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ANAEROBIC CAPACITY OF LOWER LIMBS IS CRUCIAL FOR GYMNAST'S PERFORMANCE

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(Original scientific paper)

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Abstract
Artistic gymnastics is a sport in which athletes perform short routines (ranging from about 30 to 90 seconds) on different apparatuses and requires physical strength, power, agility, flexibility, grace, control, coordination, and balance. The aim of the present study was to investigate how anaerobic capacity is important for routine tests during preparation period of gymnasts. Thirteen subjects (8 males and 5 females, age 10.8±1.9 years, height 143.1±12.6 cm, weight 36.4±10.2 kg) participated in the study. We choose two test that are common for males and females that gymnasts pass during their preparation period (long jump and repeated jumps). Body Analyser was used for determination of their body mass and body composition IOI353, and for anaerobic capacity – Wingate anaerobic test and Sargent Jump test was used. There are strong correlations between long jump performance and height, weight, muscle mass, BMI, and power determined by two methods. There are correlations between muscle mass, BMI and repeated jumps. Both tests rely on strength of lower limbs so the anaerobic capacity is very important. They could be used to track the effect of strength training of gymnasts.

Key words: *Wingate test, Sargent jump test, long jump, repeated jumps*

Introduction

Artistic gymnastics is a sport where the overall strength and dexterity, boosting muscle strength are crucial. Muscle strength and power is very important for explosive movements such as jumps (Benefice & Malina, 1996). On vault, balance beam and floor the explosive force of the legs plays an important role in the connecting elements and the acrobatic series. Jumping is one of the most important movements in floor combinations and vaults and is developed by gymnasts at an early age as part of daily training (Marina & Torrado, 2013). Children are more often engaged in very intense, short-duration activities than in less intensive activities of longer duration (Bailey et al., 1995). Moreover, most daily tasks, games, or youth sports primarily require short bursts of intense exercise (Rowland, 2005). At the beginning of their carrier gymnasts work mainly aerobically, but over the time an increase in both the volume and intensity of training for strength and power required for difficult technical skills lead to improving the anaerobic capacity. Gymnasts are encouraged to learn more difficult skills from an early age, to ensure a higher start value that leads to a higher score, in order to reach the highest levels of competition. This suggests that modern artistic gymnasts have to develop their anaerobic metabolism at an early age in order to perform at the highest technical levels. Nowadays, it is very common to see two-year-old children in a gymnasium initiation programme, because it typically takes about 10 years for a gymnast to reach the elite level (Jemni, 2011).

Currently, there is no specific ergometer to assess gymnasts. Sport scientists commonly apply standardized ergometry tests in the laboratory or in the gym. The Wingate test consists of measuring not only the peak power generated during the first 10 seconds of a full out 30-second cycling exercise but also the mean power generated during the same period. Regrettably, gymnasts are not used to cycling or arm cranking and therefore they are somewhat disadvantaged compared to other athletes. However, performing such recognized standard tests allows for comparisons with other athletes.

Gymnasts perform different types of jumps during their daily practice, in particular in floor exercises and vault routines. Gymnastic bouncing, tumbling and short run-ups followed by dynamic take-offs require the stretch-shortening cycle of muscles. So, the jumping test is more appropriate for gymnasts' power determination. A variety of jumping tests have been devised since Sargent (Sargent, 1921) came up with his first test (Bosco, 1985; Bosco & Komi, 1979).

The aim of the present study was to investigate how anaerobic capacity is important for routine tests during preparation period of gymnasts.

Material & methods

Subjects

Thirteen subjects (8 males and 5 females, age 10.8±1.9 years, height 143.1±12.6 cm, weight 36.4±10.2 kg) participated in the study. It was conducted on January of 2020. Prior to the study, participants were asked to refrain from physical exercise, food, and fluid intake. A parent of each participant in the study signed a declaration of informed consent and the study was approved by the Scientific Research Committee of South-West University "Neofit Rilski". The subjects came once at the Center for Functional Studies in Sport and Kinesitherapy of South-West University "Neofit Rilski" - Blagoevgrad, where the anthropometric measurements were made.

Determination of body composition was done with Body Composition Analyzer, model IoI 353. The participants in the study were wearing the lightest possible clothes and took off socks before the measurement. From the obtained results, we used Body Mass Index (BMI) and Soft Lean Mass (SLM) or muscle mass.

Wingate test

The test is carried out with the Monarch 828 E mechanically-braked cycle ergometer. The Wingate typically involves 30 seconds of maximal exercise on either an arm-crank or leg-cycle ergometer. The testing device is a mechanically-braked cycle ergometer. Following a five-minute warm-up, which includes three sprints at varying resistances, the athlete may get off the bike during a three-minute recovery or stay on the bike and spin lightly. The athlete then begins to pedal as fast as possible without any or minimal resistance. Within three seconds, a fixed resistance is applied to the flywheel and the athlete continues to pedal “all out” for the duration of the test (e.g. 30 seconds). The resistance is applied to the flywheel by adding a predetermined amount of weight to the bicycle’s weight tray. The resistance is a percentage of the athlete’s body weight. At the end of the test, the maximum power (Peak Power) is set for 5 seconds. This is the maximum power the person can develop during the first 5 seconds. The relative maximum power is determined by dividing the maximum weight of the subject's weight. The system also allows determining the average power for 30 seconds.

Sargent test

The purpose of this test is to determine the explosive force of the muscles of the lower limbs (Sargent, 1921). We need a wall, a centimeter strip of 1 meter long, a chalk and an assistant to perform the test. The subject puts chalk on the tip of his fingers. He stands sideways to the wall with the two soles firmly on the ground, stretches one hand at a maximum and marks the wall reached with his fingers (M1). He jumps to the maximum height from a fixed positon and again marks the wall with chalk-coated fingers (M2). The difference M2-M1 was determined. The test is conducted three times, taking the best achievement.

The prediction equation (1) of Sayers et al. (1999) was used to calculate the peak power of the legs.

(1) Peak power (W) = 60.7 x VJ (cm) + 45.3 x mass(kg) – 2055, where Peak power - maximum power, VJ - height of the vertical jump (cm), mass - weight of the person under study (kg).

To date, a prediction equation for children is not validated, so the Sayers equation, which includes the height of the jump and mass of the participant (Taylor, et al., 2010) has been used. This equation, developed by jumps performed on a rebound platform, has a difference in adults of 2.7% with the power calculated by the platform (Sayers, et al., 1999). The Sayers equation is an improvement of the Lewis formula (Fox & Mathews, 1974), which is reported to underestimate the projected peak power by 70% (Harman, et al., 1991). It is also recommended as a substitute for Lewis's physical assessment score (Payne, et al., 2000).

Field Tests

Two tests common for male and female were performed in the gym – long jump (a) and repeated jumps (b).

a) Long jump is a common and easy to administer test of explosive leg power. The athlete stands behind a line marked on the ground with feet slightly apart. A two foot take-off and landing is used, with swinging of the arms and bending of the knees to provide forward drive. The subject attempts to jump as far as possible, landing on both feet without falling backwards. Three attempts are allowed. Gymnasts get point for their jumps (Хаджиев, 1976).

b) Maximal repeated jumps: from a lying position on the back and with a full body extension, the subject stands up and makes a vertical jump with arms swing, then gets back to the initial position, this is repeated 15 times for 30 s. The subject obtains points (Хаджиев, 1976), and the maximal points that can be obtained are 50.

Data analysis

For data processing and analysis GraphPad Prism (Ver 3.0) were used. The mean values and standard deviations of all variables were calculated by descriptive statistics. For the data analysis we conducted Pearson correlation analysis for the control of the relationship between the measured variables.

Results

Means and standard deviations of the measured anthropometric parameters and the athletes' performance in selected technical skills are presented in table 1.

Table 1. Anthropometric parameters, data from anaerobic tests and technical characteristics of young basketball players ($M \pm SD$).

Variable	**N=15**
Age (years)	10.8 ± 2.0
Height (cm)	143.1 ± 12.6
Weight (kg)	36.4 ± 10.2
SLM (kg)	28.9 ± 7.8
BMI (kg/m^2)	17.4 ± 2.0
Vertical jump (cm)	32.7 ± 5.1
Power, Sayer's eq. (W)	1577.3 ± 641.9
Peak power, WT (W)	246.9 ± 79.5
Relative peak power, WT (W/kg)	6.1 ± 1.2
Long jump (point)	19.8 ± 19.8
Repeated jumps (points)	40.0 ± 10.8

SLM – soft lean mass, BMI – body mass index

Correlations between all of the measured variables are presented in the below table 2.

Table 2. Pearson correlations between all the measured variables.

	Age	**BH**	**BW**	**SLM**	**BMI**	**VJ**	**CP**	**PP**	**RPP**	**LJ**	**RJ**
Age	1.00	0.92 ***	0.91 ***	0.86 ***	0.79 **	0.25 ns	0.77 **	0.55 ns	-0.7 ns	0.70 **	0.42 ns
BH		1.00	0.98 ***	0.90 ***	0.82 ***	0.36 ns	0.87 ***	0.71 *	0.08 ns	0.68 **	0.28 ns
BW			1.00	0.93 ***	0.92 ***	0.36 ns	0.89 ***	0.77 *	0.13 ns	0.70 **	0.41 ns
SLM				1.00	0.87 ***	0.38 ns	0.85 ***	0.77 *	0.23 ns	0.71 **	0.48 ns
BMI					1.00	0.32 ns	0.82 ***	0.84 **	0.23 ns	0.66 *	0.59 *
VJ						1.00	0.75 **	0.63 ns	0.72 *	0.46 ns	0.25 ns
CP							1.00	0.85 **	0.48 ns	0.73 **	0.41 ns
PP								1.00	0.72 *	0.75 *	0.52 ns
RPP									1.00	0.56 ns	0.63 ns
LJ										1.00	0.74 **
RJ											1.00

BH – body height; BW – body weight; VJ – vertical jump; CP – calculated power by Sayer's equation; PP – peak power; RPP – relative peak power; LJ – long jump; RJ – repeated jumps. * = $p<0.05$; ** = $p<0.01$; ***=$p<0.001$; ns = non significant correlation.

Discussion

Currently, the Wingate anaerobic test (WT) in a laboratory setting on a cycle ergometer is accepted as golden standard for determining anaerobic performance. Performing a WT requires a combination of phospholytic, glycolytic, and aerobic power. Peak power (PP) reflects the ability of the leg muscles to produce short term mechanical power (peak phospholytic power), whereas mean power (MP) best represents glycolytic power (local muscle endurance) of the legs. The WT has shown to be reliable and valid even in children and adolescents with various chronic conditions. Some authors suggest shortening the Wingate test in children and running it instead of 30 seconds for 20 seconds (Chia et al., 1997), as the reason for this was that children work mainly in aerobic mode even at highly intensive loads. This test determines the anaerobic capacity, which is extremely important in gymnastics. Most of the exercises required both technique and great explosive force. Children work mostly in aerobic mode, but under the training their body gradually adapts to the anaerobic regime. Usually, children started practicing gymnastics very early (about 3-4 years) when they started with general training and gradual inclusion of power elements. Even the smallest in the studied group had a gymnastics experience of about 4 years, time enough to bring about some adaptations.

Sargent test measured the vertical jump height. Along with height of the jump we calculated the peak power of the subjects. Because the Sayers formula counted the weight of the participant, the maximum power correlated better with the muscle mass.

The results of long jump test well correlate with age, height, weight, soft lean mass and BMI, while those of repeated jumps test – only with BMI. The long jump also depends on calculated and peak power. In order to perform better in long jump, explosive power of legs is very important. A jump is the final part of repeated jumps test, so the technical skills are even more important than power. The results of both tests corelate well. This means that when the gymnast is well-trained physically and technically, he performs well in both tests. Usually with years of training, the results of both tests get improved. The long jump shows the dependence on the age clearly, while in the long jump this dependence is not significant. Consideration should also be given to the fact that gymnasts perform the tests for the first time and without prior preparation. In the next test, they are likely to show better results.

Test batteries are an extremely important way of tracking the physical and technical development of athletes. Coaches often do not find time in the busy training program of the athletes to conduct them. But, along with functional tests, they are the most appropriate tool, the results of which would help to adjust the training to improve it.

Conclusions

Anaerobic capacity is extremely important in gymnastics. Increasing it leads to better jump tests results and, accordingly, enables gymnasts to perform more technically sophisticated elements more easily and with greater precision.

Conflicts of interest - The author declares that he has no conflicts of interest.

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