STUDIES IN PHYSICAL CULTURE AND TOURISM
Vol. 14, No. 1, 2007

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THE EFFECT OF TRAINING DURING AN ANNUAL PREPARATORY COURSE ON NORMAL PARAMETERS OF FIELD ATHLETES

Key words: anaerobic capacity, Wingate test, preparation period, cardiac frequency, training volume.

ABSTRACT

The purpose of this study was to evaluate the development of anaerobic performance (Wingate test) and cardiorespiratory adaptations (HR) in runners, during the phases of an annual training period. The sample consisted of 13 runners and the training phases, of total duration of 38 weeks, concerned the period of preparation, which included the introductive period (4 weeks with general training content), the general preparation (15 weeks with increased volume and intensity of training), the special preparation (8 weeks with maintenance of volume and increase of intensity of training), the pre-contest period (8 weeks with reduction of volume and increase of intensity of training), as well as the three first weeks of the contest period. The results showed an increase of the body mass (BM) of athletes during the general and special preparation ($p<0.001$), which remained increased during the pre-contest period as compared to the introductive period ($p<0.01$). The maximum and relative power output showed an increase during the special and pre-contest period ($p<0.001$) as compared to the introductive period and the general preparation period. At the same time, the rate of reduction of power output was influenced, in absolute as well as relative values. The HR presented a slight reduction during pre-contest as compared with the introductive period ($p=0.05$), while the recovery HR presented positive functional adaptations during the general and special preparation period, and was maintained in the pre-contest period ($p<0.001$), despite a significant increase of the output in the Wingate test during the same times. Therefore, the use of balanced volume and intensity training stimuli, dependent on individual training phases, increases the ability of production of anaerobic power output and progressively increases the cardiovascular adaptations in runners.

INTRODUCTION

The basic aim of an annual training plan is the tactical and proper for each training phase provision of the appropriate stimulant of volume and intensity in order to maximize the physiological functions and to obtain the maximum performance in a given period of time. The training process aims to improve the aerobic as well as the anaerobic mechanism of energy production and directly depends on the kind and type of each sport.

Heart Rate (HR) during exercise is related to many physiological but also psychological factors [10], whereas it is higher during periods of increased training volume, but also in specific environmental circumstances. Furthermore, important factors that affect the HR during the training process are the level of the physical state of

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the trainee as well as the duration of the training session [5]. Aerobic training causes a slight reduction in the recovery HR. This physiological adaptation is caused by the increase in the plasma volume in the blood, by the reduction of the sympathetic autonomous function and through the reduction in the concentration of catecholamine [12].

The anaerobic capacity as a natural function does not only depend on the training intensity, but on the individual specialness of each person. Factors that directly affect the anaerobic capacity are the age [7, 3, 4, 9], the hormone-related differences in relation to the gender, differences in the action of the functional systems [13, 2, 6, 8, 11], as well as the quantitative distribution of the muscle fiber types [4, 1].

Today, the most common method of measuring the anaerobic capacity is the Wingate test which can provide useful and exact information for several parameters of an aerobic capacity (ex anaerobic potency, mean and minimum potency, level of tiredness) of the trainee. The aim of the current study was: a) the measurement and record of the anaerobic capacity as well as the HR of exercise/rehabilitation, through the Wingate test, in different phases of the annual training period and b) the evaluation of the effect of the differentiation of the volume of each training phase in the production of power and in the cardiovascular function of the field athletes.

METHODS

Sample

The study was carried out in a sample of 13 sprint runners and semi endurance runners (10 male and 3 female athletes) aged 18±2.7 years old, with the body height of 178±6.9 cm, body weight of 66.1±10.3 kg, with a training experience of 5.8±3.2 years and VO_{2max} 51.73±5.75 $ml.kg.min^{1}$. The athletes took part in the research voluntarily after having been informed in detail about the aims of the study.

Planning of the training difficulties

The annual training plan for the sample was 38 weeks. The training period started with the four-week-long introductory phase which included general training subjects, aiming to prepare the athletes for the safe application of the contents of the general and special preparation. The general preparatory period during which the volume as well as the intensity of the training were increased lasted 15 weeks, whereas the special preparation during which the training volume remained stable, but the intensity was increasing lasted 8 weeks. During the general preparation the intensity of the running training increased by 70-75% of the individual performance of the distance of the previous year, while the intensity in the weight lift training was in the 50-60% of one maximum repetition (1 MR). In the special preparation the intensity in the running training remained unchanged, while the intensity in the weight lift training increased by 50-90% and the number of the repetitions was reduced. Following that, in the pre-contest period the training volume was decreased and the training intensity was increased. For the running training the intensity reached 80-100% of the individual performance, while for the weight lift training the intensity was raised by 75-85% of one Maximum Repetition. Finally, in the contest period the volume in the weight lift training was standardized in 80%, whereas in the running training it reached up to 90-100%. The data was collected in the first three weeks of the contest period when the training volume was decreased even more, while in the last day of the third week the final measurement took place as well as the record of the physiological traits of the sample of the study. The choice of the specific period of time instead of the typical end of the last training phase was made in order to help the accumulated tiredness due to training to go away, so as to enable the objective measurement of the "pure gain" that came about for the anaerobic capacity from the training stimulant of the training period, but also in order for a time difference to exist from the contest obligations of each athlete.

Counting Protocol

The effects of the phases of the training planning on the anaerobic capacity and on the HR of exercise/recovery were evaluated with four measurements: a) at the end of the introductory period (4^{th} week), b) at the end of the general preparation (19^{th} week), c) at the end of the special preparation (27^{th} week) and d) at the end of the 3rd week of the contest period (38^{th} week) from the beginning of the training procedure. All measurements were carried out at the same time, in the

afternoon before the beginning of the athletes' training.

Counting Procedure

The Wingate Test was applied when the subjects reached the maximum spin speed, a speed that was recorded for each person before the beginning of the main test (BASES Protocol). The parameters of the Wingate test that were counted were the maximum, mean and minimum power in absolute (Watt) and relative values (Watt. kg^{-1}), as well as the volume reduction in absolute (Watt. $Sec.^{-1}$) and relative values (Watt. Sec. kg^{-1}). The reduction of work production was estimated by the mean value of six values, which were taken down every five seconds on the whole of the test and were related to the proportional (%) reduction in the produced task (number of cycles) each specific time. Last, the reduction of the volume production (%) was estimated by the mean of the six values of the produced volume (Watt), which were recorded every five seconds on the whole of the test. Furthermore, the HR (Pollar sport tester 3000) was recorded immediately after the end of the Wingate test (HR test), four minutes after the completion of the test (HR rehabilitation test) as well as in the four measurements that took place at the end of each training phase of the annual planning.

Statistical Analysis

The statistical analysis was carried out with a repeated measures analysis of variance (ANOVA), in order to evaluate the effects of each training phase of the annual planning on the parameters of the Wingate test and on the HR of exercise and recovery. In order to trace the differences in homogeneous subgroups the Tukey test (post hoc) was used. The level of significance for the control of the correlations in this study was set at $p<0.05$.

RESULTS

The analysis of the data showed differences in the body mass (BM) of the runners between the training phases ($p<0.001$). An increase in the BM was taken down at the end of the general and special preparation ($p<0.001$) with the mass remaining increased up to the end of the pre-contest period ($p<0.01$) as compared with the introductory period.

Differences between the training phases were taken down in the maximum power in absolute ($p<0.001$) as well as relative values ($p<0.001$). Specifically, the maximum power in absolute prices was increased at the end of the special preparation ($p<0.001$), as well as in the pre contest period ($p<0.001$) compared with the introductory period. Furthermore, the maximum volume in absolute numbers was raised in the end of the special preparation ($p<0.001$), as well as at the end of the pre-contest period ($p<0.001$) as compared with the general preparation. In relative values maximal power was increased at the end of the special preparation ($p<0.05$) as well as at the end of the pre-contest period ($p<0.001$) as compared with the introductory period. Likewise, maximal volume was raised in the end of the special preparation ($p<0.001$) and at the end of the pre-contest period ($p<0.001$) as compared with the general preparation. In relation to the absolute and relative mean and minimal power, differences between the training phases were recorded only in the absolute mean power ($p<0.05$), and concerned its increase in the period of special preparation as compared with the introductory period ($p<0.01$).

Concurrently, significant differences between the training phases were recorded in the declining rhythm of the power in absolute and relative values ($p<0.001$). In absolute values the declining rhythm was increased in the special preparation ($p<0.001$), as well as in the pre-contest period ($p<0.001$) as compared with the introductory and general preparation, whereas a rise was recorded in the pre-contest period as compared with the special preparation ($p<0.05$). In relation to the relative values a rise in the decreasing rhythm of power was taken down in the special preparation ($p<0.05$), as well as in the pre-contest period ($p<0.01$) as compared with the introductory period. Furthermore, a rise in the declining rhythm of the power was taken down in the special preparation ($p<0.01$) and in the pre-contest period ($p<0.001$) as compared with the overall preparation as well as in the pre-contest period compared with the special preparation ($p<0.5$). Lastly, significant differences ($p<0.001$) between the training phases were taken down in the proportional reduction of the produced power. The above parameters representing the level of tiredness was increased in the special preparation ($p<0.05$) and in the pre-contest period ($p<0.001$) as compared with the introductory period and the overall preparation, while in the pre-contest period

it was increased ($p<0.05$) as compared with the special preparation.

As far as the HR is concerned, during the Wingate test a borderline reduction ($p<0.05$) was recorded in the pre-contest compared to the introductory period. The recovery HR showed significant differences between the measurements ($p<0.001$). A borderline reduction ($p<0.01$) of the cardiac frequency was recorded in the general preparation, which remained in the special preparation ($p<0.001$), as well as in the pre-contest period ($p<0.001$) as compared with the introductory period. Table 1 presents all the mean values enrolled in all the parameters in this study.

the "structural" training prevails. This means that training helps muscular hypertrophy, aiming to create the base that will support the high-intensity application of training loads of the pre-contest period. This increase of the BM in runners was obviously not a result of the muscular hypertrophy alone, but of the procedures such as the rise of the protein concentration that characterizes the procedure of muscular hypertrophy. The mean mass value of the runners as compared with the introductory phase displays a rise of 6.7% during the preparatory period, then starts to decrease resulting in the runners reaching the contest period with 4.5% more BM compared with that of the

Table 1. Body mass, performance in parameter Wingate test and HR exercise and rehabilitation in the four training periods

Parameters	Introductory period	General preparation	Special preparation	Pre-contest period
Body mass (kg)	66.1±2.8	69.4±2.8 α	70.6±2.8 α	69.1±2.6 α
Peak Power (Watt)	624.6±43.1	646.2±51.3	741.6±51.1 α,β	769.8±49.7 α,β
Peak Power (Watt.kg^{-1})	9.3±0.37	9.0±0.45	10.4±0.36 α,β	11.00±0.38 α,β
Mean Power (Watt)	497.7±34.2	528.4±36.2	554.4±36.4β	533.5±33.6
Mean Power (Watt. kg^{-1})	7.4±0.27	7.5±0.27	7.7±0.26	7.7±0.27
Minimum Power (Watt)	391.6±29.4	400.3±24.1	411.7±25.4	375.0±23.8
Minimum Power (Watt.kg^{-1})	5.85±0.26	5.76±0.17	5.83±0.18	5.46±0.21
Power drop (Watt.sec^{-1})	7.56±0.761	7.86±1.06	10.85±1.1 α,β	12.7±1.09 α,β
Rate of Power drop (Watt. sec kg^{-1})	0.113±0.00	0.112±0.01	0.147±0.01 α,β	0.180±0.01 α,β
Power drop (%)	10.09±0.82	9.77±0.80 α	12.96±0.96 α	15.80±1.04 α
HR exercise (b.min^{-1})	185.4±2.33	179.1±1.68	184.2±2.66	177.9±2.89 α
HR recovery (b.min^{-})	148.6±3.85	133.2±3.17 α	132.8±3.85 α	136.9±4.15 α

α $p<0.05$ from the introductory period
β $p<0.05$ from the general preparation

DISCUSSION

In this study the effects of the training phases of an annual running plan on the BM, the HR of exercise/recovery and on the anaerobic performance were examined. The training procedure resulted in a significant increase of the BM at the end of the preparatory period. Even though a muscular biopsy was not performed a rise in the BM in the general and special preparation was expected due to the nature of the training stimulant and mainly due to the weight-lift training, in which initial measurement. Apart from the training procedure a factor affecting the BM is the athletes' quantitative and qualitative nutrition. During the preparation with the high-training loads there is a tendency of protein over-consumption (nutrition and nutritional supplements), whereas controlling the BM is not considered to be necessary, something that happens during the pre-contest period. Therefore, the athletes' body mass depends on the training phase, mainly because it is affected by the quantity and strength of the training stimulants, but also partly on the reduction of

calories intake, that the majority of the athletes follow during the pre-contest period in order to contest with the ideal "contest weight" that the running sports demand.

In relation to the performance in the Wingate test parameters, a continuous increase of the maximal power was noticed to be relavant to the training phase, in absolute as well as in relative values. The rise from the introductory phase at the end of the pre-contest period was 23.3% in absolute values, and 16.8% in relative values. The biggest part of the rise in the maximum power (14.8%) was noticed at the end of the special preparation. A large part of this rise may be attributed to the adjustment of the physiological performance systems, after a period of fifteen weeks of training especially when the most significant part in this training phase is the power increase in the training content of strength of the special preparation since the training intensity for the 8 weeks of the special preparation reached 90% as compared with the 60% of the previous phase. Likewise, in the maximum power in relative values, the highest rise (14.8) was noticed at the end of the special preparation. The only differentiation in the maximum power as compared with the BM of the runners' bodies concerns the reduction (–3.4%) that was taken down at the end of the general preparation compared to the introductory period, a fact that can be explained from the significant rise of BM in this period, something that possibly affected negatively the performance, because the relative maximal power connects to the BM. The absolute mean power marked a 11.4% rise only at the end of the special preparatory as compared with the introductory period, while the absolute rhythm of power decline, as it was expected, presented the highest rise (38%) at the end of the special preparation, where the highest peak value in the absolute maximal power was noticed.

The overall depiction of the decreasing rhythm of the power, in absolute and relative values, presents a continuous increasing tendency from one training phase to the other, following the simultaneous raising tendency of the maximal power in these periods. Lastly, as far as the proportional decline in power production is concerned, a continuous rising tendency between the measurements was recorded. The highest rise occurred at the end of the pre-contest period, where the highest value in absolute and relative maximal power appeared.

The heart rate during the Wingate test displayed variations in the training phases with borderline differences recorded in its reducing tendency during the pre-contest period in relation to the values of the introductory period. In the current study, if the HR of the exercise is measured in relation to the absolute maximal task production during the Wingate test, it seems that the maximal performance that was obtained at the end of the pre-contest period was followed by the minimal HR of a task, while the highest HR values of exercise and the lowest for the absolute maximal ergo production were noticed in the introductory period. The combination of the above suggests a favorable adaptative response of the cardiovascular system in favor of the maximal anaerobic ergo with the best correlation having been recorded at the end of the pre-contest period. The slight rise that was recorded in the HR of exercise at the end of the special preparation, possibly could partly be, a premature answer to the differentiation of the training stimulants of this period (rise of the training volume), and it could also be related to the significant rise in the power production that was recorded during the Wingate test in this training period.

However, while the HR of exercise presented variations through different measurements, the recovery HR displayed a significant declining tendency, which was combined with a rise in the anaerobic exercise performance in the progress course of the training phases. This observation supports the view of the positive adjustment reaction of the cardiovascular system to the support of the anaerobic power which steadily improves during the training phases and follows the effect of the HR of exercise in the equivalent training periods. On the whole, from the introductory period up until the pre-contest period the proportional level of the recovery HR almost doubles (–8%) the equivalent of the HR of exercise (–4%). The biggest, therefore, adjustment response of the cardiovascular system in the training process, refers to the recovery HR and much less to the HR of exercise, a state that is not considered to be impossible since the adjustment ability of the athletes to the training stimulants may be as high as the improvement ability of the functional system of their bodies.

Conclusively, the preparation period (general and special), which includes training parts of quantity and intensity, affects positively not only

the anaerobic capacity but the functional adjustments of the cardiovascular system, a course that peaks at the end of the preparation period. Thus, entering the pre-contest period allows the safe application of the training principles of intensity, the size of which could predict the final performance of the period, at least as far as the performing ability of the specific functional systems is concerned. In this way, when the training stimulants, on the basis the conducted measurements in each training phase, do not seem to lead to the target-aim, the instructor has the ability to differentiate and re-plan the training.

REFERENCES

[1] Bar-Or O., Dotan R., Inbar O., Rothstein A., Karlsson J., Tesch P., Anaerobic capacity and muscle fiber type distribution in man, *International Journal of Sports Medicine*, 1980, 1: 82-85.

[2] Ben-Sira D., Sagiv M., The effect of gender on left ventricular function immediately after the Wingate test, *European Journal of Applied Physiology*, 1997, 75: 549-553.

[3] Blimikie C.J.R., Roache P., Hay J.T., Bar-Or O., Anaerobic power of arms in teenage boys and girls: relationship to lean tissue, *European Journal of Applied Physiology*, 1988, 57: 677-683.

[4] Froesse E.A., Houston ME., Performance during the Wingate anaerobic test and muscle morphology in males and females, *International Journal of Sports Medicine*, 1987, 8: 35-39.

[5] Gilman M.B., The use of heart rate to monitor the intensity of endurance training, S*ports Medicine*, 1996, 21: 73-79.

[6] Gratas-Delamarche A., Le Cam P., Monnier M., Konbi H., Lactate and catecholamine responses in male and female sprinters during a Wingate test, *European Journal of Applied Physiology*, 1994, 68: 362-366.

[7] Hebestreit H., Mimura K.I., Bar-Or O., Recovery of muscle power after high-intensity short-term exercise: comparing boys and men, *Journal of Applied Physiology*, 1993, 74, 6: 2875-2880.

[8] Hill D.W., Smith J.C., Gender difference in anaerobic capacity: role of aerobic contribution, *British Journal of Sports Medicine*, 1993, 27: 45-48.

[9] Inbar O., Bar-Or O., Anaerobic characteristics in male children and adolescents, *Medicine and Science in Sports and Exercise*, 1986, 18: 264-269.

[10] Robinson D.M., Robinson S.M., Hume P.A., Hopkins W.G., Training intensity of elite male distance runners, *Medicine and Science in Sports and Exercise*, 1991, 23: 1078-1082.

[11] Serresse O., Ama P.F.M., Lortie G., Bouchard C., Boulay M.R., Anaerobic performance of sedentary and trained subjects, *Canadian Journal of Sports Science*, 1989, 14: 46-52.

[12] Wilmore J.H., Stanforth P.R., Gagnon J., Leon A.S., Rao D.C., Skinner J.S., Bouchard C., Endurance exercise training has a minimal effect on rest heart rate: the HERITAGE study, *Medicine and Science in Sports and exercise*, 1996, 28: 829-835.

[13] Zouhal H., Gratas-Delamarche A., Rannou F., Granier P., Bentue-Ferrer D., Delamarche P., Between 21 and 34 years of age ageing alters the catecholamine responses to supramaximal exercise in endurance trained athletes, *International Journal of Sports Medicine*, 1999, 20: 343-348.