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Original Research

The Effects of Using Double Density Spiked Shoes and Regular Spiked Shoes on VO_2Max Values and Physiological Energy Economy in Endurance Runners

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ABSTRACT

Today, many people in society choose running as a general or special activity in order to improve their physical and physiological capabilities. Choosing the right shoes in endurance running can have a great impact on the athlete's performance. Physiological energy economy and maximal oxygen consumption are of particular importance not only among runners but among all athletes. Therefore, the purpose of this research is to compare VO_2 Max values and physiological energy economy when using double density spike shoes compared to simple spike shoes. Current study is semi experimental. The statistical sample of the current study includes 30 runners from Ardabil city, who were organized in a group, and the parameters of physiological energy economy, maximum oxygen consumption, resting heart rate, systolic blood pressure and 1600 meters running record were measured during running with both double density spiked shoes and regular spiked shoes. Also, to analyze the data, the analysis of variance test with repeated measurements was used at a significance level of P=0.05. The results of the present study showed not statistically significant difference in the values of maximum oxygen consumption, heart rate and 1600 meters running record with two simple and double density shoes after performing 1600 meters running test. However, the systolic blood pressure values while running with double density shoes were less different than the control shoes (P<0.001). It seems that the use of double density shoes does not have much effect on maximum oxygen consumption, heart rate and physiological energy

economy. Therefore, in order to receive more confidence and make a more decisive conclusion, there is a need to conduct more research.
Keywords: VO_2 Max, Physiological energy economy, Sports shoes.

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INTRODUCTION

Running is one of the popular activities among the public, which attracts many enthusiasts [1]. Approximately 42 million people participate in recreational runs each year [2]. The goal in competitive distance running is to run a given distance in the least amount of time, or at least faster than the next best competitor in slower tactical races [3]. Various factors can affect the activity of these athletes and even reduce their performance. The improvement of three physiological characteristics helps the success of athletes in endurance competitions [4, 5]. According to the previous studies, running economy can vary by up to 30% among elite runners with similar VO_2Max [6]. Running economy is inversely related to metabolic cost, as running economy improves, metabolic cost decreases and consequently improve performance [7]. The changes that have been made in running shoes in recent years include changes in mass, energy return, insoles, and stiffness-flexibility. Shoes that have less mass create more impact. Carbon soles can be much more efficient in cases where running economy is the main concern [8-14]. There are many factors for success in the sports field, and the training and equipment used in it is considered an important part of it [1]. The main function of spike shoes is increasing the friction force between the shoe and the track to improve propulsion during running [15]. Compared to normal shoes, spike shoes have less mass and this is due to the thinner sole and heel [16]. Furthermore, due to the constant advancement in technology, materials, and research evaluation capabilities, producing the ideal running shoe is likely to be a never-ending pursuit. Many physiological, anatomical, biomechanical and external factors affect running economy [4, 6, 17-19]. Since running economy is one of the most important factors in long distance running, even a small change in oxygen absorption will have a significant effect on the performance of a long distance runner. Based on a previous study, it has been shown that long distance runners run distances of 150 to 260 kilometers during a week [20, 21]. Therefore, considering the importance of the issue for long distance runners, it is necessary to investigate the effects of using double density spike shoes from a physiological point of view.

Aerobic exercises are one of the most common training methods to improve the performance of endurance athletes. Some of the physiological adaptations that usually occur after a period of aerobic interval training include a decrease in blood lactate concentration, pulmonary ventilation, oxygen consumption, and heart rate at a given intensity of activity [22]. It seems that in endurance training, there is a minimum intensity that training with less intensity with any training volume will not have much effect on endurance performance, especially in trained people. Of course, continuous exercises are also effective on endurance performance. Although training is done with different physical, technical and tactical goals, the role of physical and physiological factors is very prominent in athletic disciplines, especially in track and field [23]. Based on this, some endurance trainers believe that people with higher VO_2Max have better performance. Anyway, more recent studies show that the endurance performance of athletes, depending on the type of training, in addition to the maximum aerobic power, factors such as motor efficiency, neuromuscular adaptations, anaerobic capacity, endocrine device adaptations, threshold Lactate and the ability to delay it are affected [24]. Especially the effect of these factors is more prominent in trained athletes who have reached the stability of VO_2Max. Running training is often done periodically throughout the season and mainly consists of moderate to vigorous exercise at or slightly below race pace. [25]. HIIT trainings and competition of more than 5000 and 10000 meters are mostly done on the track using spiked shoes [25]. Spike shoes lead to an increase in the friction force between the shoe and the track and ultimately lead to an improvement in the running performance of athletes [15]. Previous studies have shown that professional long-distance runners (5,000 or 10,000 meters) use spiked running shoes for approximately three hours during daily training and four days a week [26]. Compared to regular running shoes, studded shoes have less cushioning and a thinner heel to reduce the weight of the shoe [8]. Between the summers of 2020 and 2021, new world records have been set in various athletics events, including the 5,000 and 10,000 m endurance events

in both men's and women's divisions. Now the question is to what extent these developments are related to the athletes' shoes and to what extent the advanced sports shoes have improved the athletes' performance [27, 28]. According to past studies, various shoes have been researched to minimize the forces on the joints of the lower limbs, to reduce the maximum injuries caused by running and to improve the running economy in runners (especially endurance runners). These shoes have been proven to reduce some of the risk factors associated with lower limb joints. Despite these effects of using double density shoes on physiological variables such as running economy, maximum oxygen consumption, systolic blood pressure, heart rate and 1600 meters running record have not been investigated so far. Therefore, the aim of this research is to compare the values of VO_2 max and physiological energy economy when using double density spike shoes compared to control shoes.

MATERIAL AND METHODS

Subjects

The current research was of semi-experimental type. 30 long distance runners were purposefully selected as a sample of the present study. The athletes were organized in a group with age range (18-32 years), height (179.60 ± 4.69 cm), weight (75.0 ± 9.39 kg). The exclusion criteria included history of skeletal-muscular surgery in the trunk or lower limbs, neuromuscular or orthopedic disorders, lower limb length difference greater than 5 mm, and intense physical exercises 2 days before data collection. Also, the consent form was obtained from the subjects to participate in the research.

Protocol

Firstly, the subjects were asked to perform the warm-up program for 15 minutes. Before starting the test, all subjects were first familiarized with how to work and how to do the exercises [29]. Before the test, the athletes ran on the run way for 10 minutes in order to adapt and stabilize their running pattern with the new double density spike shoes. After familiarizing with double density spike shoes, the test was performed. First, the athletes performed two 1600 meters in one day with control shoes, then three days later they performed the desired test with double density spike shoes.

Running shoes

Based on the availability at the local market, the following shoe model (Nike, Nike Zoom Rival, USA) was selected and adapted according to spike softness/stiffness (single versus dual-stiffness spike running shoes). In single-stiffness spike distance running shoes, we used regular (softer) spikes/nails in the medial and lateral part of the shoes (Fig. 1- left side). In dual-stiffness spike distance running shoes, we used regular or softer spikes/nails in the lateral part of the shoe and stiffer or harder spikes/ nails in the medial compartment of the shoe (Fig. 1- right side). The mass of the shoes was similar for single and dual-stiffness spike running shoes and amounted to 310±10 g. In other words, besides the reported differences in spike softness/stiffness, the running shoes were similar. The spike configuration in terms of soft and stiff nails was adapted by an expert sport shoe manufacturer in Ardabil city. The Vickers hardness test was used to assess spike/nail hardness value. Regular spike/nail and stiffer or harder spike/nail hardness were 190±8 HV30/20 and 478±9 HV30/20, respectively. Regular spikes/nails consisted of Iron [Fe] (98.41%), Manganese [Mn] (1.11%), Sulfur [S] (0.34%), and Silicon [Si] (0.14%) elements. Harder spikes/nails were made up out of Fe (98.60%), Mn (0.93%), and Si (0.47%) elements.

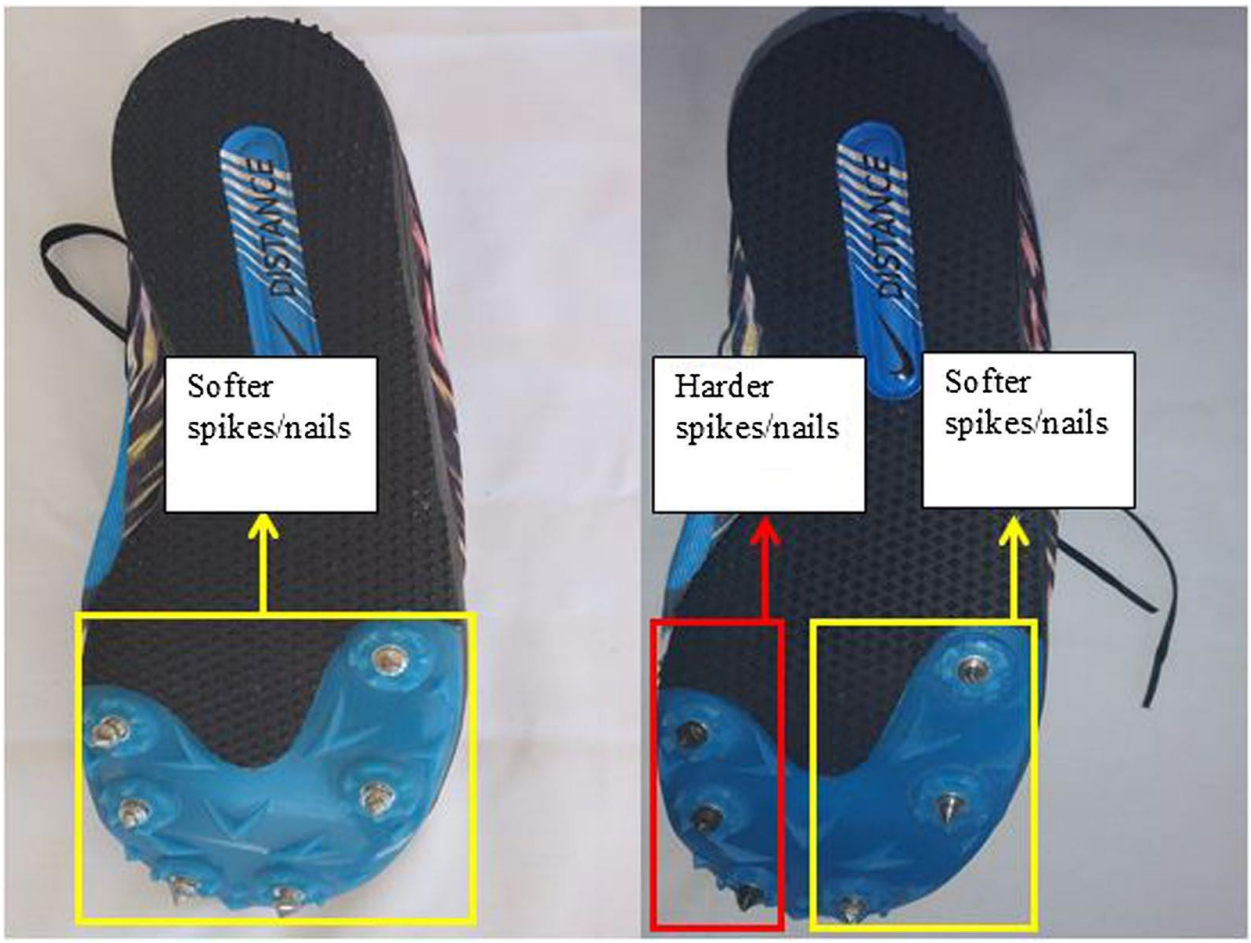

Fig 1. Single-stiffness (left side) and dual-stiffness (right side) spike distance running shoes used in this study.


Fig 2. dual-stiffness spike distance running shoes used in this study.

Anthropometric measurements

Anthropometric measurements were performed by an expert according to the reference guide [30]. Before starting the test height and weight were measured.

Measurements

To determine VO_2Max, the 1600 meters' test was used, in which subjects were asked to run and walk the desired distance. The heart rate of the runners was measured at the end of the test, then the maximum oxygen consumption was estimated using the following formula [31].

VO2max = 132.853−(0.0769 × body weight in pounds) −0.3877 × age in years+(6.315 × sex score) −(3.2649 × time in minutes to walk 1 mile) −(0.1565 × heart rate at the end of the walk)

For the sex score, males were given a score of 1 and females a score of 0. The values of systolic blood pressure and VO_2Max were measured with both shoes before and after the test.

Data analysis

Shapiro-Wilk test was confirmed the normal distribution of the data. The repeated measurements ANOVA was used for the data analysis at a significance level of P=0.05. All statistical analysis was done using spss version 23. The following equation was used to calculate the effect size (d) [32].

$$d = \frac{\text{Mean (treatmet)} - \text{Mean (control)}}{\text{Standard deviation}}$$

RESULTS

Demographic data was demonstrated in Table 1.

Table 1. General characteristics of the subjects.

Variables	Mean ± SD	Min	Max
Age (year)	24.10 ±3.96	18	32
Height (cm)	179.60 ± 4.96	173	187
Weight (kg)	75.30 ± 9.39	60	88

The values of maximum oxygen consumption during running with double density spiked shoes and control spiked shoes were showed in Table 2. The findings showed that there was no statistically significant difference in the maximum oxygen consumption during running with two control and double density shoes (p=0.580). Also, the results showed that there was no significant difference in the values of the 1600 meters running record when running with double density shoes compared to the control shoes (p=0.470).

Table 2. VO2 Max levels and 1600 meters running record during running with double density and simple spike shoes.

Variables	Mean ± SD		Sig	Effect size
	Double density shoes	Simple spike shoes		
VO2 Max	67.41±4.65	66.86±4.61	0.580	0.11
1600 running record (min)	7.22±1.19	7.53± 0.52	0.47	0.18

*significance level P<0.05

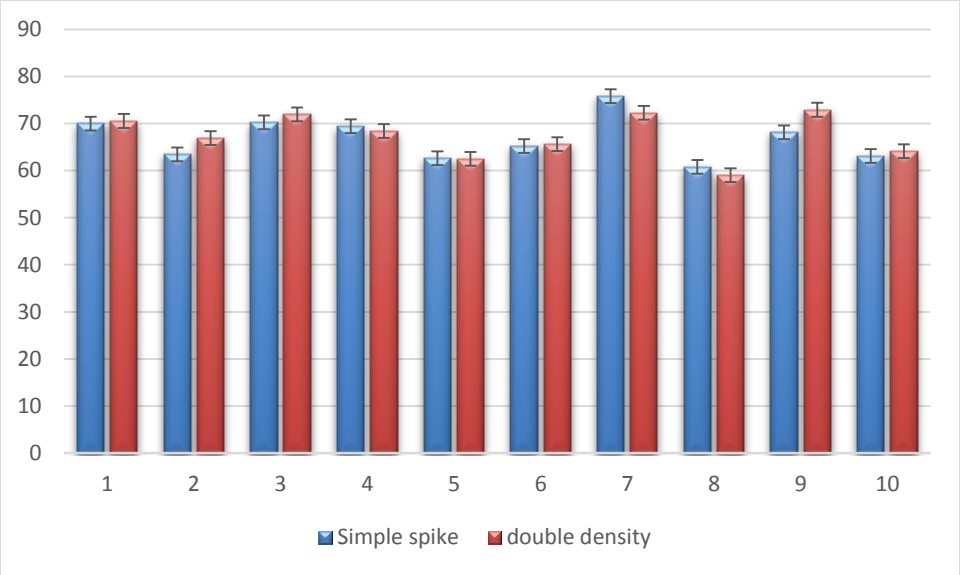

Fig 3. VO2 Max levels in each subject during running whit double density and simple spike shoes.

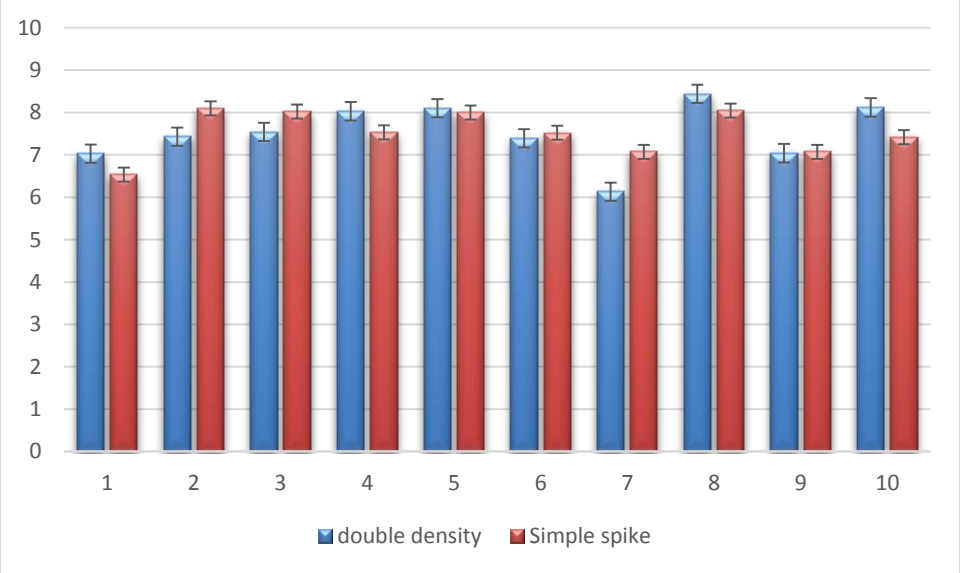

Fig 4. 1600 meters running records (minute) in each subject during running with double density and simple spike shoes.

The findings showed that when running with control shoes and double density shoes, the heart rate increases significantly compared to the baseline state ($p<001$) (Table 3). While, statistically, heart rate values during running with two simple spike shoes and double density shoes did not show a significant difference between the two conditions ($p=1.000$). The findings showed that the systolic blood pressure values increased after running with both shoes compared to the resting state, also the blood pressure values after running with the control shoes showed significant differences and the blood pressure values before the test and after the test with double density spike shoes, there was less difference than the control shoes ($P<0.001$).

Table 3. Heart rate and systolic blood pressure values during running with two double density and simple spike shoes.

Variables	Simple Spike shoes		Double density shoes		Sig(effect size)
	Pre	Post	Pre	Post	
Heart Rate	97.90±20.44	163.50±0/52	20.44 97.90±	160.10±18.8 8	P> 0.001
Systolic blood pressure	13.04±1.34	14.44±0.91	13.04±1.34	14.32±1.10	*P< 0.001

*significance level P<0.05

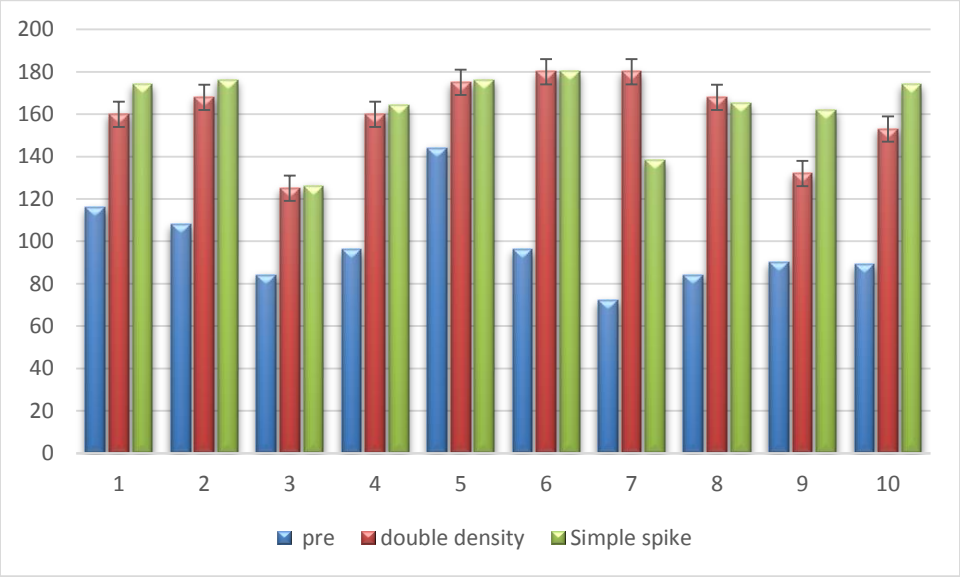

Fig 5. Heart rate values in each subject during running with two double density and simple spike shoes.

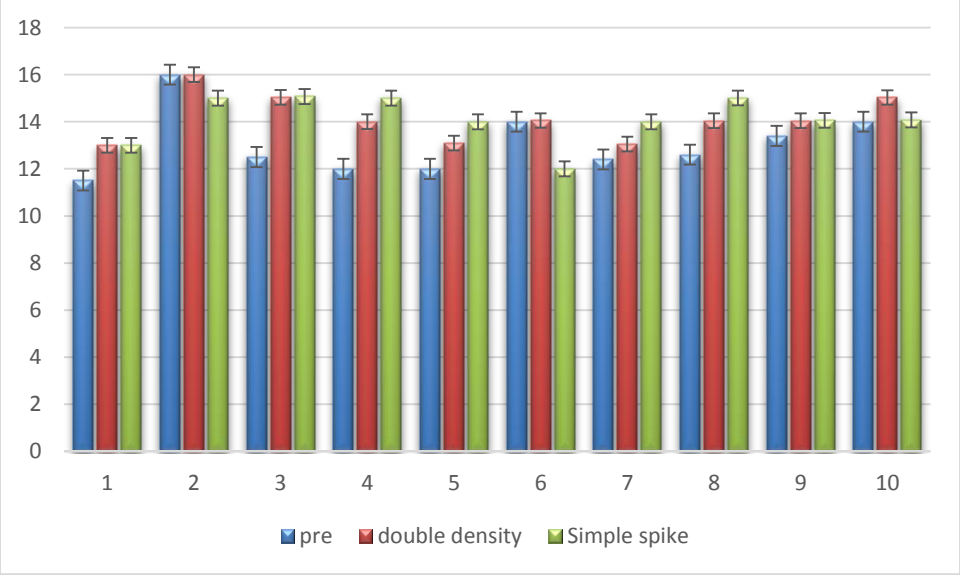

Fig 6. Systolic blood pressure values in each subject during running with two double density and simple spike shoes.

DISCUSSION

The aim of the present study was to compare VO_2 Max values and physiological energy economy when using double density spike shoes compared to simple spike shoes. The results did not show any significant differences in VO_2 Max values while using double density spike shoes compared to control shoes. In line with the findings of the present study, Eslami et al. (2014), during a study entitled "the effect of increasing the weight of sports shoes by 50 grams on running economy during a 50-minute treadmill running protocol" showed that increasing the weight of shoes during a 15 minutes run can increase the amount of maximum oxygen consumption [33]. The reason for the inequality of the results of the present study can be related to the weight of the shoe, which has not changed in current study. Contrary to the current research, Jones et al. (2007) showed greater energy consumption and heart rate while wearing boots[34]. A large part of this increase may be attributed to the weight of the shoe. In addition, the increased energy cost of walking with boots seems to place a limiting stress on untrained individuals which was consistent with the present research [35]. According to the cross-sectional research conducted by Ardigo et al. (2021), the energy cost increases when using both shoes, but there is a pattern that spikes are beneficial at higher speeds. Therefore, at higher speeds, it is very important to improve the adhesion record of shoes and nails with the ground [36].

From a mechanical point of view and according to the feelings of athletes about double density shoes and the mechanism of placement of double density nails in the desired shoe, it is easier to run with this shoe due to some inherent features. But in spite of this issue, it does not seem that these changes made in the past two years have any effect [37]. In line with the current research, in terms of the lack of relevant changes even in other sports such as basketball, despite the increase in the stiffness of the insole with fiberglass, it was visible [38]. Recent researches have presented very different results compared to previous reports. More recent findings showed that the results depend heavily on the research methods and also very rapid changes in the ingredients of shoes [39-40].

There are some limitations to this research. First, the number of participants in this study was limited, but it is never easy to recruit experienced athletes, so this evaluation in an outdoor location wearing double density studded shoes and control shoes is very special. In addition, different levels are used for running paths, which can affect the performance and even the results of the research.

CONCLUSION

The findings of the research showed a significant difference in pre-test and post-test heart rate and blood pressure values, so probably double density shoes can have a more appropriate effect on these two variables than control shoes. But it did not show any statistically significant difference in the components of physiological energy economy, maximum oxygen consumption and the record of two 1600 meters.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Data will be available at request.

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اثرات استفاده از کفش میخی دبل دنسیتی و کفش میخی معمولی بر مقادیر VO_2 max و اقتصاد انرژی فیزیولوژیک در دوندگان استقامتی

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چکیده:

امروزه بسیاری از افراد جامعه فعالیت دویدن را به عنوان یک فعالیت عمومی و یا اختصاصی خود به منظور بهبود قابلیت‌های جسمانی و فیزیولوژیکی خود انتخاب می‌کنند. انتخاب کفش‌های مناسب در دوهای استقامتی می‌تواند تأثیر زیادی بر عملکرد ورزشکار داشته باشد. اقتصاد انرژی فیزیولوژیک و حداکثر اکسیژن مصرفی نه تنها در بین دوندگان بلکه در میان تمام ورزشکاران از اهمیت ویژه‌ای برخوردار است. لذا هدف از پژوهش حاضر مقایسه مقادیر VO2 Max و اقتصاد انرژی فیزیولوژیک هنگام استفاده از کفش میخی دبل دنسیتی در مقایسه با کفش کنترل می‌باشد. پژوهش حاضر از نوع نیمه تجربی و میدانی می‌باشد. نمونه آماری مطالعه حاضر شامل ۳۰ نفر از دوندگان شهرستان اردبیل می‌باشد که در یک گروه سازماندهی شدند و شاخصه‌های اقتصاد انرژی فیزیولوژیک، حداکثر اکسیژن مصرفی، ضربان قلب استراحتی، فشار خون و رکورد دوی ۱۶۰۰ متر مورد سنجش قرار گرفت. همچنین برای تحلیل داده‌ها از آزمون تحلیل واریانس با اندازه‌گیری مکرر در سطح معناداری P= ۰/۰۵ استفاده شد. نتایج مطالعه حاضر در مقادیر حداکثر اکسیژن مصرفی، ضربان قلب و رکورد دوی ۱۶۰۰ متر با دو کفش کنترل و دبل دنسیتی پس از انجام تست ورزشی تفاوت معناداری را به لحاظ آماری نشان نداد. در حالی که مقادیر فشار خون سیستولی حین دویدن با کفش دبل دنسیتی اختلاف کمتری نسبت به کفش کنترل داشت (P<۰/۰۰۱). به نظر می‌رسد که استفاده از کفش دبل دنسیتی تأثیر چندانی بر مقادیر حداکثر اکسیژن مصرفی، ضربان قلب و اقتصاد انرژی فیزیولوژیک ندارد. از این‌رو، برای کسب اطمینان بیشتر و نتیجه‌گیری قاطع‌تر، نیاز به انجام تحقیقات بیشتر می‌باشد.

واژه‌های کلیدی: حداکثر اکسیژن مصرفی، اقتصاد انرژی فیزیولوژیک، کفش ورزشی.