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Original Research

The Training Load Indices in Professional Soccer Players: Pre-Season Index of Overall Demand

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ABSTRACT

The index of overall demand as an output of the training factors (volume, intensity and density), is an all-around index for assessment of training loading pattern. The aim of this study was to investigate the index of overall demand in Iranian premier league professional soccer players during pre-season phase of annual plan. Nineteen professional soccer players (age mean and SD: 25.1 ± 0.6 years, height mean and SD: 176.5 ± 0.78 centimetres, weight mean and SD: 80.5 ± 8.54 kilograms) belonging to an Iranian professional soccer team, participated in this study. All players included participated in the pre-season. For this longitudinal study, training load data were collected over a 4-week period during pre-season. The GPS system with the 15 Hz MEMS was used in all the training sessions. Additionally, flashing RED light was used to track HR. Higher training duration were showed in the microcycle 1 compare to the microcycle 4. The relative as well as the absolute volume of the training decreased from the first to the fourth microcycles, On the contrary, the partial and overall training intensity increased during the pre-season phase. We showed no significant changes in the relative and the absolute density of the training. The index of overall demand as an all-around index of training loading pattern decreased from the first to the third microcycles, while it increased in the fourth microcycle. According to our findings the volume, intensity and density of training are three key factors in training and optimal adaptation to these components leads to the improvement of performance. The index of overall demand as a training main variable reflects the actual training load. The index of overall demand, help coaches to manage the training load of athletes.

Keywords: Training load indices, Professional soccer players, Index of overall demand

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INTRODUCTION

The training load indices such as volume, intensity and density are the key variables of the training programs [1]. In fact, the efficiency of a training program results from the manipulations of these variables. Training variables should be handled according to the physiological requirements of the training goal. Thus, when designing the training program, it must be first decided which variable to emphasize to meet the performance goal. The manipulations of these variables will establish distinct training-induced outcomes that can significantly affect the athlete's performance [2]. The training program should emphasize training variables in proportion to the athlete's needs [3].

Specifically, this index is derived from the overall intensity, absolute density, and absolute volume of training. Although determining the relative and absolute volume, intensity, and density of training can be useful for establishing effective training sessions, index of overall demand reflects the actual training load [4].

The simple definition of volume is the total quantity of activity performed in training. The volume of training incorporates the time or duration of training, the distance covered or the tonnage in strength training, the number of repetitions of an exercise or technical element an athlete performs in a given time. Volume can also be considered the sum of work performed during a training session or phase. Two types of volume are the absolute and relative. The absolute volume is represented by the total volume of work that the individual performs, whereas the relative volume represents the total amount of time (duration) for a training session [5].

Intensity is another important training variable. Intensity [6, 7] defined in relation to power output, opposing force, or velocity of progression. According to this definition, the more work the athlete performs per unit of time, the higher the intensity [8-10]. The heart rate response to training can be a useful tool for prescribing and evaluating training intensities. Heart rate may be used to compute the intensity of training as an expression of the total demand experienced during a training session. There are two types of intensities: absolute intensity, which corresponds to the percentage of maximum necessary to perform the exercise, and relative intensity, which measures the intensity of a training session or micro cycle, given the absolute intensity and the total volume of work performed in that period.

The frequency or density of training can be defined as the distribution of training sessions [10]. The frequency of training can be thought of as a relationship that is expressed in units of time between working and recovery phases of training. Thus the greater the frequency of training, the shorter the recovery time between working phases of training. When increasing the frequency of training, a balance must be established between work and recovery to avoid inducing excessive levels of fatigue or exhaustion, which can lead to overreaching and overtraining termed the relative density. The relative density is the percentage of work volume the athlete performs compared with the total volume within the training session [11]. Although the relative density has some value, the absolute density of training is more important. The absolute density can be defined as the ratio between the effective works an athlete performs. The absolute density or effective work is calculated by subtracting the volume of rest intervals from the absolute volume. Because training frequency is a factor of intensity, determining the relative and absolute density of training can be useful for establishing effective training sessions [12].

Halson et al. showed that appropriate monitoring of training load can provide important information to athletes and coaches [13]. In addition, Anta and Esteve-Lanao demonstrated that quantification of the training loading indices can be an easy tool for the coach to compare designed versus reported training load both daily and on a cumulative basis [14]. Caoimhe et al. revealed that monitoring of the training loading indices may be a more sensitive measure for detecting a player at a higher risk of an injury [15].

Although each of the relative and absolute variables of training such as volume, intensity and density can represent a portion of the training load, the index of overall demand is an all-around index for assessment of training loading pattern. In addition, the index of overall demand importance becomes more apparent

when overreaching and overtraining are considered in the long-term training program [16, 17]. Therefore, the aim of this study was to investigate the index of overall demand in Iranian premier league professional soccer players during pre-season phase of annual plan.

MATERIAL AND METHODS

Participants

Nineteen professional soccer players (age mean and SD: 25.1 ± 0.6 years, height mean and SD: 176.5 ± 0.78 centimetres, weight mean and SD: 80.5 ± 8.54 kilograms) belonging to an Iranian professional soccer team, participated in this study. All players included participated in the pre-season. All analysed players participated in 80 training sessions. Participants were familiarised with the training protocols prior to study. This study was conducted according to the requirements of the Declaration of Helsinki and was approved by the University of Isfahan research ethics committee.

Data collection Procedures

Data were collected all over the course of different microcycles. All analysed microcycles included consecutively training sessions. Day-off only occurred in the last days of the week. Although other weeks also fit the descriptions provided, all weeks selected met the criteria for participants, meaning that they completed all training sessions during the chosen weeks. This study did not influence or alter the training sessions in any way. Training data were collected at the soccer club's outdoor training pitches. Data was analysed per days of the week (i.e., day-1, day-2… and day-7).

For this longitudinal study, training load data were collected over a 4-week period during pre-season. For the purposes of the present study, all training sessions conducted during the main team sessions were considered. Data from rehabilitation or recuperation was excluded. The duration of the training sessions includes the warm-up, main and cool-down phases, plus stretching. All training programs were planned by the coach and staff, and the researchers only standardized the first 20 min and the final 15 min (i.e., before and after each training session) for research procedures. The weeks were chosen based on similar characteristics in pre-season periods. The characterization of weekly training microcycles analysed is described in Figure 1.

Training load assessment

The GPS system with the 15 Hz MEMS (GPSPORTS systems Pty Ltd, model: SPI HPU, Australia) was used in all the training sessions. The GPS size dimensions were (74 mm × 42 mm × 16 mm; Image 1). Additionally, it is water- resistant and uses infra- red and weighed 56 g for data transmission. The validity and reliability of the device have been confirmed by Tessaro and Williams (2018) study [18].

Image 1. The GPS system with the 15 Hz MEMS

Flashing RED light was used to track HR. We placed each unit perpendicular to the bag and made sure the logo on the unit was facing backwards and the RED light was on. In the GPS the following variables were

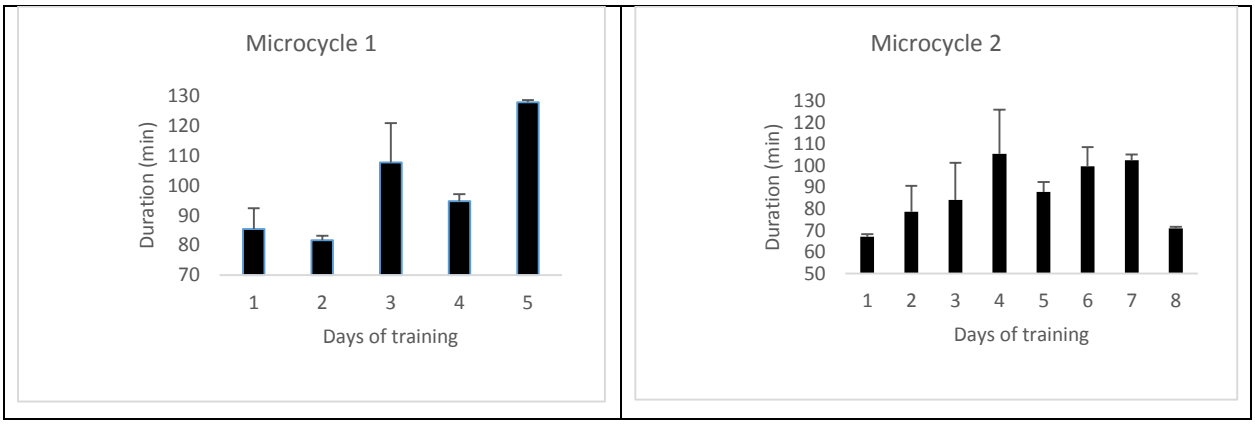
selected: HRmax and HRavg. Then, weekly HRmax (wHRmax) and HRavg (wHRavg) were calculated by the average value for each microcycles, sessions as well as each players, respectively. The way this information was recorded was similar to previous studies [19, 20].
The variables of the training session loads were calculated by using the series of equations proposed by Iliuta and Dumitrescu [18]. For calculating the partial and overall intensity following equations were used:
Partial intensity= (HRp×100)/HRmax.
Overall intensity=Σ(Partial intensity×Volume of exercises)/Σ(Volume of exercises). The absolute volume is represented by the total volume of players work, whereas the relative volume represented the total amount of time (duration) for a training session. The relative as well as the absolute density calculated as follows:
Relative density= (Absolute volume ×100)/Relative volume.
Absolute density= [(Absolute volume–Volume of rest intervals) ×100]/Absolute volume.
The index of overall demand (IOD) calculated with the equation proposed by Iliuta and Dumitrescu as follow 21]:
Index of overall demand (IOD) = (Overall intensity×Absolute density×Absolute volume)/10000.

Statistical Analysis

Data were analysed using the SPSS version 26 (SPSS Inc., Chicago, IL) for Windows statistical software package. Initially, descriptive statistics were used to characterize the sample. Shapiro-Wilk and Levene tests were conducted to determine normality and homoscedasticity, respectively (Shapiro-Wilk > 0.05). The repeated measures with the Bonferroni post-hoc test to compare variables for days of the week. This process was repeated to also allow a comparison between all microcycles. The results are significant for a $p \leq 0.05$.

RESULTS

The daily training volume variations as well as the weekly min, max, mean and standard deviation of the training duration along the pre-season microcycles presented in the figure 1 and table 1, respectively. Higher training duration means were showed in the microcycle 1 compare to the microcycle 4 (Table 1).



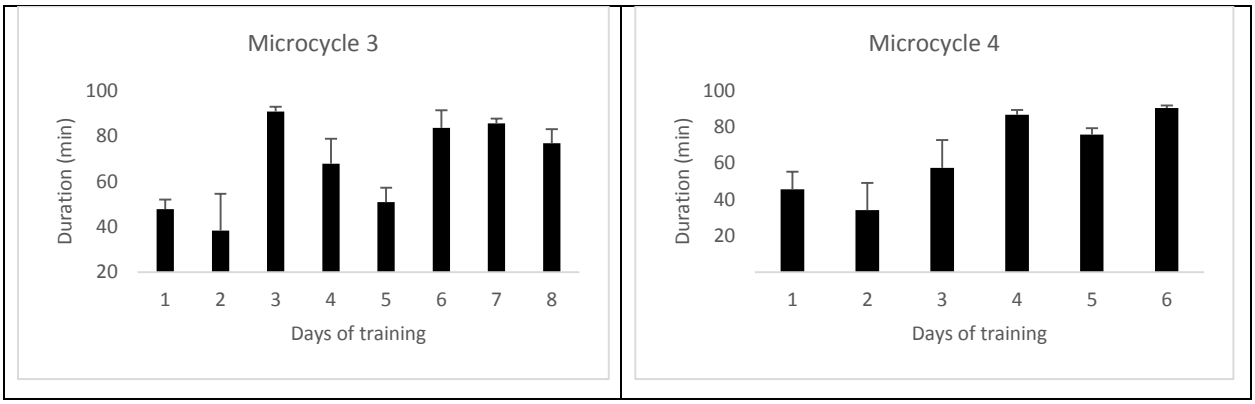


Figure 1. The daily training volume variations during pre-season microcycles.

Table 1. Training duration of the pre-season phase

Statistics / Microcycles	Minimum	Maximum	Mean	Std. Deviation
Micro cycle 1	81.72	127.84	99.4906	18.77144
Micro cycle 2	67.08	105.53	87.0299	14.54381
Micro cycle 3	38.41	90.88	67.7617	19.74929
Micro cycle4	34.30	90.47	65.1075	22.85907

The relative as well as the absolute volume of the training decreased from the first to the fourth microcycles (Figure 2), On the contrary, the partial and overall training intensity increased during the pre-season phase (Figure 3).

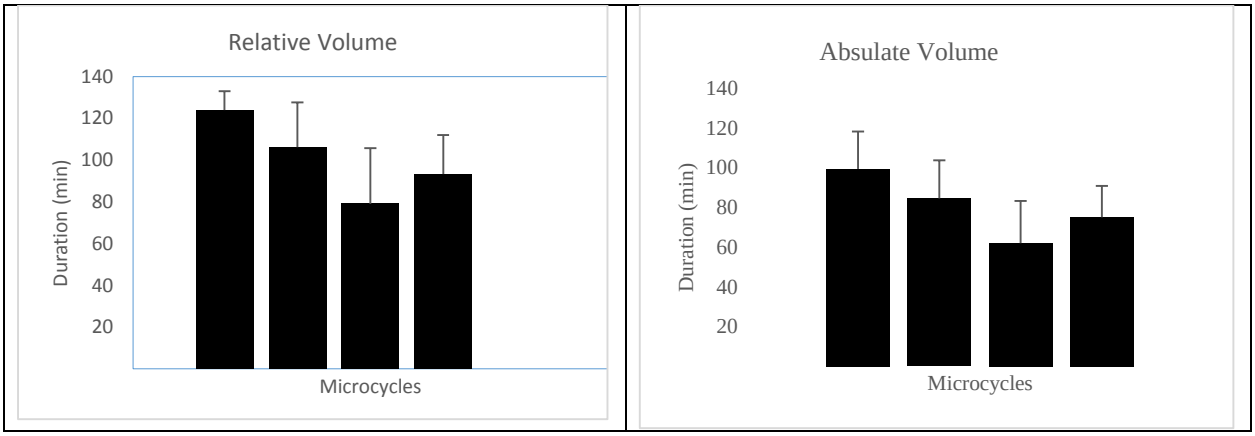


Figure 2. The relative and absolute volume of training during pre-season phase

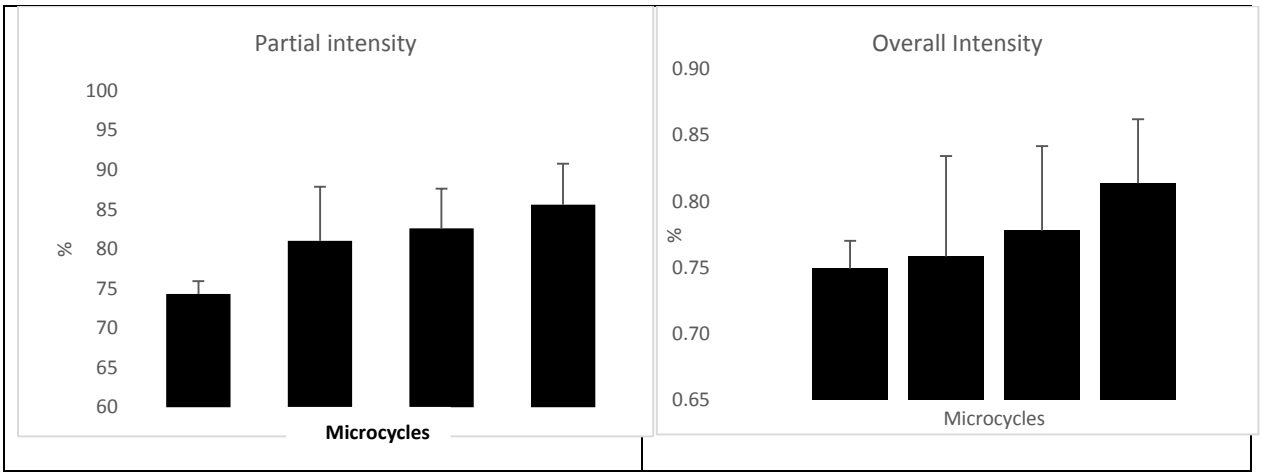


Figure 3. The relative and absolute volume of training during pre-season phase

We showed no significant changes in the relative and the absolute density of the training during pre-season phase of the soccer players (Figure 4).

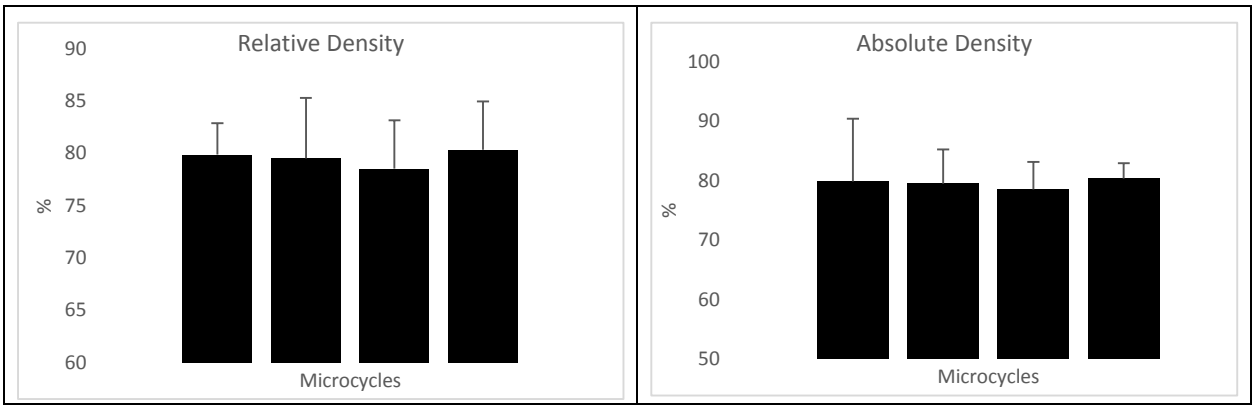


Figure 4. The relative and absolute density of training during pre-season phase

The index of overall demand as an all-around index of training loading pattern decreased from the first to the third microcycles, while it increased in the fourth microcycle and was almost equal to the second microcycle (Figure 5).

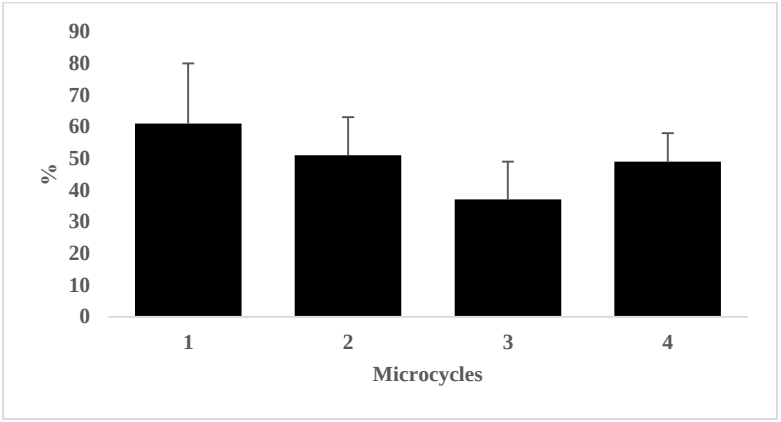


Figure 5. The index of overall demand of training during pre-season phase

DISCUSSION

According to the findings of this research, the overall intensity of training increases significantly during the training microcycles. Also, relative and absolute density has faced a significant increase in the fourth microcycle despite the decrease in the first to third microcycles. Among the other results of this study, we can mention the volume that the relative and absolute volume in the pre-season period was associated with a downward trend in the first to third microcycle, which increased in the fourth microcycle. Also, the index of overall demand decreased from the first to third period, but increased again in the fourth microcycle.

Any physical activity can lead to many changes including anatomical, physiological, biochemical and psychological. All these changes require the implementation of a training program with important training indicators that must be observed in the implementation. In designing a pre-season training program, considering the goals of the training and achieving success are the vital elements. It is also important to know about how athletes progress training variables to increase performance [22, 23].

Of the training variables, training volume is very important in professional athletes. For elite athletes, there are no shortcuts to the many exercises they must do. In the planning of training program, performing high-volume training results in certain physiological results, without which athletes cannot achieve the desired adaptations [24, 25]. The researchers reported that the high volume of training is the most important variable in the preparation as well as the pre-season phases in endurance sports. This characteristic plays a significant role in technical and tactical skills [26]. Fiskersfrand et al. (2004) reported that between 1970 to 2001, training volume in Norwegian international rowers increased by 22% [27]. Pugliese et al. (2015) concluded that in skilled swimmers, increasing training volume may lead to improved peak $\dot{V}O2$ and performance in middle to long distances [28].

Increasing the training volume lead to improved recovery time. It should be noted that an excessive increase in training volume can lead to injury and decrease in muscle efficiency [29-31]. Therefore, the best way to increase the volume of training is to increase the number of training sessions per week according to the athlete capacity [32, 33]. Siler reported that endurance athletes achieve high performance using high-volume and well controlled training intensity throughout the training microcycles [34]. On the other hand, Asghari et al. reported that the training with high intensity and low volume is more efficient than the low intensity and high volume training in terms of RER, VO2peak , Lacmax variables [35]. Considering the time limit in the training program, this model may be a good alternative to long-term models.

Another important result of this study was related to the partial and overall intensity of the training. The intensity of training depends on the strength of nerve impulses of the athlete during training [22, 36, 37]. The training intensity changes according to the characteristics of the sport [38]. One of the intensity evaluation methods is the classification of the energy systems involved in producing energy. In team sports such as soccer, aerobic and anaerobic systems produce energy due to the rapid change of the rhythm of the game and the intensity variation of the activity [39]. Hence, various physiological adaptations occur in athletes. Therefore, athletes control the training intensity based on these adaptations.

Additionally, the distribution of training intensity in sports is different, which shows that training intensity depends not only on the volume of training, but also on the technique of its distribution. Guellich et al. showed although rowing competitions are among the shortest in terms of duration (7-8 minutes), international rowers perform 85-90% of their training at moderate intensity and only 3 percentage of their exercises are performed with high intensity [40]. Burgess et al. rep, orted that distribution of exercise intensity is an important aspect of the exercise process. In fact, proper distribution of intensity prevents inconsistency in exercises and optimizes sports performance [41]. However, Laursen et al. reported that combining high-intensity training with low-intensity lead to greater improvements in endurance performance. This seems to be largely due to the improved ability of the skeletal muscle involved in aerobic ATP production [42]. Long-term, low-intensity training facilitates aerobic adaptation. However, the intensity should be sufficient to promote the athlete's autonomic balance, recovery, and health. Some important molecular signals induced by different forms of training include AMPK and calcium-calmodulin

kinase, which are likely to be activated in response to intense and prolonged exercise, respectively. Both of these signals in skeletal muscle cause the development of aerobic muscle phenotype [42].
In the longitudinal study we showed that there is an inverse relationship between volume and intensity of training. This relationship follows the 2nd degree non-linear function in which the training volume is the dependent and the training intensity is the independent variable [43]. It should be noted that low-intensity exercises lead to sufficient adaptation despite slowing down the progress. At the same time, in intense training, despite the faster progress, the establishment of lasting adaptations is less. Therefore, determining the relationship between exercise volume and intensity is of particular importance. Therefore, a high volume of low-intensity training in the pre-season can provide the basis for intense training and increase performance stability in the rest of the season [44-46].
Training density deals with the relationship between training and rest time. Appropriate training density can guarantee the absence of fatigue and overtraining [22]. It should be noted that rest intervals between training sessions directly depend on the intensity, duration, athlete's physical fitness, and training phase. The higher the exercise intensity, the longer the recovery time [32, 47, 48]. In addition, exercise is a function of the three main components of intensity, volume and density. The coach considers the changes of these components as an index of overall demand, based on the training phase and the adaptation of the athletes [49-51]. Thus, the index of overall demand as an output of the training factors, is the actual load of training and in the long term it is fundamental in terms of organism physiological and pathological responses such as overreaching and overtraining. In the present study, the index of overall demand had the highest percentage in the first microcycle and gradually this percentage decreased until the third cycle and increased in the fourth cycle. These sinusoidal changes can imply the improvement of performance.

CONCLUSION

Our findings showed that the volume, intensity and density of training are three key factors in training and optimal adaptation to these components can lead to the improvement of the athlete's fitness. The index of overall demand as a training main variable reflects the actual training load. The index of overall demand, help coaches to manage the training load of athletes.

Author Contributions:

Conceptualization, methodology, AF, MM; formal analysis, FAA, AF, MM; investigation, FAA; resources, FAA, AF; data curation, AF, FAA, DK, MM; writing—original draft preparation, MM, AF, FAA; writing—review and editing, MM, AF, DK; supervision, DK, AF; project administration, AF. All authors have read and agreed to the published version of the manuscript.

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The current research protocol was approved by the ethics committee of the Research Institute of Physical Education and Sports Sciences.

Data Availability Statement:

Data will be available at request.

Conflict of interest

The authors declare that there is no conflict of interest in the present study and that the present study was carried out at the expense of the authors.

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شاخص های بار تمرینی در بازیکنان حرفه‌ای فوتبال: شاخص تقاضای کلی پیش از فصل

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چکیده

هدف: شاخص فشار کلی به عنوان خروجی متغیرهای تمرینی (حجم، شدت و چگالی)، شاخص همه جانبه برای ارزیابی الگوی باردهی تمرین است. هدف از این مطالعه بررسی شاخص فشار کلی بازیکنان فوتبال حرفه‌ای لیگ برتر ایران در مرحله پیش‌فصل برنامه سالانه بود.

روش: ۱۹ بازیکن حرفه‌ای فوتبال (میانگین سنی و انحراف معیار: ۰/۶ ± ۲۵/۱ سال، میانگین قد و انحراف معیار: ۰/۷۸ ± ۱۷۶/۵ سانتی‌متر، میانگین وزن و انحراف معیار: ۸/۵۴ ± ۸۰/۵ کیلوگرم) در این مطالعه شرکت کردند. در این مطالعه طولی، داده های بار تمرین در یک دوره ۴ هفته ای در طول پیش فصل جمع آوری شد. در تمامی جلسات تمرینی از سیستم GPS با MEMS 15 هرتز استفاده شد. علاوه بر این، چراغ قرمز چشمک زن برای ردیابی ضربان قلب استفاده شد.

یافته‌ها: مدت زمان تمرین در میکروسیکل اول نسبت به میکروسیکل چهارم بیشتر بود. حجم نسبی و مطلق تمرین از میکروسیکل اول تا چهارم کاهش یافت، در مقابل، شدت نسبی و کلی تمرین در طول دوره افزایش یافت. در فاز پیش فصل هیچ تغییر معنی داری در تراکم نسبی و مطلق تمرین دیده نشد. در نهایت، شاخص فشار کلی به عنوان شاخص همه جانبه الگوی باردهی تمرینی از میکروسیکل اول تا سوم کاهش و در میکروسیکل چهارم افزایش یافت.

نتیجه‌گیری: بر اساس یافته‌های تحقیق حجم، شدت و تراکم تمرین سه عامل کلیدی در تمرین هستند و سازگاری بهینه با این مؤلفه‌ها منجر به بهبود عملکرد ورزشی می‌شود. شاخص فشار کلی به عنوان متغیر اصلی تمرین، بار واقعی تمرین را منعکس می کند. شاخص فشار کلی به مربیان کمک می کند تا بار تمرینی ورزشکاران را مدیریت کنند.

کلیدواژه ها: شاخص های بار تمرینی، بازیکنان حرفه ای فوتبال، شاخص فشار کلی