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TRACKING OF CHANGES IN ANTHROPOMETRIC AND ANAEROBIC PARAMETERS OF ELITE GYMNASTS

T. Dzimbova*, A. Markov

Faculty of Public Health, Health Care and Sports, South-West University "Neofit Rilski", Blagoevgrad, Bulgaria

ABSTRACT
PURPOSE: The aim of the present study is to track changes in anthropometric and anaerobic indicators of elite gymnasts over a period of one year. METHODS: Measurements of anthropometric data and anaerobic capacity of upper and lower limbs were carried out with the Wingate test twice, at the beginning and at the end of the one-year period. RESULTS: Lower and upper limb power data during this period showed that there were no statistically significant differences in measurements of maximum leg and arm power, relative maximum leg and arm power, and decline in leg and arm performance in the study group, although all mean values increased. CONCLUSIONS: The cycle ergometry test, although is a standard test for determining maximum power, includes movements that are not typical of gymnastics. This means that the results most likely do not correspond to the true capabilities of the athletes. However, the results obtained could be used to monitor the fitness of gymnasts, and also they could be compared with other gymnasts or athletes involved in other sports.

Keywords: Wingate test, Peak power, Work capacity

INTRODUCTION

Artistic gymnastics is characterized by a very high level of strength, flexibility, and muscular endurance combined with speed and coordination (1). Men compete on six different apparatus. Men's artistic gymnastics routines vary in duration: ~5 seconds on vault, ~35 seconds on rings, pommel horse, parallel bars, and high bar, and ~70 seconds on floor (2). The physical abilities required to successfully perform each apparatus vary considerably depending on the neuromuscular strength, power, flexibility, speed, coordination, balance, and energy system demands required (3). The routines of vault, pommel horse, parallel bars, and high bar are primarily fueled by anaerobic metabolism. During the vault, the primary source of energy comes directly from the breakdown of ATP and creatine phosphate in the muscle with a small contribution from glycolysis and a small contribution from aerobic metabolism. The pommel horse, parallel bars, and high bar routines are mainly powered by glycolysis after an initial contribution of high-energy phosphates, with the aerobic contribution increasing with the duration of the routine. This means that this sport requires high anaerobic power, as the technical difficulty is constantly increasing. According to the latest Code of Points (2025-2028), the levels of technical skills have been increased to 10 (A, B, C, D, E, F, G, H, I, J). In addition to these levels being associated with increasing difficulty, a routine that contains elements with a higher level of difficulty has a higher starting score. This forces gymnasts to learn more difficult skills, ensuring a higher starting score, which, if performed well, leads to a better competitive result.

Gymnastics training begins in early childhood (5-6 years), with the volume and complexity of training constantly increasing. Thus, gymnastics training causes significant physiological stress, which affects the homeostasis of the body and its functioning (4). Gymnastics training undergoes continuous changes associated with an increase in the duration. An elite gymnast spends an average of 5-6 hours in the gym. Gymnasts train about 1500 hours a year, with training taking place on

Tatyana Dzimbova, Faculty of Public Health, Health Care and Sports, South-West University "Neofit Rilski", Blagoevgrad, Bulgaria, 66 Ivan Mihailov str., Blagoevgrad, tel. 0898939285, email: tdzimbova@swu.bg

300-310 days (5). The time spent training increases with age and the level at which gymnastics is competed, and can reach from 27 hours per week (6, 7) to 32-36 hours per week for elite competitors (8). Long-term training is undoubtedly important for improving important qualities for gymnasts such as flexibility, coordination, and developing muscle strength and endurance, as even young gymnasts have a high anaerobic capacity.

The aim of the present study is to track changes in the anthropometric and anaerobic parameters of elite gymnasts over a period of one year.

METHODS

Subjects of the study

The study involved 9 gymnasts from the Bulgarian men's national gymnastics team (age 17.7 ± 2.3 years). The study was approved by the Research Ethics Committee of the South-West University "Neofit Rilski", Blagoevgrad, and each participant in the study or their parents signed a declaration of informed consent. The study was conducted twice over a period of one year. Anthropometric and anaerobic parameters were measured.

Anthropometric measurements

The day before the measurement, the participants were asked to limit their physical activity. Height and girth were determined with an accuracy of 0.5 cm. Weight and body composition were determined using an IOI 353 bioelectrical impedance analyzer, and for the purpose of the study, data for LBM, BF and SLM were used.

Wingate test

The research is conducted on Monark 828E bicycle ergometer for lower limbs and Monark Ergomedic 891E for upper limbs. Both tests involved 30 seconds of maximum load with a fixed weight of 7.5% of the weight of the subject. Peak power was the maximum power for the first 5 s. The relative maximum power was obtained by dividing the maximum power by the subject's weight.

Data analysis

GraphPad Prism (Ver. 3.0) was used for data processing and analysis. Means and standard deviations of all variables were calculated using descriptive statistics. Experimental data are presented in two ways: - as mean values ± SD; and – as individual values for each subject. Statistical software GraphPad Prism was used for statistical analysis of the results (Wilcoxon signed rank test).

RESULTS

The study was conducted twice over a period of one year. Both the average values of the team indicators of the competitors and their individual values were compared. The group of subjects studied consisted of 9 elite gymnasts, part of the national artistic gymnastics team of Bulgaria. They were aged 15 to 20 years at the beginning of the study (17.7 ± 2.3 years). The anthropometric data are presented in **Table 1.**

Table 1. *Anthropometric data of the subjects studied at both measurements over a period of 1 year.*

ID	Height, cm		Outstretched arms distance, cm		Wegiht, kg		SML,kg		BF, %		MM, %	
	1	2	1	2	1	2	1	2	1	2	1	2
G1	158,5	167,0	168,0	170,0	44,6	53,5	41,7	49,0	6,5	4,5	48,5	47,3
G2	167,5	167,5	172,0	172,0	54,8	58,5	50,9	54,2	7,2	7,4	48,4	48,1
G3	152,0	161,0	164,0	165,0	43,8	52,4	40,6	47,2	7,3	9,9	46,4	47,0
G4	161,5	161,5	167,5	167,5	58,1	56,8	53,4	51,9	8,1	8,6	48,6	48,5
G5	165,0	165,0	166,0	166,0	47,5	55,0	42,8	49,2	9,9	10,5	45,3	47,1
G6	166,5	170,5	171,0	171,0	55,5	59,5	51,5	54,0	7,2	9,2	49,6	47,6
G7	162,0	162,0	169,0	169,0	56,5	55,5	51,9	50,5	8,2	9,0	53,7	52,4
G8	157,0	157,0	164,0	164,0	51,2	54,5	47,3	50,2	7,6	7,8	48,2	48,4
G9	161,0	161,0	170,0	170,0	61,0	61,0	54,8	53,9	10,1	11,6	46,6	45,6
Mean	161,2	163,6	167,9	168,3	52,6	56,3	48,3	51,1	8,0	8,7	48,4	48,0
± SD	4,9	4,2	2,9	2,8	6,1	2,9	5,4	2,5	1,2	2,0	2,4	1,9

1 – First measurements, 2 – second measurements, ±SD – standard deviation

Despite the changes in height in some of the subjects, there was no statistically significant difference (Wilcoxon signed rank test) in height at both measurements. There was no statistically significant difference in both measurements of the gymnasts' outstretched arms distance, which correlated with height. However, when measuring weight, there was a statistically significant difference in both measurements (Wilcoxon signed rank test, P value = 0.039).

Table 2 presents the data from the anaerobic test for lower and upper limbs.

Table 2. *Anaerobic parameters of lower and upper limbs in both measurements over a period of 1 year.*

ID	Maximal power (leg), W		Relative maximal power (leg), W		Decline in the working capacity (leg), %		Maximal power (arm), W		Relative maximal power (arm), W		Decline in the working capacity (arm), %	
	1	2	1	2	1	2	1	2	1	2	1	2
G1	689,2	811,4	15,5	15,2	67,2	72,7	467,7	513,5	10,5	9,6	77,9	69,0
G2	692,0	761,1	12,6	13,0	61,7	58,5	478,3	549,1	8,7	9,4	61,0	71,2
G3	505,2	713,1	11,5	13,6	59,2	61,0	408,8	568,8	9,3	10,9	60,2	65,7
G4	525,6	565,1	9,0	9,9	54,7	59,4	536,8	627,5	9,2	11,0	57,4	69,7
G5	403,8	490,7	8,5	8,9	52,5	71,1	289,4	291,0	6,1	5,3	62,7	48,9
G6	687,3	720,3	12,4	12,1	70,8	62,9	372,8	495,0	6,7	8,3	53,2	59,3
G7	726,1	626,5	12,9	11,3	61,3	47,2	441,2	406,3	7,8	7,3	53,2	47,6
G8	576,4	647,8	11,3	11,9	56,0	60,9	577,0	624,9	11,3	11,5	74,4	71,4
G9	673,2	552,5	11,0	9,1	67,1	56,7	499,1	583,4	8,2	9,5	59,6	60,3
Mean	608,8	654,3	11,6	11,7	61,2	61,2	452,3	517,7	8,6	9,2	62,2	62,6
± SD	110,8	105,9	2,1	2,1	6,2	7,6	87,1	109,4	1,7	2,0	8,6	9,2

1 – First measurements, 2 – second measurements, ±SD – standard deviation

When measuring the anaerobic power of the lower and upper limbs during this period, it turned out that there were no statistically significant differences in the measurements of maximum power of the legs and arms, relative maximum power of the legs and arms, and in the decline in the working capacity of the legs and arms in the studied group, although all average values increased.

No correlations were found between anthropometric data and anaerobic power.

DISCUSSION

Short stature is an advantage in gymnastics. In the process of selection in elite gymnastics, athletes with relatively shorter stature remain to compete. In the studied group, only two gymnasts changed their height significantly (one by 8.5 cm and the other by 9 cm), and these are the youngest, and in the third gymnast the change was only 4 cm. The remaining gymnasts did not change their height during this one-year period and probably reached their maximum height. Despite the changes in height in some of the studied individuals, there was no statistically significant difference (Wilcoxon signed rank test) in height in both measurements.

There was no statistically significant difference in both measurements of the gymnasts' outstretched arms distance, which correlates with height.

When measuring weight, however, there was a statistically significant difference between the two measurements (Wilcoxon signed rank test, P value = 0.039). Weight increased by an average of 3.7 kg. Active body mass, however, did not change statistically, nor did the percentage of body fat and the percentage of muscle mass. These data show that despite the change in body mass, the gymnasts maintained their body composition in percentage terms.

Measuring the anaerobic power of the lower and upper limbs during this period, it turns out that there are no statistically significant differences in the measurements of maximum power of the legs and arms, of relative maximum power of the legs and arms and in the decline in the working capacity of the legs and arms in the studied group, although all average values increased.

In seven of the studied individuals, the maximum power of the lower limbs increased, but in only five this was associated with an increase in relative maximum power. Maximum upper limb power increased in eight of the subjects studied, but in only six was this associated with an increase in relative maximum power.

The decline in lower limb performance decreased in four of the gymnasts, with one of them having a decrease in maximum power, but at the expense of improving relative power (the decline decreased from 70.8% to 47.2%). This is a significant improvement in endurance. In the same athlete, an increase in upper limb endurance was observed at the expense of a decrease in maximum power (the decline decreased from 53.2% to 47.6%). Unlike lower limbs, endurance improved in only three of the subjects studied, and these were not subjects with improved lower limb endurance. From this it can be concluded that athletes pay more attention to individual parts of the body during training. This indicator could be useful for athletes and coaches when planning training sessions with the aim of simultaneously improving strength and endurance, both in the upper and lower limbs.

No correlations were found between anthropometric data and anaerobic power. The cycle ergometry test, although a standard test for determining maximum power includes movements that are not typical of gymnastics. This means that the results most likely do not reflect the true capabilities of the athletes. However, the results obtained could be used to monitor the anaerobic fitness of gymnasts, and also be compared with other gymnasts or athletes involved in other sports.

CONCLUSION

Monitoring changes in the anthropometric and anaerobic parameters of gymnasts is of utmost importance and needs to be done constantly. On the one hand, these changes show the real condition of the athletes, and on the other hand, they could serve as a starting point for coaches in recovery, as well as in drawing up a training schedule for the next year. The schedule should be personalized depending on the need to improve certain parameters in the respective gymnast, which will lead to an increase in sports results.

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