Anaerobic Power Profile

Talent-Selected Female Gymnasts Age 9-12 Years

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ABSTRACT:
Anaerobic Power Profile: Talent-selected Female Gymnasts Age 9-11

The purpose of this study was to descriptively characterize the anaerobic power and capacity of young talent-selected female gymnasts. A repeated jumps test was chosen to explore anaerobic power and capacity in an effort to simulate the dominant skills of gymnastics. Sixty-three female gymnasts between 9-12 years old participated in the study. The gymnasts performed a test of repeated jumps for 60 seconds with controlled knee flexion during landing and hands constrained to grasping the waist throughout the test. Data were collected via custom computer software, apparatus, and interface. Results showed that the gymnasts reached peak average power during the 10-20 second time interval. Mean total average power was 28.4 W/kg. No statistically significant difference between age groups, between test time intervals, nor the interaction were found. The results of this study indicate these young gymnasts were more powerful than their Senior National Team counterparts, and that the power values were dramatically higher than those obtained by Wingate-type tests. We conclude that repeated jumps-type tests are worthy of further research.

Portraying the characteristics required for high level performance is often difficult due to a lack of agreement on definitions and the multi-dimensional nature of human performance. While scientists continue to debate the role of the various biochemical pathways in producing the energy needed for muscle tension, a practical framework for evaluating relatively short term power and capacity has been proposed by Bouchard, Taylor, Simoneau, and Dulac (1991). These investigators characterized anaerobic power and capacity as energy production which is dominated by non-oxidative processes. Moreover, the authors described the energy production in three categories:

- short-term anaerobic performance capacity which occurs during maximal exercise lasting less than about 10 seconds.
- intermediate-term anaerobic performance capacity which occurs during maximal exercise lasting about 30 seconds.
- long-term anaerobic performance capacity which occurs during maximal exercise lasting about 90 seconds.

Gymnastics involves anaerobic power and capacity in all of these categories. Vaulting is performed in 5-10 seconds, uneven bars in 30-40 seconds, and balance beam and floor exercise are performed in 100 to 120 seconds. Characterizing anaerobic power and capacity capabilities of gymnasts has been undertaken primarily by Wingate or Wingate-type tests (Heller, Tuma, Dlouha, Bunc, & Novakova, 1998; Moffatt, Surina, Golden, & Ayres, 1984; Montgomery & Beaudin, 1982; Sands, et al., 1987a). The Wingate test involves pedaling a bicycle ergometer against a relatively high resistance that is based on body mass (Bar-Or, 1987; Bar-Or, Dotan, & Inbar, 1977; Bouchard et al., 1991; Smith & Hill, 1991). The Wingate test involves concentric tension almost exclusively, and therefore cannot reflect the stretch-shortening cycle activity that predominates in gymnastics performance.

Jumping and landing predominates in women's gymnastics. Only the uneven bars emphasizes skills that do not involve jumping and landing movements except for the mount and dismount. In light of this, a jumping test involving repeated jumps over a prescribed duration would appear to be more sport-specific for gymnasts than the typical Wingate test (Sands, W. A., 2000a). Bosco has designed a repeated jumping test involving various durations (Bosco, 1985; Bosco, Luhtanen, & Komi, 1983; Bosco, Mognoni, & Luhtanen, 1983).

The purpose of this study was to descriptively characterize the anaerobic power and capacity of talent-selected female gymnasts between 9 and 12 years of age using a test that more closely resembles the type of movements used by gymnasts. This study may serve as a starting point to provide useful comparison for future tests of female gymnasts and their anaerobic power and capacity capabilities.

Methods

Participants. Approximately seventy of the best gymnasts from an initial population of nearly 1500 were selected by USA Gymnastics and invited to a December 2000 training camp (Sands, W. A., 1993, 1994; Warren, 1995). Sixty-three of the female gymnasts (10.2±1.1 yr; 135.0±7.4 cm; 30.1±5.1 kg) participating in the annual training camp volunteered to participate in this study. This study was approved by California Lutheran University Institutional Review Committee on human subjects.

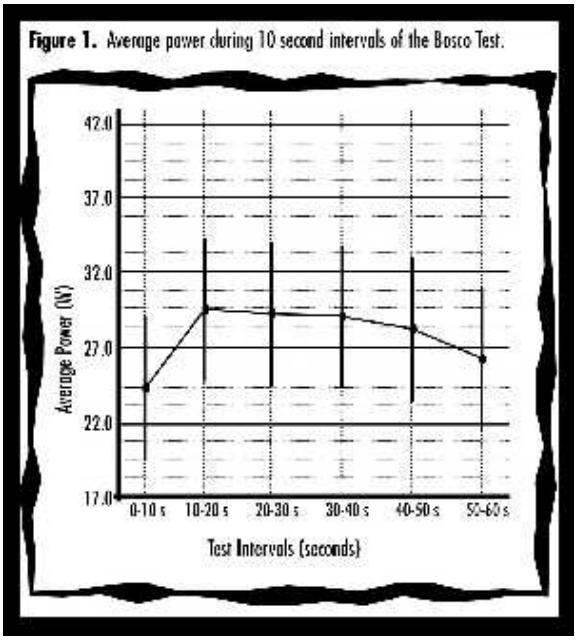
Instrumentation. The gymnasts were assessed for jumping power via custom computer software and custom switch mats. The computer was programmed to record both the ground-time and flight-time of each jump. The switch mats were computer interfaced via the parallel port (Bergsman, 1994). The timing software was accurate to microseconds (Ryle Design, 1995). The duration of the test was also controlled by the computer. The average power for the test duration and the average power for each 10 second interval were calculated and stored.

Procedures. Data collection began with height and mass measurements. Age was recorded to the nearest year. The gymnasts then received instructions on test performance. The gymnasts were required to flex their knees to approximately 120 degrees during each landing. The chosen knee angle represents roughly the middle of a range of gymnastics-related tumbling, jumps, and landings based on kinematic analyses (Sands & McNeal, 1997). A plastic goniometer was used to demonstrate the flexion position for each gymnast prior to each test. The investigator then observed all landings during the test and directed the gymnast to bend more or less depending on her landing performance. Gymnasts were instructed and then verbally encouraged to repeatedly jump as high as they could on each jump, return to a 120 degree flexed position on landing, and then jump again as high as they could. The gymnasts were also encouraged to jump as rapidly as they could. The hands of the gymnasts remained on their waists throughout the test to avoid upper extremity contribution to jump height. The duration of the test was 60 seconds. The protocol is described by Bosco and colleagues (Bosco, Luhtanen, & Komi, 1983; Bosco, Mognoni, & Luhtanen, 1983), and listed among tests for elite athletes (Bouchard et al., 1991) and children (Van Praagh & Franca, 1998).

Analysis. Due to the exploratory nature of this study descriptive statistics and correlations were calculated. Inferential statistics consisted of a 3 by 6 (age group by test interval) ANOVA with repeated measures on the second dimension. The age groups were: 9 yr (n=20), 10 yr (n=20), 11 yr (n=12), 12 yr (n=11). Due to the disparity in size of the age groups, the 11 and 12 yr ages were analyzed as a single group.

Results

The mean total jumps performed by the gymnasts in 60 seconds was 96.2 jumps (±8.4 jumps). Average power over the full test duration was 28.4 W/kg body mass (±6.5 W/kg). Figure 1 shows the means and standard deviations of the average power for each 10 second timing interval of the 60



second test. Note that the maximum average power achieved during a 10 second interval occurred during the interval from 10-20 seconds and exceeded 30 W/kg body mass. Following the maximum average power there appears to be a gradual decline in average power through the 20-40 second intervals, followed by a rapid decline after 40 seconds.

Analysis of these data showed that there were no statistical differences based on time intervals, age groups, or the age groups by time intervals interaction (all $p>.05$). Table 1 shows the Pearson Product-Moment correlations of the average power during each timing interval and the total average power.

Table 1. Correlations

Variable: Average Power						
Total (60 s)	0-10 s	10-20s	20-30s	30-40s	40-50s	50-60s
0-10 s	.80	.88	.90	.92	.91	.85
10-20 s	.74	.76	.67	.64	.50	
20-30 s		.74	.75	.76	.72	
30-40 s			.81	.75	.67	
40-50 s			.81	.78		
50-60 s				.80		

Note: All correlations in Table 1 are statistically significant ($p< .01$).

Discussion

The magnitude of the power performance of these athletes is quite high. Previous investigation of U.S. Senior National Team members using the same protocol and instrumentation found the mean total average power was 23.7 ± 5.0 W/kg, and the peak power mean value for the 10-20 second interval was 25.3 ± 5.7 W/kg (Sands, 2000b). The younger athletes in this study outperformed their senior counterparts by more than 16% in total average power and by 17% in their peak average power. This performance disparity may reflect the decline in strength and power relative to body mass and age that has been seen in female gymnasts as they mature (Irvin, Major, & Sands, 1992; Sands, Mikesky, & Edwards, 1991). The differences may also be due to the talent-selection process that resulted in the sample of young gymnasts studied here. The TOPs program participants are selected based on the physical abilities and not via a competitive score. In contrast, the Senior National Team athletes are selected based on competition scores, and tests such as the Bosco Test are used only to monitor fitness.

The average power values obtained using Wingate-type tests have been considerably lower than those obtained in this study. Lower extremity average power in Wingate-type tests were 8.6 W/kg (Heller, Tuma, Dlouha, Bunc, & Novakova, 1998) and 7.1 W/kg (Sands et al., 1987b). These dramatic differences are likely due to the mode of testing. Concentric tension is less likely to produce the levels of force and power that can be achieved during tests involving the stretch-shortening cycle (Aura & Komi, 1986;

Bosco, Tarkka, & Komi, 1982; Cavagna, Dusman, & Margaria, 1968; Hudson & Owen, 1985; Komi & Bosco, 1978). Bosco found a similar discrepancy due to test mode with the average power of a 60 second jump test of 20 W/kg versus a 60 second Wingate-type test which elicited 7 W/kg and a Margaria test which showed 14 W/kg (Bosco, Luhtanen, & Komi, 1983).

The correlation matrix of the various time intervals and the total average power indicate that all the variables are intercorrelated. Moreover, it does not appear that any specific test duration is markedly inferior to the 60 second test duration. However, from the standpoint of ease of administration, it appears that a 30-40 second test may be sufficient to discover the overall anaerobic power and capacity capabilities of these gymnasts. The relatively high correlation coefficients indicate that the various time intervals are measuring the same characteristic.

This study has described the average power profile of young talented gymnasts and may serve future research by providing a baseline for comparison of anaerobic power and capacity in this population. Future research should explore the relationship between anaerobic power and capacity and gymnastics routine performance and safety.

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