Translated from the original in spanish*

**Original article**

# Critical eye-fusion frequency behavior in national track and field preselection athletes

# Comportamiento de la frecuencia crítica de fusión ocular en atletas de carreras de la preselección nacional de atletismo

# Comportamento da frequência crítica da fusão ocular nos atletas da equipe nacional de pré-seleção do atletismo

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**Received**:09/13/2020.
**Approved**:10/01/2022.

How to cite ítem: López Rodríguez, L. (2022). Critical eye-fusion frequency behavior in national track and field preselection athletes/Comportamiento de la frecuencia crítica de fusión ocular en atletas de carreras de la preselección nacional de atletismo. *PODIUM - Journal of Science and Technology in Physical Culture, 17*(1), 149-161. Retrieved from https://podium.upr.edu.cu/index.php/podium/article/view/996

## ABSTRACT

The correct combination of the volume and intensity of the stimuli of training loads and the control of the impact that they have on the organism of the athletes constitute two of the aspects that awaken more interest in the high performance sport. The present research aims to describe the behavior of the critical eye-fusion frequency (FCFO in Spanish) before and after undergoing track races, in three macrocycles of athletes of the running modalities of the national athletics preselection and to check if these values differ according to the different mesocycles of preparation and gender. The study was carried out with 38 athletes (20 men and 18 women) subjected to 84 measurements of the Flicker or Fatigtest-USB, before and after the load in three macrocycles, which

included different preparation mesocycles. Statistical analysis of the data was performed through SSPS, version 20.0, specifically Studenty's ¨t¨ test and analysis of variance. The results showed that there is a significant increase in the values of critical frequency of ocular fusion and, consequently, in the levels of cortical activation after the load, without significant differences between these values in the different types of mesocycles, although there were significant differences between the average values of men and women before and after the load; the values reported by men were lower. These analyses constituted references for the interpretation of the test values in order to improve in the process of psychological control of training and advice to trainers about the adequate assimilation of training loads.

**Keywords**: Fatigtest-USB; Critical ocular fusion frequency; Track races.

## RESUMO

A combinação correta do volume e intensidade dos estímulos das cargas de treinamento e o controle do impacto que elas têm sobre o organismo dos atletas representam dois dos aspectos que mais despertam o interesse pelo esporte de alto rendimento. O objetivo desta pesquisa é descrever o comportamento do FCFO antes e depois de se submeter a correr em pista, em três macrociclos dos atletas das modalidades de corrida da pré-seleção nacional de atletismo e verificar se estes valores diferem de acordo com os diferentes mesociclos de preparação e gênero. O estudo foi realizado com 38 atletas (20 homens e 18 mulheres) que foram submetidos a 84 medições do teste Flicker ou Fatigtest-USB, antes e depois da carga em três macrociclos, que incluíram diferentes mesociclos de preparação. A análise estatística dos dados foi realizada usando SSPS, versão 20.0, especificamente Studenty's ¨t¨ teste e análise de variância. Os resultados mostraram que há um aumento significativo nos valores da frequência crítica de fusão ocular e, consequentemente, nos níveis de ativação cortical após a carga, sem diferenças significativas entre estes valores nos diferentes tipos de mesócitos, embora houvesse diferenças significativas entre os valores médios de homens e mulheres antes e depois da carga; os valores relatados pelos homens eram menores. Estas análises constituíram referências para a interpretação dos valores do teste, a fim de melhorar no processo de controle psicológico do treinamento e aconselhamento aos treinadores sobre a assimilação adequada das cargas de treinamento.

**Palavras-chave:** Fatigtest-USB; Frequência crítica de fusão ocular; Track running.

## RESUMEN

La correcta combinación del volumen y la intensidad de los estímulos de cargas de entrenamiento y el control del impacto que tienen en el organismo los deportistas constituyen dos de los aspectos que más interés despiertan en el deporte de alto rendimiento. La presente investigación tiene como describir el comportamiento de la FCFO antes y después de someterse a carreras en la pista, en tres macrociclos de los deportistas de las modalidades de carreras de la preselección nacional de atletismo y comprobar si estos valores se diferencian en función de los diferentes mesociclos de preparación y del género. El estudio se realizó con 38 deportistas (20 hombres y 18 mujeres) sometidos a 84 mediciones de la prueba Flicker o Fatigtest-USB, antes y después de la carga en tres macrociclos, en los que se incluían diversos mesociclos de preparación. Se realizó el análisis estadístico de los datos a través del SSPS, versión 20.0, específicamente la prueba ¨t¨ de Studenty el análisis de varianza. Los resultados demostraron que existe un aumento significativo de los valores de frecuencia crítica de

fusión ocular y, por consiguiente, de los niveles de activación cortical después de la carga, sin existir diferencias significativas entre estos valores en los diferentes tipos de mesociclos, aunque sí existieron diferencias significativas entre los valores promedios de los hombres y de las mujeres antes y después de la carga; los valores manifestados por los hombres fueron inferiores. Estos análisis constituyeron referencias para la interpretación de los valores de la prueba y así poder mejorar en el proceso del control psicológico del entrenamiento y la asesoría a los entrenadores acerca de la adecuada asimilación de las cargas de entrenamiento.

**Palabras clave**: Fatigtest-USB; Frecuencia crítica de fusión ocular; Carreras en la pista.

## INTRODUCTION

The correct combination of the volume and intensity of the stimuli of training loads and the control of the impact they have on the body of athletes are two of the aspects that arouse most interest in high performance sport.

The practice of high-performance physical activity today has experienced an exponential increase in its social and personal significance (Puni, 1969). Increasingly demanding competitive schedules have also imposed considerable rigor on the rational dosage of loads during the annual cycle and its stages.

Verkhoshansky (2002) considers that, in order to achieve greater effectiveness in training, it is necessary to increase the specific loads, the application of means and methods oriented to the solution of the task, as well as the concentration of these specific training loads in certain stages of the annual cycle and their distribution in time. A scientific indicator through which the process of assimilation of training loads can be studied, allowing its correct planning, is the response emitted by the central nervous system of the athletes, that is, the level of cortical activation or the state of activation that exists in the cerebral cortex.

One of the most widely used direct methods for measuring cortical activation levels is the critical frequency of ocular fusion (FCFO). This parameter is an objective measure obtained through the Flicker test or the Cuban variant known as Fatigtest-USB which constitutes the modernized version of the Fatigtest developed in 1990 by Cetra, currently the Center for Environmental Research (Cimab) in Havana (Lorenzo, *et al.,* 2018).

This method stands out for its usefulness and efficiency in the control and psychological preparation of the athlete, in control and influence of training loads and allows improving the assistance work of the specialist in Psychology in the counseling and psychological intervention to the athlete to raise their sports performance (Lorenzo, *et al.,* 2018 and Mesa and Suárez, 2015).

The method provides a critical ocular fusion frequency index, which is nothing more than the eye's capacity to fuse images on the retina. In this regard, Martínez (2011b.) points out:

> "It is a central psychophysiological phenomenon, since the visual receptor, the transmission pathways and the cerebral cortex are involved in its production, which, according to the degree of activation it possesses, will condition the critical frequency values of ocular fusion".

The FCFO has been used in studies of fatigue caused by sports activity, because its production is essential for the development of the physical potential of athletes. The appearance of fatigue during training and its subsequent disappearance provide the necessary adaptation to the loads or supercompensation.

In fatigue studies, the comparison of the values of the FCFO before and after the supply of the training load brings us closer to the repercussion that this has on the nervous system of the athlete. In this sense, (Martínez, 2011a.) explains the existence of three types of responses after the supply of training loads:

1. When there are increases in the values of FCFO, the stimulus is in accordance with the thresholds of adaptive responses that the subjects possess, the effect of the load is expected and has a stimulating character on the muscular system and the nervous system.

2. When there are decreases in the FCFO values, the stimulus does not fulfill its tonic influence at the level of the Central Nervous System and an inhibition is produced as a real expression of a central fatigue process. The effect of the load is not expected and there is a decrease in cortical activation.

3. When the FCFO does not undergo variations, it does not produce a significant action on the central levels, the effect is not expected, but it is not negative either. It usually happens when the loads do not reach the level of individual development or when there has been a high strengthening of the defense mechanisms against the loads at the central level.

There are references of several evaluations of the FCFO in different groups of athletes subjected to certain types of previously designed physical exercises, for example: in high-performance Yucatecan swimmers stimulating the different qualities or functional areas, with Cuban judo athletes in the top of preparation of each of the training stages and in Cuban gymnasts during the accumulation-transformation-realization training (ATR) 1. In all cases, a movement in cortical activation levels is demonstrated with a significant increase after the load, in addition to taking into consideration the type of training load to which the athletes are subjected (Mesa and Suárez M., 2017; Suárez S., 2018).

In athletics, one of the antecedents of its application of the Flicker or Fatigtest-USB was aimed at testing the usefulness of the three methods of movement of the light stimulus (ascending, descending and alternating combination) that this test offers. In the ascending method, the test begins with the light flashing and the athlete must indicate only when he/she perceives that it has become fixed; in the descending method, the test begins with the light fixed and the athlete must indicate only when he/she perceives that it begins to flash; in the alternating combination method, the athlete indicates when he/she perceives the light changes between fixed and flashing. It was demonstrated that the descending method is the one that presents less variability and its reliability was proven (Barrios, *et al.,* 2003). At present, there are no other scientific antecedents of the application of the test in this sport.

In the modalities of athletics races (sprint, long-distance and middle-distance), track races (stretches on the track) constitute one of the means used in the application of training loads to stimulate the development of the different physical and technical capacities. This type of means is applied throughout the preparation, regardless of the type of planning used. In this sport, the mesocycles are worked under the conception of

what is known as training by functional areas, taking into account the impact on the cardiopulmonary and hemomuscular level. The duration of the sections, the distance, the intensity, the number of repetitions and the recovery vary according to the preparation mesocycle and the modality (Hegedüs, 1996).

The stretches on the track are directly related to competitive performance and performance. For coaches, it is a challenge in planning to work not only endurance and speed, but also technical elements and other capabilities such as strength and coordination. Such flexibility in planning is shown in assertions of authors such as Becali and Romero (2014) who express that, in high performance, there are no dogmas in the training process, innovation and the application of new technologies and scientific technical advances that increasingly contribute to high results are taken into consideration.

Therefore, it is necessary to introduce scientific methods to guide the sports planning process and to provide coaches of athletic modalities with information about the assimilation of any type of load stimulus, in this case, one of the most used ones, such as stretches or races on the track.

For the development of this research, it was consulted research that in one way or another have had to do with the physiological aspects of athletics (Rodríguez, Bustos, 2017; Zapata *et al.,* 2018; Ruiz, 2019; Guavita, Trujillo, 2019; Álvarez, 2020; Duarte, Hernández, 2020; Mangine *et al.,* 2020; Méndez-Pérez, 2020).

The objective of this research is to describe the behavior of the FCFO before and after undergoing track races, in three macrocycles of the athletes of the running modalities of the national preselection of athletics and to check if these values differ according to the different mesocycles of preparation and gender. This allows having references for the interpretation of the FCFO values and thus being able to improve in the process of the psychological control of the training and the advice to the coaches about the process of assimilation of the loads. In this research, different instruments taken from the following sources were used (Martínez 2011; Mesa and Suárez, 2015; Martínez and Suárez, 2016).

## MATERIALS AND METHODS

A descriptive-correlational study was performed. The Flicker test or the Fatigtest-USB system was used for data collection. This new version presents an electronic viewer and an attached panel inside which a visual stimulus consisting of a red light that appears and disappears at different frequencies is generated. Its exposure range varies between 10 and 60 hertz (htz). Depending on the chosen variant, the athlete must stare at the light and press a button as a signal that he/she has noticed that the light has started to flicker.

### Sample

In this study, 38 athletes from the running area of the Cuban national athletics team participated in the sprint, middle-distance and long-distance modalities. Of these, 18 were women and 20 men. The average age of these athletes was 21.8 years and the average sport experience was 11 years. Fifty-four percent had outstanding results at the international level.

ISSN: 1996–2452 RNPS: 2148
*PODIUM Journal*, January-April 2022; 17(1):141-161



## Procedure

The measurements were taken in training sessions corresponding to the different mesocycles of general, special and competitive preparation during three macrocycles, I and II towards the Pan American Games of Lima 2019 and macrocycle I towards the Olympic Games of Tokyo 2020.

The loads of these macrocycles varied according to the pedagogical objectives of the described mesocycles, taking into consideration the relationship between volume and intensity.

Fundamental pedagogical objectives in the various mesocycles of the career modalities (Table 1).

**Table 1** - Pedagogical objectives by area and mesocycles

| | General preparation/pedagogical objectives | | | Special/pedagogical objectives | | Competitive/ pedagogical objectives |
|---|---|---|---|---|---|---|
| **Mesocycles** | **I Introductory** | **II Basic developer** | **III Developer** | **IV Basic stabilizer** | **V Precompetitive** | **VI Competitive** |
| **Short speed, long speed, middle distance** | Aerobic capacity. | Aerobic capacity and power. | Lactic Anaerobic Power | Alactic Anaerobic Capacity | Anaerobic Alactic Power | Control of sports fitness. |
| **Fund** | Aerobic capacity | Mixed capacity (aerobicanaerobic) | Extensive Aerobic Power | Intensive aerobic power | Lactic capacity | Control of sports fitness |

These objectives were described in the preparation plans approved by the technical methodological collective of the National Athletics Commission and reviewed and approved by the Technical-Methodological Department of the National Institute of Sports and Physical Education of Cuba.

A total of 84 measurements were taken, all of them in the morning, taking into consideration the irrelevance of another schedule due to the changes produced by the organism before other stimulations. Each measurement consisted of a collection of five records of the descending method before the load and another of similar characteristics between five and ten minutes after running on the track. This time is estimated due to the fact that the Central Nervous System recovers after the peripheral level and according to methodologies used that demonstrate the effect of the load in approximately that time.

Of the 84 measurements, 38 for men and 46 for women, 54 were taken in the general preparation mesocycles and 30 in the special-competitive mesocycles.

For data processing, a database containing the FCFO records before and after undergoing track races in the three macrocycles of preparation was made. The statistical package SPSS *software* version20.0 was used. The descriptive analysis was performed, the values of central tendency of the sample. The Student's t-test for the comparison of means for

related samples, which assessed whether there were significant differences in the means of the FCFO values before and after the supply of loads. The significance index chosen (α = .05). When the p value is less than the significance level α = .05, then the differences in means are said to be due to significant causes, i.e., training load and not to chance. And finally, analysis of variance (ANOVA) to compare whether the values of FCFO before and after loading of one data group are significantly different from the values of FCFO before and after loading of another data group, specifically in the male and female and general and special-competitive preparation stage data groups.

## RESULTS AND DISCUSSION

The descriptive statistics reflected in Table 2 show the minimum and maximum values, mean and standard deviation before and after loading (Table 2).

**Table 2. -** Descriptive statistics of preload and afterload FCFO

| | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| **Preload** | 84 | 23.38 | 46.42 | 35.5146 | 4.86350 |
| **Afterload** | 84 | 21.52 | 50.48 | 36.6455 | 4.88779 |
| **Difference** | 84 | -10.32 | 13.82 | 1.1312 | 4.69484 |

It was found that the values between which the preload (23.38 to 46.42 htz) and postload (21.52 to 50.48 htz) FCFO oscillates offer a range of 22.94 and 28.96 respectively. The average FCFO value obtained before loading was 35.5 htz. The one obtained after loading was 36.6 htz, i.e., it increased by more than one unit. This increase of the FCFO, after the application of the loads, demonstrated an expected effect of the loads, with a stimulating character on the muscular system and the nervous system, the difference between the average FCFO value before the load and the value obtained after is 1.1, which represents a variation of 3.2 % of the initial value. This coincides with authors who have addressed the subject (Martínez and Góngora, 2010, Martínez and Suárez, M., 2017, Suárez, S., 2018) in studies with populations of Cuban high-performance athletes such as swimming, judo and artistic gymnastics, with data collection at different stages of preparation with similar results. For example, Martínez and Suárez (2017), one of the most recent research, found that the average FCFO index before was 33.32 htz, with a standard deviation of 3.85 and after loading their average FCFO values increased to a 35.55 htz, with a deviation of 3.50. Thus, the results of these researches may indicate that the FCFO in high performance athletes exhibits values close to 30 to 37 Hz. On the other hand, other non-sporting populations exhibit lower FCFO values as a consequence of work, being non-significant (Blanco, 2004).

The standard deviations of the FCFO values before and after the load were 4.86 and 4.88 respectively, indicating that there were data that were far from these averages, this alludes to the individualities according to the specific characteristics of the athletes.

The results of the "t" test showed significant differences between the average values of FCFO before and after the previously analyzed load (Table 3 and Table 4).

**Table 3. -** Comparison of means for related samples

| | | N | Correlation | Sig. |
|---|---|---|---|---|
| | Preload and Postload | 84 | .536 | .000 |

r=.536, p≤ 0.05 showed that the data samples before and after loading are related.

**Table 4. -** Test ¨t¨ of difference of means for related samples

| | Mean | Std. Deviation | Std. Error Mean | 95 % Confidence Interval of the Difference | | t | Df | Sig. (2tailed) |
|---|---|---|---|---|---|---|---|---|
| | | | | Lower | Upper | | | |
| Preload-Posload | -1.13083 | 4.69510 | .51228 | -2.14973 | -.11193 | -2.207 | 83 | .030 |

The t-value (-2.207) and the significance index (p=0.030) provide evidence of the significant difference in the mean values of the measurements before and after loading. With respect to men and women, Table 5 shows an analysis of variance to determine whether there are significant differences (Table 5).

**Table 5. -** ANOVA of FCFO before and after loading and the difference between men and women

| | | Sum of Squares | Df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| FCFO Preload | Both groups | 101.757 | 1 | 101.757 | 4.482 | .037 |
| | Between groups | 1861.497 | 82 | 22.701 | | |
| | **Total** | 1963.254 | 83 | | | |
| FCFO Afterload | Both groups | 109.881 | 1 | 109.881 | 4.811 | .031 |
| | Between groups | 1873.032 | 82 | 22.842 | | |
| | Total | 1982.912 | 83 | | | |
| Difference | Both groups | .157 | 1 | .157 | .007 | .933 |
| | Between groups | 1829.291 | 82 | 22.308 | | |
| | **Total** | 1829.447 | 83 | | | |

The results of the last column show that there are significant differences between the mean values of preload FCFO of men and women (F=4.482, p=.037). It is also shown that the afterload FCFO values are different between men and women (F=4.811, p=.031). However, the value of the difference between the FCFO values of men and women is not significant (F=.007, p=.933) (Table 6).

ISSN: 1996–2452 RNPS: 2148
*PODIUM Journal, January-April 2022; 17(1):141-161*

**Table 6. -** Descriptive statistics of FCFO values of men and women before and after loading

| | N | Mínimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| Preload Men | 38 | 23.38 | 46.42 | 34.3037 | 4.55664 |
| Postload Men | 38 | 21.52 | 46.84 | 35.3871 | 4.93356 |
| Preload Women | 46 | 28.40 | 46.36 | 36.5150 | 4.92898 |
| Postload Women | 46 | 31.20 | 50.48 | 37.6850 | 4.64866 |
| Valid N (listwise) | 38 | | | | |

The table showed the mean of the FCFO values of men and women before and after the load. In the case of men before, the value is 34.3 htz and after 35.4 htz and in the case of women before, 36.5 htz and after 37.6 htz after loading. The value of the difference preload and postload for women is 1.17 htz and for men 1.08 htz. The standard deviations in both cases before and after loading behave around 4.5 htz and 4.9 htz. It was found that there are significant differences between the average values of FCFO of men and women before and after the load. However, the value of the difference between the values of FCFO of men and women was not significant, these are very similar approximately one unit (1.1 htz) which represents a percentage of 3.2 in the increase of the values after the load. Therefore, for the analysis of the cortical activation of these athletes, the gender differences in the mean values of preload and postload FCFO should be taken as a reference, but not for the percentage increase in the postload values, which is evident in both sexes.

The following table shows the results regarding the significant differences in the FCFO values between the different preparation mesocycles. (Table 7).

**Table 7** - ANOVA of the FCFO before and after the load and the differences according to the general (G) and special-competitive (E-C) preparation mesocycles

| | | Sum of Squares | Df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Preload | Between G and E-C | 33.083 | 1 | 33.083 | 1.405 | .239 |
| | IntraG and E-C | 1930.171 | 82 | 23.539 | | |
| | **Total** | 1963.254 | 83 | | | |
| Afterload | Between G and E-C | 45.936 | 1 | 45.936 | 1.945 | .167 |
| | IntraG and E-C | 1936.976 | 82 | 23.622 | | |
| | Total | 1982.912 | 83 | | | |
| Difference | Between G and E-C | 1.043 | 1 | 1.043 | .047 | .829 |
| | IntraG and E-C | 1828.404 | 82 | 22.298 | | |
| | **Total** | 1829.447 | 83 | | | |

The results of the last column show that there are no significant differences between the average values of preload FCFO of the general preparation and special-competitive mesocycles (F=1.405, p=.239) and there are no significant differences between the values of postload FCFO (F=1.945, p=.067). The same happens with the value of the difference between the FCFO values of mesocycles (F=.047, p=.829).

The FCFO values of the athletes of the running area, before and after the load, in the general and special-competitive stages did not present significant differences, therefore, the track races and their variations given by the pedagogical objectives of the different mesocycles caused an increase of the cortical activation, but with similar values, this also happens thanks to the stimulating character that well-planned training load stimuli possess, as well as to the characteristics of the supercompensation created in this type of athletes studied; this process of adaptation of the organism is produced by the workrest relationship and due to the adequate supply and dosage of the loads.

However, other researches in other sports have found an increase of the loads, but with significant differences between the values of FCFO of the mesosystems, for example, in judo athletes, the greatest difference between before and after the load occurs in the mesosystem of varied special preparation (1.66) and in mesosystem of stabilization of the sport form is found the lowest of such values (1.18). (Mesa and Suárez M, 2017). This evidenced that the results of the FCFO measurements should continue to be particularized according to the type of sport and load stimulus.

## CONCLUSIONS

The results of this research allow the Sport Psychology professional to have reference FCFO values for the interpretation of the Flicker or Fatigtest-USB test, aimed at assessing the levels of cortical activation of the nervous system after the supply of training loads in Athletics athletes of the running modalities, who were subjected to a specific and necessary load stimulus such as running on the track. The increase of the cortical activation after the load was given and the significant differences between the average values of FCFO of men and women could be observed. In turn, it allows a more effective advice to the technical staff about the process of assimilation of the athletes' loads and provides scientific elements for the solidity in the planning of the training loads or in the restructuring of the same.

The fundamental limitation of the study lies in the statistical analysis of the FCFO values in the different mesocycles, specifically in those of special and competitive preparation that were carried out with few data collected from the mentioned mesocycles. This may restrict the possibilities of interpretation of the results obtained in the differences between the mesocycles.

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**Conflict of interests:**
Los autores declaran no tener conflictos de intereses.

**Authors' contribution:**
**Larién López Rodríguez**: Conception of the idea, literature search and review, instrument making, instrument application, compilation of information resulting from the instruments applied, statistic análisis, 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