Journal of Physical Education and Sport ® (JPES), 17 Supplement issue 5, Art 231, pp. 2214 - 2217, 2017
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

Response of the respiratory system of long and middle distance runners to exercises of different types

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Published online: November 24, 2017
(Accepted for publication November 15, 2017
DOI:10.7752/jpes.2017.s5231

Abstract
This article describes research findings concerning the identification of special features of response of the respiratory system of long-distance runners and middle-distance runners to exercises of different types and its effect on the recovery rate.
It has been revealed that the balanced combination of aerobic and anaerobic mechanisms intended for support of muscle activities and their development to full potential during workout sessions is most preferable for quick rehabilitation of the runners.
Key words: respiratory system; long and middle-distance runners, response to exercise, exercises of different types.

Introduction

be considered as mobilization of the internal reserves of their bodies. Any trained human body has more energy reserves and can use them better with increased load. Adequate and purposeful structure of training sessions increases the metabolic processes in the bodies of long and middle-distance runners and contributes to a more efficient growth of the sport results [1-3, 5].

The properly structured systematic physical exercises enhance not only the growth of the runners' sport results but facilitate quick recovery after the completion of heavy work [3, 7-8].

Almost any exercise that develops strength, speed and general endurance was considered as a specific conditioning method of training for long and middle-distance runners [4, 6, 9, 10]. Therefore, it was assumed that the proper use and combination of these exercises during the session for long and middle-distance runners would enhance not only the growth of the runners' sport results but facilitate quick recovery after the completion of heavy work. Preliminary studies showed that identification of special features of response of the respiratory system of long-distance and middle-distance runners to exercises of different types can serve as an accurate indicator of the recovery rate after the completion of heavy work.

Materials and methods

Research objective is to identify the specific features of response of the respiratory system of long-distance and middle-distance runners to exercises of different types.

Research method. The respiratory system of the runners was analysed using "Spirolab III". The device consists of a mini flowmeter sensor, a power supply unit, a CD winspiro PRO, a roll of thermal paper, a nose clip, paper mouthpieces, disposable turbines, reusable turbines, and a spare fuse.

"Spirolab III" is a spirometer with an oximetry option. The device is intended for the complete analysis of pulmonary function. The given device enables to test FVC (Forced Vital Capacity), VC (insp/exp), MVV (Maximum Voluntary Ventilation), to identify breathing pattern and calculate both oxygen saturation and pulse rate. Index of test acceptability, test quality control and assessment of the test results were carried out using this device.

The main spirometric parameters were calculated using the given device. The data obtained were displayed, and there was a possibility to print them.

For the proper interpretation of spirometric results, the measured values were compared with the normal and predicted values, which were calculated based on the anthropometric characteristics of the runners. Then, the data were compared with the best individual performances of the sportsmen. It was considered that the best individual performances of the runners may differ significantly from the predicted values.

In our study, we used five spirometric tests: VC (Vital Capacity, L), FVC (Forced Vital Capacity, L), MVV (Maximum Voluntary Ventilation, L/min), EVC (Expiratory Vital Capacity, L), FIV 1 (Forced Inspiration Volume in 1st second, L).

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VC (Vital Capacity). The test was preceded by a period of quiet breathing in and out. Then, the test person was asked to take the deepest breath he/she can, and then exhale into the mouthpiece for as long as possible. During the test, the curve (volume/time) was displayed.

FVC (Forced Vital Capacity). The test was preceded by several full inspirations. Then the test person was asked to take the deepest breath he/she can (as deep as possible), and then exhale for as long as possible. Then, this was followed by the fastest inhalation while keeping the mouthpiece in the mouth.

MVV (Maximum Voluntary Ventilation). During the test, the test person was asked to take several deepest breathes he/she can at a rate of 30 bmp. In 12 seconds, the test stopped automatically. After completion of the test, the recorded curves and values of measured parameters were displayed.

All of the test persons were divided into three groups. The first group consisted of middle-distance runners (8 persons), the second group included long-distance runners, majoring in 5 and 10 km, and the third group consisted of marathon runners. The second and third groups included 7 test persons in each group.

Results and discussion.

During the research, the comparative analysis of the specific features of response of the respiratory system of long-distance and middle-distance runners to exercises of different types was carried out. Responses of the runners' respiratory system at the beginning and end of the training session, which was aimed to develop strength, speed and general endurance, were reviewed to identify the effect of physical activities of different types on the runners' bodies.

During the first stage, we used strength exercises: 60-metre race at maximum speed (10 repetitions); squatting (3 sets, 8-10 repetitions per set); leg press (3 sets, 7-9 repetitions per set); additional: bench-press (2 sets, 4-6 repetitions per set); exercises for strengthening stomach and body muscles (3 sets, 10 repetitions per set).

After every set, the runners had a 5-minute break. The exercises were preceded by a 15-minute warmup.

Table 1 shows the changes in the runners' respiratory system depending on the physical exercises, which aimed to develop strength endurance.

The obtained results indicate that the parameters of the runners' respiratory system of the 1 and 2 groups reacted to physical exercise by increasing the values. The physiological functions of the sportsmen bodies become activated.

Table 1. Parameters of the respiratory system prior to and after the exercises aimed to develop runners' strength endurance

Group	Test	Prior to training	After training	Increment, %
I	VC (L)	4.45±0.04	4.87±0.02	9.43
	FVC (L)	4.54±0.02	4.86±0.05	7.04
	FIV1 (L)	3.95±0.03	4.49±0.10	13.61
II	VC (L)	4.24±0.10	4.52±0.06	6.60
	FVC (L)	4.61±0.07	4.74±0.08	2.80
	FIV1 (L)	4.11±0.10	4.23±0.12	3.17
III	VC (L)	5.25±0.07	4.71±0.03	-10.28
	FVC (L)	5.13±0.11	5.00±0.08	-2.53
	FIV1 (L)	4.76±0.04	4.59±0.08	-3.70

Notes: VC – Vital Capacity; FVC – Forced Vital Capacity; FIV1 – Forced Inspiration Volume in the first second

At the beginning of training, the parameters of the first group of runners were as follows: VC 4.45±0.04 L, FVC 4.54±0.02 L, and FIV1 3.95±0.03 L. At the end of training, VC was 4.87±0.02 L (increment 9.43%); FVC 4.86±0.05 L (increment 7.04%); FIV1 4.49±0.10 L (increment 13.61%). The second group of runners had the following parameters of the respiratory system prior to training: VC 4.24±0.10 L; FVC 4.61±0.07 L; FIV1 4.11±0.1L. However, at the end of training, the parameters were: VC 4.52±0.06 L; FVC 4.74±0.08 L; FIV1 4.23±0.12 L. The increment is significantly lower compared with the results of the first group of runners. The values were 6.60%, 2.80%, and 3.17%, respectively.

It has been determined that physical exercises aimed to develop strength endurance produce various reactions in the body, which is reflected in changes of parameters of runners of different types. The first group of runners reacted to the load more evidently than the second group. Marathon runners, which were included into the third group, showed the following results at the beginning of training: VC 5.25±0.07 L, FVC 5.13±0.11 L, FIV1 4.59±0.08 L. At the end of training, reduction in the respiratory system parameters was observed. The parameters were as follows: VC 4.71±0.03 L, FVC 5.00±0.08 L, FIV1 4.59±0.08 L. Response of the respiratory system of the third group runners happened to be lower that the results of the first and second groups of runners:

10.28%, 2.53%, and 3.70%, respectively. The runners majoring in middle-distance racing reacted to strength exercises more expressively than long-distance runners.

Table 2 demonstrates the response of the runners' respiratory system to speed exercises. The following exercises, which aimed to develop the speed performance of a runner, were used: dedicated running exercises with increasing speed (3-4 times, 20-30 m) (focusing on frequency of motion); races from crouch start (6-8 times, 20-30 m); races from flying start 40-60 m (at maximum speed). There were 3-4-minute breaks, which were intended for relaxation and returning of pulse to normal up to 110-120 bpm between exercises.

The obtained results, which demonstrated response of the runners' respiratory system to speed exercises, showed that parameters of all three groups had a positive development.

Therefore, a substantial increment in FIV1 was observed in the first group. In the second and third groups, the increment in FIV1 was even higher. Therefore, under the speed load, the runners are found to have an ability to consume the maximum air volume in the first seconds of physical exercises.

The next stage of research was a review of response of the runners' respiratory system to the physical exercises aimed to general endurance. For this purpose, a continuous 10-km race at a steady pace (within 35 minutes) and a 3-km running uphill (within 15 minutes) were used during the training session.

Table 2. Parameters of the respiratory system of the runners prior to and after the speed training session

Group	Test	Prior to training	After training	Increment, %
I	VC (L)	4.78±0.06	5.04±0.04	5.43
	FVC (L)	4.81±0.02	4.83±0.05	0.41
	FIV1 (L)	3.66±0.05	4.51±0.06	25.27
II	VC (L)	4.87±0.04	5.05±0.07	3.69
	FVC (L)	4.81±0.07	4.83±0.11	0.41
	FIV1 (L)	3.91±0.06	4.13±0.10	5.62
III	VC (L)	4.87±0.02	5.05±0.06	3.69
	FVC (L)	4.01±0.08	4.11±0.07	2.49
	FIV1 (L)	3.91±0.04	4.13±0.07	5.62

Note: VC – Vital Capacity; FVC – Forced Vital Capacity; FIV1 – Forced Inspiration Volume in the first second

Table 3 presents the parameters of the respiratory system of the runners during the exercises aimed to develop general endurance. The obtained results, which demonstrate the response of the runners' respiratory system to exercises aimed to improve general endurance, showed that parameters of all three groups had a positive development.

Table 3. Parameters of the respiratory system of the runners prior to and after the training session aimed to develop general endurance

Group	Test	Prior to training	After training	Increment, %
I	VC (L)	2.84±0.02	3.41±0.10	20.07
	FVC (L)	3.96±0.06	4.14±0.11	15.0
	FIV1 (L)	3.6±0.05	3.79±0.06	5.27
II	VC (L)	4.71±0.06	4.85±0.04	3.11
	FVC (L)	5.57±0.09	5.77±0.02	5.26
	FIV1 (L)	4.09±0.12	4.78±0.05	18.78
III	VC (L)	4.79±0.08	4.95±0.06	3.34
	FVC (L)	5.47±0.06	5.78±0.07	5.66
	FIV1 (L)	4.04±0.07	4.88±0.02	20.79

Note: VC – vital capacity; FVC – Forced Vital Capacity; FIV1 – Forced Inspiration Volume in the first second

Thus, a substantial increment in FIV1 was observed in all groups. It was observed that the respiratory system of the body reacted to physical exercises, which were aimed to develop general endurance better and more effectively. It was determined that marathon runners had a more developed mechanism of energy supply involving oxygen during muscle activities compared with the runners of the first and second groups. When the work cycle is long, the runners of the first and second groups demonstrated a more evident fatigue due to oxygen debt. That is why the runners from these groups should improve human performance by eliminating oxygen debt using a higher control over breathing. Thus, all cycle exercises should be performed at a high power level. The work at this level should last from 3-5 to 30-40 minutes. Due to the enhanced intensification of function of the

runners' cardiorespiratory system, the percentage of maximal oxygen consumption and its delivery to tissues reaches the highest possible level.

Conclusions

During the research undertaken, it was determined that:

1) The response of the respiratory system of middle and long-distance runners to exercises of different types had specific features.

2) Middle-distance runners had a more developed anaerobic mechanism for supporting muscle activities. However, aerobic mechanisms intended for supporting muscle activities operate better in long-distance runners.

3) Discrepancies in response of the respiratory system of middle and long-distance runners to exercises of different types had an effect on recovery rate.

4) The balanced combination of aerobic and anaerobic mechanisms, which are intended for supporting muscle activities and their development to full potential during a workout session, is most preferable for quick rehabilitation of the runners.

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