# High-intensity functional training and quantification by Perceived Exertion Scale in physically active subjects

## Entrenamiento funcional de alta intensidad y su cuantificación por Escala de Esfuerzo Percibido en sujetos físicamente activos

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**Abstract**

The purpose of the study was to determine the relationship between internal and external load in physically active subjects (11 men and 5 women) during a high-intensity functional training session, using different load markers: heart rate, perceived effort and the Edwards index. The maximum heart rate was assessed during a maximal incremental endurance test (Course Navette). Thereafter each participant performed a high-intensity functional training session (Workout of the Day - Pukie), while wearing a heart rate monitor, and the perceived effort was assessed with the 0-10 point scale at 0-min, 10-min, 20-min, and 30-min. Thereafter the Edwards index was calculated. The perceived effort was positively correlated with the heart rate and the Edwards index during the different time-points analyzed (Spearman r = 0,76-0,88; p<0,01). In conclusion, perceived effort can be used as a low-cost and logistically convenient method to assess the internal load experienced by physically active participants during a high-intensity functional training session.

**Keywords:** Physical conditioning, exercise, exercise test (Source: Mesh).

**Resumen**

El propósito del estudio fue determinar la relación entre la valoración del esfuerzo percibido en la sesión (EPES) y el Índice de Edwards (IE) para cuantificar la carga interna basado en la frecuencia cardíaca en el entrenamiento funcional de alta intensidad con sujetos físicamente activos. Estudio descriptivo de tipo correlacional con una muestra por conveniencia conformada por 11 hombres y 5 mujeres. Para valorar la frecuencia cardiaca máxima se utilizó el Test de Course-Navette, posteriormente se realizó el Workout of the Day (WOD) denominado "Pukie" donde cada participante contaba con un pulsómetro Polar H7, que recolectaba la escala de percepción subjetiva de la sesión (0-10), a partir de estos datos se calculó el IE. En el software PSPP (p-valor de 0,05) se llevó a cabo el análisis estadístico donde se manejó un coeficiente correlacional de Spearman para relacionar la EPES y el IE. La relación entre la escala recolectada en los diferentes fragmentos de tiempo post-ejercicio y el IE fue positiva, y el resultado obtenido fue muy significativo (r = 0,76-0,88; p < 0,01). Se puede concluir que la EPES es un método viable, económico y de fácil aplicación para cuantificar la carga interna en el entrenamiento funcional de alta intensidad con sujetos físicamente activos.

**Palabras clave:** Acondicionamiento físico, ejercicio, test de ejercicio (Fuente: Mesh).

## Introduction

High intensity functional training or high intensity functional training (HIFT) is credited with employing high volumes and intensities of training (Teixeira, 2020), which is considered a novel way to perform exercises that test some of the body systems (muscular, nervous, respiratory, skeletal) and challenges people's abilities to complete the mechanical work (Crawford et al., 2018). Next, one of the HIFT training modalities that is currently listed by the training environment as the fastest growing in the world is CrossFit® (Claudino et al., 2018), likewise, this modality requires a high technical level of maximum effort and incomplete recovery between blocks and sessions (Camacho- Cardeñosa et al., 2020).

However, there is a need to control certain variables of the training load by specialized professionals, physical trainers and/or sport scientists (Balaguer & Caparrós, 2021), since there is a continuous challenge regarding the dosage of the training load, due to the possibility of obtaining an effective adaptation of the training, minimizing fatigue, inhibition of performance, overtraining and the occurrence of injuries (Halson, 2014; Jones et al., 2017). Because, within the training process an important factor is the quantification of the internal load (González-Fimbres et al., 2020), however, regarding HIFT there is still a lack of information on the monitoring and control of training methods (Alsamir-Tibana & De Sousa, 2018), therefore, it is necessary to expand scientific knowledge to improve preparation methods (Reche-Soto et al., 2020).

In the context of research one of the ideal topics is to compare, relate and analyze the influence of high intensity training with health and sports performance (Bustos-Viviescas et al., 2021a), from this previous research has contrasted the reliability and applicability of the subjective perception of effort scale in the session to assess the internal load in HIFT, however, this has been carried out mainly with subjects trained in this training modality (Tibana 2018c; Crawford et al., 2018; Tibana 2019a; Tibana 2019b; Falk et al., 2020),

This could be of concern for coaches of this modality, since there is no research to identify whether this method of effort quantification is valid for populations with no previous experience in HIFT.

Therefore, the purpose of the present study is to determine the relationship between the assessment of perceived exertion in the training session and the Edwards Index (1993) with the purpose of quantifying the internal load based on heart rate in high-intensity functional training with physically active subjects.

## Method

### Type of study

Descriptive correlational study. The type of sampling was by convenience. This study is a secondary result of the project called "Analysis of physical condition through weight training and fitness in physically active university students".

### Participants

The sample was composed of 14 men and 6 women who met the following inclusion criteria: 1) Voluntary participation, 2) Being a student of the Bachelor's Degree in Physical Education, Recreation and Sports at the University of Pamplona (Villa del Rosario).

The following students were excluded from the study: 1) Presence of any type of cardiovascular and/or metabolic pathology that could affect performance in the tests, 2) Presence of any pathology or injury that could affect muscle strength and/or have a feeling of discomfort or pain during the evaluation, 3) Be trained in high intensity functional training (experience greater than 3 months).

### Ethical considerations

This study was developed considering the parameters established for research with human beings in the Declaration of Helsinki of the World Medical Association (2013) and the ethical standards established for research in sport and exercise sciences (Harriss et al., 2017). On the other hand, Resolution No. 008430 of 1993, issued by Ministry of Health of the Republic of Colombia, article 11, was considered, classifying this study in the category of major risk, therefore, the participants signed an informed consent, which, contained the objective of the study, the description of the tests, risks, benefits and contributions at the level of training. Likewise, this study has the endorsement of the Ethics and Environmental Impact Committee of the University of Pamplona by means of Act No. 002 of March 4, 2019.

### Procedure

The study was carried out over two days, with a 72-hour break in between to perform the assessments. On the first day, data on height, body mass and cardiorespiratory fitness assessment test were collected by means of the Course-Navette test (Léger & Lambert, 1982). The macro anthropometric data were collected on an empty stomach (6:00 am) and the cardiorespiratory fitness test was performed hours after breakfast (10:00-11:00 am). On the second day, the Workout of the Day WOD "Pukie" was performed to obtain the time to complete the training, which consists of performing 150 burpees in the shortest possible time. It counts as burpee, the exercise that combines the squat and the front support on the floor and the vertical jump (burpee). It should be noted that prior to the development of the tests, a familiarization with the technical execution of the burpee and the scale of subjective perception of effort was performed.

The heart rate was assessed in each period of the test with the Polar H7 heart rate monitor to obtain the maximum heart rate (HRmax), while the exercise intensity during the training session was recorded every 30 burpees, so that the heart rate collected presented 5 data during the training session in order to avoid interfering with the normal development.

In the Course-Navette Test (Léger & Lambert, 1982) the participant must move from one line to another, located 20 meters apart and making the change of direction according to the rhythm imposed by the sound signal, which is progressively increased by means of a recorder, and the test culminates when the examiner considers that the participant is not able to reach the line with the sound signal twice in a row or when he/she retires due to fatigue. The initial speed of the test is 8.5 km/h and will increase by 0,5 km/h every minute.

### Load quantification

### Edwards Method

For the quantification of the training load, the training zone summation method of Edwards (1993) was used:

The equation for the Edwards training load is:

Edwards CE = (duration in zone 1 × 1) + (duration in zone 2 × 2) + (duration in zone 3 ×3) + (duration in zone 4 × 4) + (duration in zone 5 × 5).

Where: zone 1 = 50 - 60% of maximum HR, zone 2 = 60 - 70 % of max HR. Zone 3 = 70 - 80 % max HR. Zone 4 = 80 - 90 % max HR. Zone 5 = 90 - 100 % max HR.

The duration in zone is expressed in minutes, therefore, considering the 5 records obtained during the session, it was decided to average the intensity zone according to the maximum heart rate and multiply it by the total duration in minutes of the Pukie WOD to obtain the Edwards Index.

### Subjective perception of effort scale

To calculate the training load, the method suggested by Foster et al., (2001) was used, which consists of multiplying the total duration by the training intensity; consequently, the modified version of Borg's CR-10 scale of perceived exertion (Borg, 1982) was used to measure the intensity (Table 1).

**Table 1. Subjective perception of effort scale from 0 to 10 points (Borg, 1982)**

| Points | Description |
|---|---|
| 0 | |
| 1 | Extremely weak |
| 2 | Weak |
| 3 | Moderate |
| 4 | |
| 5 | Strong |
| 6 | |
| 7 | Very Strong |
| 8 | |
| 9 | |
| 10 | Extremely strong |

**Source:** Borg CR-10 Scale of Perceived Effort (Borg, 1982).

The evaluation of the subjective perception of the training session was obtained from the participants once the WOD was finished and at 10, 20 and 30 min after it. The question "How hard was your training?" was used, so that the training load was expressed as a single value in arbitrary units (AU), the total time in minutes to perform the WOD was multiplied and multiplied with the arbitrary units obtained to identify the scale of subjective perception of the effort in session.

For example, at the end of the training (0 min) the effort perception scale (EPE) was 9 and the duration of the WOD was 10 minutes, this would give a training load of 90 arbitrary units (AU).

It should be noted that a familiarization with the instrument was carried out prior to the training session.

### Data analysis

The data were analyzed with the statistical package PSPP (Free License), and measures of central tendency and dispersion were calculated.

Subsequently, a Shapiro-Wilk normality test and a Spearman correlation coefficient were applied to establish the correlation between the subjective perception of effort in the session scale (EPES) and the Edwards Index obtained in the Pukie WOD.

A confidence level of 95% and a p-value of 0,05 were considered for the statistical analysis.

On the other hand, the magnitude ranges proposed by Cohen for correlation were considered: trivial ($r \leq 0,1$), small ($0,1 < r \leq 0,3$) moderate ($0,3 < r \leq 0,5$), large ($0,5 < r \leq 0,7$), very large ($0,7 < r \leq 0,9$) and almost perfect ($r \geq 0,9$) and perfect ($r = 1,0$) (Cohen, 1988).

## Results

Table 2 shows that the age of the participants by sex was similar, although men had greater height and body mass than women, which translates into a higher body mass index (BMI).

**Table 2. General characteristics**

| Participants | Age | Body Weigth (kg) | Size (m) | BMI (kg/m$^2$) |
|---|---|---|---|---|
| Men (n = 14) | 22,96±1,91 | 71,61±10,01 | 1,75±0,05 | 23,25±2,79 |
| Woman (n = 6) | 23,50±1,76 | 59,05±12,87 | 1,55±0,03 | 24,69±6,04 |
| Total (n = 20) | 23,12±1,83 | 67,84±12,12 | 1,69±0,10 | 23,68±3,92 |

Table 3 shows the values obtained in the field test and the Pukie WOD. It can be evidenced that the subjective perception of effort in the session (EPES) scale was categorized as "Very strong" according to the Borg's CR-10 scale.

Likewise, the Edwards Index value and the EPES (0 min, 10 min, 20 min and 30 min) showed a non-symmetrical distribution of the data (p<0,05).

**Table 3. Participants' internal load variables**

| | Mean ± DS |
|---|---|
| WOD Time (sec) | 876,90±373,06 |
| HRmax Test (bpm) | 192,70±7,46 |
| HR WOD Pukie total (bpm) | 179,12±9,72 |
| HR WOD Pukie total (%) | 93,04±5,34 |
| Edwards index | 69,76±32,49 |
| EPE (0 min) | 9,00±1,34 |
| EPE (10 min) | 8,65±0,49 |
| EPE (20 min) | 8,40±0,50 |
| EPE (30 min) | 8,10±0,55 |
| EPES (0 min) | 132,34±61,80 |
| EPES (10 min) | 126,18±54,73 |
| EPES (20 min) | 123,09±55,33 |
| EPES (30 min) | 118,70±51,98 |

Next, Table 4 shows that there is a positive and highly significant relationship between the subjective perception of effort scale of the training session and the Edward index (p < 0,01), likewise, the magnitude of the correlation between the Edward index and the subjective perception of effort scale was classified as very high (r = 0,76 to 0,88).

**Table 4. Relationship between variables**

| | Edward Index | |
|---|---|---|
| | Coef. Spearman | Sig. (Bilateral) |
| EPES 0 min post-exercise | 0,76 | 0,00 |
| EPES 10 min post-exercise | 0,79 | 0,00 |
| EPES 20 min post-exercise | 0,88 | 0,00 |
| EPES 30 min post-exercise | 0,84 | 0,00 |

## Discussion

The objective of this study was to determine the relationship between the assessment of perceived exertion in the training session and the Edwards Index for quantifying internal load based on heart rate in high-intensity functional training with physically active subjects.

Among the main findings of this research, a positive and highly significant relationship was evidenced between the Edwards Index for internal load and the subjective perception of effort scale in the training session (r = 0,76-0,88; p < 0,01).

A study developed by Crawford et al., (2018) with recreational athletes inexperienced in high-intensity functional training programs concluded that the subjective perception of exertion scale in the session significantly predicted the Edwards index in two training blocks separated by three weeks (r = 0,818-0,885, p < 0,001).

Recently Tibana et al., (2018c) validated the subjective perception of effort scale in subjects practicing high-intensity functional training finding a positive and highly significant association (r = > 0,8; p < 0,01).

On the other hand, this scale in high-intensity functional training has obtained some significant relationships with workload variables (training heart rate x session duration) (r = 0,426; p = 0,019) (Drake et al., 2017), lactate (r = 0,66; p = 0,005), number of completed repetitions (mechanical work) (r = 0,55; p = 0,026) (Tibana et al., 2019b).

Now, regarding the usefulness of this scale for the evaluation and prescription in high intensity functional training, the literature is still scarce, but several works stand out among which we find the assessment of the internal load during a period of 38 weeks with an elite female athlete in high intensity functional training (Tibana et al., 2019a), and the quantification of the load during 6 weeks of high intensity functional training on physical performance in participants with different training volumes and frequencies (Teixeira et al., 2020).

For example, one method of training load quantification is the training impulse (TRIMP), which suggests combining the elements of training intensity and duration into a single index concept (Foster et al., 2017), and a recent study prepared by Falk et al., (2020) in which they concluded that, EPES is more accurate than the training impulse quantification method (TRIMP) in representing the overall load in HIFT sessions.

In the same way, this scale enables self-regulation of internal load during these high- intensity functional training sessions (Tibana et al., 2019b).

Similarly, another study concluded that it is possible to obtain potential benefits in aerobic capacity, strength, cardiovascular performances and body composition with HIFT training controlled by heart rate variability even with fewer sessions performed at high intensity in physically active subjects (DeBlauw et al., 2021), consequently, accurate quantification of the HIFT training load is essential to determine and examine the relationship between training and physiological adaptations obtained with this type of high-intensity exercise.

Now, regarding the evaluation of the internal load in different WODs we evidenced that it was lower than that obtained in the WOD "Fight Gone Bad" (77,7±4,9) although higher than the WOD "Fran" (19,8±8,4), this can be explained by means of the subjective perception scale of the session and the own duration of each training (9,6±0,5 and 8,7±0,8; 17 minutes and 4 minutes respectively) (Tibana et al., 2018b).

Continuing the comparison of the internal load in WOD according to its modality, it was evidenced that according to the priority of the WOD (time, task/mark and single element) there are higher values in time priority training (14,7±0,7 EPE; p = 0,000) and task/mark priority (14,8±0,5 EPE; p = 0,000) compared to element or single element priority training (9,4±0,8 EPE) (Borg Scale 0-20) (Drake et al., 2017).

Although HIFT is not synonymous with HIIT (High Intensity Interval Training) both share a common factor that they are high intensity (Lu et al., 2021), for this reason, one aspect that may explain the differences between the results of this work and the others mentioned are the characteristics of the WOD from its structure (AMRAP, For Time, among others) or its components/movements (lifting, calisthenics/gymnastics and aerobic), since, an exercise session with the aforementioned movements induces a higher increase in the subjective perception scale of the session, compared to another exercise session (metabolic predominance in calisthenic exercises) (8,0±1,2 EPE) (p<0,02) (Tibana et al., 2018a).

Following, the analysis of the WOD "Pukie" was applied in this research where a single calisthenic element (Burpee) was performed, which is an exercise that improves endurance to fatigue (Maté-Muñoz et al., 2018) and cardiorespiratory capacity (Mangine et al., 2020). Likewise, this is a high-intensity exercise that is complicated to quantify and qualify, given the wide technical variation, sequence and morphological characteristics of the athletes (Bingley et al., 2019).

For such reason, it is advisable that in these trainings that include mainly calisthenic/gymnastic exercises, the external load be prescribed from the time of the stimulus and the recovery of the physical effort (Machado et al., 2018), in addition, it is advisable that the frequency of training and the exercises assigned during the training be prescribed with respect to the functional capacity of the participant (Machado et al., 2017).

Experience in high intensity functional training can also influence the subjective perception of effort, authors such as Gomes et al., (2020) compared the RPE of the AMRAP WOD "Cindy" between an experienced group and a non-experienced group, concluding that the cardiovascular responses were similar (93,1±0,6 %HRmax vs 93,0± 0,8 %HRmax) but with a slightly higher perception of effort in the non-experienced (7,5±0,3 RPE vs 8,1±0,3 RPE).

A recent research evaluated the internal load of three WOD For Time (Angie plus, Grace and Karen) performed continuously and uninterruptedly by subjects trained in HIFT, this work evidenced that the subjective perception ranged between in women an RPE of 7,17±0,71 AU in intermediate and 7,33±1,15 AU in advanced, while in men the RPE was 7,67±0,33 AU for intermediate and 7,67±0,47 AU in advanced, finding that when WODs of different modalities are combined, very hard efforts are obtained for subjects conditioned in HIFT (Bustos-Viviescas et al., 2021b).

Among the limitations of this work we can highlight the small sample of participants, likewise, we could not compare the internal load for the same WOD between various groups of experience (advanced vs recreational vs non-practitioners), because it would be interesting for decision making in terms of exercise prescription in high-intensity functional training. In addition, current evidence suggests that load quantification by means of the perceived exertion scale is valid in HIFT-

trained subjects, and further research is required for its applicability in non-experienced subjects.

## Conclusions

The scale of subjective perception of effort in a training session is a valid method to quantify the internal load in high-intensity functional training sessions in physically active subjects who have no experience in these types of training, making it an economical and easily applicable tool to keep track of the periodization in this type of fitness training.

## References

Alsamir-Tibana, R. & De Sousa, N. (2018). Are extreme conditioning programmes effective and safe? A narrative review of high-intensity functional training methods research paradigms and findings. BMJ Open Sport Exerc Med, 4 (1), 1–10. DOI: https://doi.org/10.1136/bmjsem-2018-000435

Asociación Médica Mundial (2013). *Declaración de Helsinki de la AMM-Principios éticos para las investigaciones médicas en seres humanos*. DOI: https://doi.org/10.17126/joralres.2013.009

Balaguer Cabeza, O., & Caparrós Pons, T. (2021). Cuantificación de carga externa e interna en fútbol masculino semiprofesional (External and Internal Load Quantification in a semi-professional male football team). *Cultura, Ciencia Y Deporte, 16* (48), 275-284. DOI: https://doi.org/10.12800/ccd.v16i48.1750

Bingley, S., Witchalls, J., McKune, A. & Humberstone, C. (2019). The Burpee Enigma. *Literature Review, 22* (2), S78, DOI: https://doi.org/10.1016/j.jsams.2019.08.079

Borg, G. (1982). *A category scale with ratio properties for intermodal and interindividual comparison*. In: Geissler H-G, Petzold P, eds. Psychophysical judgment and the process of perception. Berlin: VEB DeutscherVerlag der Wissenschaften, 25–34.

Bustos-Viviescas, B. J., Duran-Luna, L. A., Merchan Osorio, R. D., Ortega Parra, A. J., Acevedo-Mindiola, A. A., & Garcia Yerena, C. E. (2021a). Entrenamiento funcional de alta intensidad: asociación de la grasa corporal con el fitness cardiorrespiratorio. *Revista Cubana de Medicina Militar, 50* (2), e0210910. Recuperado de: http://www.revmedmilitar.sld.cu/index.php/mil/article/view/910/727

Bustos-Viviescas, B. J., Delgado-Molina, M. C., & Rolon, N. A. (2021b). Evaluación de la carga interna en una sesión de entrenamiento funcional de alta intensidad: estudio de casos múltiples. *Revista Cubana de Ortopedia y Traumatología, 35* (1). Recuperado de http://www.revortopedia.sld.cu/index.php/revortopedia/article/view/325/246

Camacho-Cardeñosa, A., Timón, R., Camacho-Cardeñosa, M., Guerrero-Flores, S., Olcina, G., & Marcos-Serrano, M. (2020). Six-months CrossFit training improves metabolic efficiency in young trained men (Seis meses de CrossFit mejora la eficiencia metabólica en jóvenes entrenados). *Cultura, Ciencia Y Deporte, 15* (45), 421-427. DOI: https://doi.org/10.12800/ccd.v15i45.1519

Claudino, J. G., Gabbett, T. J., Bourgeois, F., Souza, H. S., Miranda, R. C., Mezêncio, B., Soncin, R., Cardoso Filho, C. A., Bottaro, M., Hernandez, A. J., Amadio, A. C. & Serrão, J. C. (2018). CrossFit Overview: Systematic Review and Meta-analysis. *Sports Medicine - Open, 4* (1), 11. DOI: https://dx.doi.org/10.1186%2Fs40798-018-0124-5

Crawford, D. A., Drake, N. B., Carper, M. J., DeBlauw, J., & Heinrich, K. M. (2018). Validity, Reliability, and Application of the Session-RPE Method for Quantifying Training Loads during High Intensity Functional Training. *Sports (Basel, Switzerland), 6* (3), 84. DOI: https://doi.org/10.3390/sports6030084

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2.ª ed). Hillsdale, NJ: Lawrence Erlbaum Associates. Disponible en: http://www.utstat.toronto.edu/~brunner/oldclass/378f16/readings/CohenPower.pdf

DeBlauw, J. A., Drake, N. B., Kurtz, B. K., Crawford, D. A., Carper, M. J., Wakeman, A., Heinrich, K. M. (2021). High-Intensity Functional Training Guided by Individualized Heart Rate Variability Results in Similar Health and Fitness Improvements as Predetermined Training with Less Effort. *J. Funct. Morphol. Kinesiol.,* 6, 102. DOI: https://doi.org/10.3390/jfmk6040102

Drake, N., Smeed, J., Carper, M. & Crawford, D. (2017). Effects of ShortTerm CrossFit™ Training: A Magnitude-Based Approach. *JEPonline, 20* (2), 111-133. Recuperado de: https://www.asep.org/asep/asep/JEPonlineAPRIL2017_Drake_Crawford.pdf

Edwards, S. (1993). *The Heart Rate Monitor Book*. Sacramento, CA: Fleet Feet Press.

Falk Neto, J. H., Tibana, R. A., de Sousa, N., Prestes, J., Voltarelli, F. A. & Kennedy, M. D. (2020). Session Rating of Perceived Exertion Is a Superior Method to Monitor Internal Training Loads of Functional Fitness Training Sessions Performed at Different Intensities When Compared to Training Impulse. *Frontiers in physiology, 11*, 919. DOI: https://doi.org/10.3389/fphys.2020.00919

Foster, C., Florhaug, J., Franklin, J., Gottschall, L., Hrovatin, L., Parker, S., Doleshal, P. & Dodge, C. (2001). A new approach to monitoring exercise training. *J. Strength Cond. Res., 15* (1), 109-115. Recuperado de: https://pubmed.ncbi.nlm.nih.gov/11708692/

Foster, C., Rodriguez-Marroyo, J. A. & de Koning, J. J. (2017). Monitoring Training Loads: The Past, the Present, and the Future. *International journal of sports physiology and performance, 12* (Suppl 2), S22–S28. DOI: https://doi.org/10.1123/ijspp.2016-0388

Gomes, J. H., Mendes, R. R., Franca, C. S., Da Silva-Grigoletto, M. E., Pereira da Silva, D. R., Antoniolli, A. R., de Oliveira E Silva, A. M. & Quintans-Júnior, L. J. (2020). Acute leucocyte, muscle damage, and stress marker responses to high-intensity functional training. *PloS one, 15* (12), e0243276. DOI: https://doi.org/10.1371/journal.pone.0243276

González-Fimbres, R. A., Ramírez-Siqueiros, M. G., Vaca-Rubio, H., Moueth-Cabrera, M. T. & Hernández-Cruz, G. (2020). Relationship Between Post-Exercise hrv and Internal Training Load in Triathletes. *Revista Internacional de Medicina y Ciencias de la Actividad Física y el Deporte, 20* (77), 87-102. DOI:10.15366/rimcafd2020.77.006

Halson, S. (2014). Monitoring Training Load to Understand Fatigue in Athletes. *Sport Med., 44* (2), s139–47. DOI: https://doi.org/10.1007/s40279-014-0253-z

Harriss, D., Macsween, A. & Atkinson, G. (2017). Standards for Ethics in Sport and Exercise Science Research: 2018 Update. *Int J Sports Med., 38* (14), 1126-1131. doi: https://doi.org/10.1055/s-0043-124001

Jones, C. M., Griffiths, P. C. & Mellalieu, S. D. (2017). Training Load and Fatigue Marker Associations with Injury and Illness: A Systematic Review of Longitudinal Studies. *Sports Med, 47* (5), 943-974. DOI: https://doi.org/10.1007/s40279-016-0619-5

Leger, L. A., & Lambert, J. (1982). A maximal multistage 20-m shuttle run test to predict VO2 max. *Eur J Appl Physiol Occup Physiol, 49* (1), 1-12. DOI: https://doi.org/10.1007/bf00428958

Lu, Y., Wiltshire, H. D., Baker, J. S., & Wang, Q. (2021). The Effects of Running Compared with Functional High-Intensity Interval Training on Body Composition and Aerobic Fitness in Female University Students. *International journal of environmental research and public health, 18* (21), 11312. DOI: https://doi.org/10.3390/ijerph182111312

Machado, A. F., Baker, J. S., Figueira Junior, A. J., & Bocalini, D. S. (2017). High-intensity interval training using whole-body exercises: training recommendations and methodological overview. *Clinical Physiology and Functional Imaging*. doi: 10.1111/cpf.12433

Machado, A. F., Miranda, M. L., Rica, R. L., Figueira Junior, A. & Bocalini, D. S. (2018). Bodyweight high-intensity interval training: a systematic review. *Revista Brasileira de Medicina do Esporte, 24* (3), 234-237. DOI: https://doi.org/10.1590/1517-869220182403176199

Mangine, G. T., Tankersley, J. E., McDougle, J. M., Velazquez, N., Roberts, M. D., Esmat, T. A., VanDusseldorp, T. A. & Feito, Y. (2020). Predictors of CrossFit Open Performance. *Sports, 8*, 102. DOI: https://doi.org/10.3390/sports8070102

Maté-Muñoz, J. L., Lougedo, J. H., Barba, M., Cañuelo-Márquez, A. M., Guodemar-Pérez, J., García-Fernández, P., Lozano-Estevan, M., Alonso-Melero, R., Sánchez-Calabuig, M. A., Ruíz-López, M., de Jesús, F. & Garnacho-Castaño, M. V. (2018). Cardiometabolic and Muscular Fatigue Responses to Different CrossFit® Workouts. *Journal of Sports Science & Medicine, 17* (4), 668-679. Disponible en: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6243628/pdf/jssm-17-668.pdf

Reche-Soto, P., Cardona, D., Díaz, A., Gómez-Carmona, C. & Pino-Ortega, J. (2020). ACELT and PLAYERLOAD: Two Variables to Quantify Neuromuscular Load. Revista Internacional de Medicina y Ciencias de la Actividad Física y el Deporte, 20 (77), 67-183. DOI:10.15366/rimcafd2020.77.011

Teixeira, R. V. (2020). *Carga interna de treinamento, desempenho e assimetria entre membros inferiores em praticantes de treinamento funcional de alta intensidade* (Tesis de maestría). Universidade Federal do Rio Grande do Norte: Brasil.

Teixeira, R. V., Batista, G. R., Mortatti, A. L., Dantas, P. & Cabral, B. (2020). Effects of Six Weeks of High-Intensity Functional Training on Physical Performance in Participants with Different Training Volumes and Frequencies. *International journal of environmental research and public health, 17* (17), 6058. DOI: https://doi.org/10.3390/ijerph17176058

Tibana, R., Almeida, L., de Sousa Neto, I. de Sousa, N., de Almeida, J., de Salles, B., Bentes, C., Prestes, J., Collier, S. & Voltarelli, F. (2018a). Extreme Conditioning Program Induced Acute Hypotensive Effects are Independent of the Exercise Session Intensity. *International Journal of Exercise Science, 10* (8), 1165-1173. DOI: https://doi.org/10.1590/1517-869220182402160028

Tibana, R., de Sousa, N., Prestes, J. & Voltarelli, F. (2018b). Lactate, Heart Rate and Rating of Perceived Exertion Responses to Shorter and Longer Duration CrossFit® Training Sessions. *Journal of Functional Morphology and Kinesiology, 3* (4), 60. DOI: https://doi.org/10.3390/jfmk3040060

Tibana, R. A., de Sousa, N., Cunha, G. V., Prestes, J., Fett, C., Gabbett, T. J. & Voltarelli, F. A. (2018c). Validity of Session Rating Perceived Exertion Method for Quantifying Internal Training Load during High-Intensity Functional Training. *Sports (Basel, Switzerland), 6* (3), 68. DOI: https://doi.org/10.3390/sports6030068

Tibana, R. A., Sousa, N. M. F., Prestes, J., Feito, Y., Ernesto, C. & Voltarelli, F. A. (2019a). Monitoring Training Load, Well-Being, Heart Rate Variability, and Competitive Performance of a Functional-Fitness Female Athlete: A Case Study. *Sports*, 7, 35. DOI: https://doi.org/10.3390/sports7020035

Tibana, R. A., Manuel Frade de Sousa, N., Prestes, J., da Cunha Nascimento, D., Ernesto, C., Falk Neto, J. H., Kennedy, M. D. & Azevedo Voltarelli, F. (2019b). Is Perceived Exertion a Useful Indicator of the Metabolic and Cardiovascular Responses to a Metabolic Conditioning Session of Functional Fitness?. *Sports, 7* (7), 161. DOI: http://dx.doi.org/10.3390/sports7070161