Research Article

Peculiarities of heartbeat rate and stroke volume of blood "negative phase" manifestation among young sportsmen after muscular load

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ABSTRACT

Aim: They studied the features of changes in heartbeat rate (HBR) and stroke volume of blood (SVB) of young athletes during the recovery period after the performance of the standard muscular load. **Materials and Methods:** To study the peculiarities of changes in HBR and stroke volume of blood (SVB) during the recovery period after a standard muscular load, we examined the athletes engaged in specialized sports schools and specialized in swimming, skiing, gymnastics, and ice hockey. To determine the reaction of the cardiovascular system of athletes to the functional test, the Harvard step test was used. **Result and Discussion:** At the same time, there was a short-term decrease in HBR and SVB below the initial values, i.e., the "negative phase" of heart rate and SVB. The decrease in HBR and SVB below the initial values in the recovery process after the performance of a low-capacity muscular load among young athletes is manifested itself most often during the stages of initial and special training. During these two stages of long-term sports training, among young athletes that the rates of heartbeat reduction were more pronounced. **Conclusion:** The "negative phase" of HBR is manifested to a greater extent at the period when the development of fitness bradycardia occurs at a significant rate. With the established bradycardia of training among young athletes, the "negative phase" of pulse is rare, and sometimes, it is completely absent.

KEY WORDS: "Negative phase," Heartbeat rate, Muscle training, Stroke volume of blood, The decrease in heart rate and stroke volume of blood stroke volume of blood below the initial values, The periods of sports training, Young athletes

INTRODUCTION

The changes in heart pumping function during the recovery period, especially immediately after the termination of muscle activity, indicate the most important regulatory changes in a body. Studying the patterns of heartbeat rate (HBR) changes during the recovery period after the performance of a standard muscular load, the researchers established a "negative phase" of pulse.[1-4] However, until recently, there has been a completely contradictory interpretation of the "negative phase" of HBR. Some researchers[2,4] regard the appearance of a "negative phase" of pulse during the recovery period as an unfavorable sign indicating overfatigue. Other researchers[1,3,5] consider the appearance of a "negative phase" of pulse as the evidence of the cardiovascular system efficiency improvement. The physiological significance of HBR "negative phase" phenomenon requires an additional research.

Access this article online	
Website: jprsolutions.info	ISSN: 0974-6943

MATERIALS AND METHODS

To study the peculiarities of changes in HBR and stroke volume of blood (SVB) during the recovery period after a standard muscular load, we examined the athletes engaged in specialized sports schools and specialized in swimming, skiing, gymnastics, and ice hockey. To determine the reaction of the cardiovascular system of athletes to the functional test, the Harvard step test was used. The frequency of HBR and the SVB among athletes was recorded using the unit for computer analysis RPKA2-01, intended for the work in the hardware-software units of medical purpose. To determine the SVB, the tetrapolar thoracic rheography method was used.[6]

RESULTS AND DISCUSSION

At the initial stage of sports training (UTG-1), the children systematically engaged in sports swimming

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Received on: 17-07-2017; Revised on: 29-08-2017; Accepted on: 19-09-2017

had the HBR of 84.1 ± 1.5 beats/min in a sitting position. When the Harvard step was performed, the HBR increased to 109 ± 1.9 beats/minute. After the end of the muscular load of the HBR of young swimmers decreased quickly and at the end of the 1st min of rest, it was established at the level of the initial values. However, at the beginning of the 2nd min of the recovery process, the heart rate decreased to 79.9 ± 1.2 beats/min, which was 4.2 ± 1.1 beats/min lower than the baseline heart rate ($P < 0.05$). "Negative phase" of HBR was observed for 40 s. At the end of the 3rd min of rest, a short-term decrease in heart rate was observed again at 4.4 ± 1.2 beats/min below the initial values ($P < 0.05$). Consequently, the young swimmers had the "negative phase" of the HBR at the beginning of the second and the end of the 3rd min of the recovery process. At the stage of special training (UTG-3), the HBR among the young swimmers was 68.9 ± 1.4 beats/min in the sitting position. During the standard muscular load, the HBR of young swimmers increased to 94.5 ± 1.5 beats/min ($P < 0.05$). At the beginning of the 2nd min of the recovery process, the young swimmers experienced the decrease in HBR below the baseline values, i.e., the "negative phase" of the pulse for 30 s. At the end of the 3rd min of rest, the young swimmers experienced the decrease of HBR below the baseline by 4.7 ± 1.2 beats/min ($P < 0.05$) for 30 s. Thus, the young swimmers, during the initial and special training within the recovery process after the Harvard step test, had the heart rate decreases below the initial values, i.e., the "negative phase" of HBR. At the same time, we established the dependence of the "negative phase" of the HBR on the degree of young swimmer training: The higher the level of fitness, the less the duration of HBR "negative phase." At the stage of sports improvement, the HBR "negative phase" among young swimmers was almost not manifested.[7]

At the stages of initial and special training in the recovery period after the Harvard step test performance, the HBR "negative phase" was observed among young skiers as well as among young swimmers. However, the total duration of HBR "negative phase" among young skiers-racers was 50 s less than among young swimmers. At the stage of special preparation, the total duration of HBR "negative phase" among young skiers-racers was 35 s, and it was more than 48 s among young swimmers. As the level of training of young skiers-racers increased, the "negative phase" was observed not so long, and it was practically not manifested at the stage of sports improvement. Consequently, the children who started muscular training at the age of 6-7 (among young swimmers), the duration of HBR "negative phase" is greater than that of the children attending sports at the age of 9-10 years (among young skiers).

Young hockey players and gymnasts after the performance a low-power muscle load during the recovery process had no reduction in the HBR below the baseline values, i.e., the "negative phase" of the HBR was not manifested.

In the process of natural growth and the development of children, sympathetic and parasympathetic influences on the regulation of HBR increase gradually, and in the future, sympathetic influence decreases. The children subjected to systematic muscle training have the decrease in sympathetic and parasympathetic influences on the regulation of heart pumping function, i.e. ,the desire of a body to self-regulation is observed.[1,3] Probably, for this reason, the "negative phase" of HBR among well-trained athletes is not always manifested, which can be associated with a more pronounced decrease of sympathetic influences on the regulation of HBR. Proceeding from the foregoing, it can be argued that the systematic performance of low-intensity exercise, alternated with rest periods, and greatly contribute to the development of fitness bradycardia among children.[8]

The reduction of the HBR is lower than the initial values, i.e. the "negative phase" of HBR in the recovery process after the muscular load performance of low intensity among young athletes is often manifested itself during the stages of initial and special training. During these two stages of a long-term sports training young athletes had a more pronounced reduction of HBR. The received data testify that the HBR decrease below the initial values after the performance of muscular load by young athletes is manifested to a greater extent at the time when the development of fitness bradycardia takes place at significant rates. Therefore, it can be argued that one of the factors contributing to the development of fitness bradycardia is the HBR reduction below the baseline one after the performance of muscle load with low intensity. With the established bradycardia of training young athletes have a rare "negative phase" of pulse, and sometimes, it is completely absent. Consequently, the development of HBR "negative phase" after the performance of low-intensity muscle load can be considered one of the previously manifested mechanisms for the development of fitness bradycardia.[9]

The SVB among young swimmers at the initial stage of sports training (UTG-1) in the sitting position was 57.2 ± 2.0 ml. During the Harvard step test performance, the systolic ejection increased up to 92.7 ± 2.1 ml ($P < 0.05$). After the completion of the Harvard step test, the systolic ejection of blood was significantly reduced among young swimmers and at the end of the 1st min of rest, it was established at the level of the initial values. However, at the end of the 2nd min of the recovery process, there was a short-term decrease in the SVB to 48.4 ± 1.2 ml. This value was by 8.8 ± 1.2 ml lower in comparison with the initial values ($P < 0.05$), i.e. we observed the "negative phase" of the SVB among young swimmers. SVB among the young swimmers during the stage of special training

(UTG-3) in the sitting position before the muscular load performance made 87.8 ± 1.9 ml. During the Harvard step test performance, systolic blood release increased to 124.7 ± 1.7 ml ($P < 0.05$). By the end of the 1st min of rest, SVB fell to its initial values. At the beginning of the 3rd min of the recovery process, there was a short-term decrease in SVB down to 78.5 ± 1.3 ml, which is 9.3 ± 1.2 ml below the initial values, i.e., there was the "negative phase" of SVB ($P < 0.05$). Thus, young swimmers, at the initial and the special stages of sports training, after the Harvard step test performance, had SVB decreases below the initial values, according to the type of HBR "negative phase." However, in the subsequent period, i.e., at the stage of sports perfection, young swimmers do not demonstrate the decrease of SVB below baseline values.

Young skiers-racers had the SVB 63.4 ± 1.5 ml at the initial stage of sports training (UTG-1) in sitting position. During the performance of the muscular load systolic ejection reached 91.1 ± 1.7 ml ($P < 0.05$). After the end of the muscular load, SVB values rapidly decreased and by the end of the 1st min of the recovery process, the SVB values decreased to 53.5 ± 1.4 ml, which was 9.9 ± 1.2 ml less than the baseline values ($P < 0.05$). At the stage of the special training (UTG-2) young skiers-racers showed SVB decrease to 65.0 ± 1.4 ml for 30 s at the beginning of the 2nd min of the recovery process, which is 8.6 ± 1.2 ml less in comparison with the initial values ($P < 0.05$). At the stage of sports perfection, the decrease of SVB less than the initial values was not observed after the muscular load.

SVB reduction below the baseline one was not observed after the muscular load by young hockey players and gymnasts.

DISCUSSION

Obviously, the decrease in the SVB below the initial values after the Harvard step test has the following physiological genesis. A heart after a muscular load tends to rest and this causes a natural decrease in the SVB. With the decrease in the SVB, there is an opportunity for the development of heart muscle, as Marcosyan once said. In its turn, the development of the heart muscle leads to the increase in cardiac contraction. SVB "negative phase," in our opinion, contributes to the increase of cardiac contraction force. According to Parin, a trained heart is characterized by the increase of the heart volume against a background of a large cardiac ejection without a preliminary dilatation, i.e., the increase in the SVB occurs due to a stronger contraction of the heart muscle. Therefore, paradoxically, the observed decrease in the SVB below the initial values during the recovery period after the performance of a low-intensity muscle load contributes to the increase in systolic blood ejection.

The analysis of the HBR and SVB "negative phase" among young swimmers and racers during the recovery period, after the Harvard step test, revealed a definite relationship between these two phenomena. During the recovery period, the highest values of the SVB were observed to a greater extent during the "negative phase" of the HBR, and on the contrary, relatively small values of the SVB were noted at a high HBR. In our opinion, this indicates the physiological phenomenon of the intercompensation nature of HBR changes and the SVB.

CONCLUSIONS

1. Young athletes, after the performance of low-intensity muscular load, show a short-term decrease of HBR and SVB below the initial values, i.e., the "negative phase" of HBR and SVB.
2. The decrease in HBR and SVB below the baseline values is most often observed during the period of the most intensive development of fitness bradycardia.
3. With the established fitness bradycardia among young athletes, the "negative phase" of HBR and SVB is registered much less often.
4. The "negative phase" of HBR and SVB is more pronounced among young sportsmen specializing in sports demanding endurance.

ACKNOWLEDGMENTS

The work is performed according to the Russian Government Program of Competitive Growth of Kazan Federal University.

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