

MOTIVATION EFFECT ON PERFORMANCE AND HEART RATE IN CIRCUM PUBERTAL AND POST PUBERTAL GIRLS

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Abstract

Purpose of this study was to test whether there are differences between circum puberty and post puberty girls in the motivation effect on exercise performance and heart rate. The Tanner's scale for sexual maturation stages has been used to divide 16 girls of age 13 to 16 years into the circum puberty group (stages II, III, IV, $n=8$) and the post puberty group (stage V, $n=8$). The peak VO_2 was assessed with the aid of incremental cycloergometric test. A 3-min all-out exercise test was performed twice on the bicycle ergometer, either in ordinary condition (ordinary trial - OT) or in condition of a competition for the highest possible work output (competition trial - CT). 5 min cycling at a moderate rate preceded to the test. Two weeks elapsed after the OT before the CT was performed. Work output was recorded every minute and heart rate was recorded continuously. The enhanced motivation induced increased work output during all the three minutes of exercise in the post puberty group, but only during the first min in the circum puberty group. In CT the total work output was increased in 7 circum puberty (by $8\pm 4.9\%$, mean $\pm$ SD) and 5 post puberty (by $15\pm 8.4\%$) girls compared to the OT. A significant motivation effect on heart rate was found in circum puberty girls during the 2nd and 3rd min of exercise, despite the lack of increased work output during these minutes of exercise in CT. Ratio work output/heart rate was increased in both groups during the 1st min of the CT. During the 2nd and 3rd min of CT the ratio was higher than in OT only in the post puberty group. In conclusion, the effects of enhanced motivation associated with increased work output and higher exercise heart rates in majority of girls of both groups. Differently from the post puberty girls, the circum puberty girls were not able to maintain the motivation effect on the performance throughout the exercise although the heart rate response elevated.

Key words: competition situation, dynamics of work output, peak heart rate, sexual maturation

Introduction

Effect of enhanced motivation on performance has been evidenced by several physiological experiments (1, 3, 4, 10). By results of Wilmore (19), in competition situation athletes demonstrated 27 % higher work output than in ordinary conditions. In the anticipatory state before competition (12, 13) as well as in competition situation (11) heart rate increases during exercises more

than during the same exercise performed in ordinary conditions. During competition, typical is hyperglycemia (20), the rise of blood lactate (5, 7, 15), increase of catecholamine output (8, 15) and suppression of insulin secretion are more pronounced (15) than in training session. Recently a possibility of increased peak VO_2 was found in competition situation in conjunction with exaggerated cortisol response (17).

During the pubertal period several critical events take place in the ontogenetic development, including improvement of motor abilities (16). These events may also influence the capacity for mobilization of exercise performance. In order to test this suggestion in female adolescents, the motivation effect on exercise performance and heart rate were compared in circum puberty and post puberty girls.

Material and methods

Sixteen girls of age 13 to 16 years gave informed consent to participate in the study. Assessment of stages of sexual maturation by Tanner's scale (14) enabled to separate circum puberty (sexual maturation stages II, III, IV) and post puberty (stage V) groups. The age of 8 circum puberty girls was 13.5 ± 0.5 and of 8 post pubertal girls 14.1 ± 1.0 years, height 158 ± 8 and 164 ± 6 cm, body mass 45.9 ± 6.7 and 57.0 ± 3.3 kg, body mass index 18.3 ± 1.6 and 20.3 ± 1.9 , respectively (mean $\pm$ SD). Differences between groups were insignificant except the fact that post-pubertal girls were heavier ($p=0.001$). Menarche has been experienced by all girls of the post-puberty group and 3 girls of the circum puberty group. All girls were considered practically healthy by school physician.

Girls performed three exercise trials on separate days. The first trial consisted in an incremental bicycle ergometer test for assessment of the aerobic power as well as for individual choice of exercise load to be used in following exercise trials. In the second and third trials girls performed 5 min warming up (100 W, 70 revolutions per min) and immediately after that a 3-min exercise at the highest possible rate of pedaling. The resistance for pedaling was adjusted by the individual highest power output in the incremental exercise - peak power output minus 20 W. The work output was recorded every minute. Heart rate

was recorded continuously using Polar PE 30000 (Finland). The second trial was the "ordinary" trial (OT) performed in usual laboratory conditions. The third trial was the "competition trial" (CT), which differed from the ordinary trial by the competition between participants for the highest work output in condition of cheering by members of research team and visitors. In order to avoid a possible training influence and diminish the learning effect the CT was performed two weeks after the OT.

Exercise trials took place between 3 and 4 PM at least two hours after meal. The subjects were asked to avoid physical exercises and emotional strain during the day of the experiment as well as a day before.

The differences between results of two groups were evaluated using one-way ANOVA and computing two-tail significance. Probability of differences between "ordinary" and "competition" situations were assessed parametrically with the aid of paired t-test. In order to evaluate the significance of aerobic capacity for changes recorded in second and third trials, the Pearson product-moment correlation coefficient was computed. The acceptable level of probability was designed at $p < 0.05$.

Results

Peak VO₂. The incremental exercise test demonstrated that the peak VO₂ per 1 kg of body mass was in the circum puberty group 36.1 ± 13.6 and in the post puberty group 44.3 ± 6.7 ml $\cdot$ min⁻¹ $\cdot$ kg⁻¹. Difference between groups was insignificant ($p > 0.05$).

Work output. In the ordinary trial post pubertal girls exceeded circum pubertal ones by work output (Table.1). During the first minute of the competition trial, the work output was significantly increased in both groups and during the second minute only in the post puberty group ($p < 0.05$). The total work output was significantly

Table 1. Work output during 3-min exercise (mean ±SD)

Group	Ordinary trial				Competition trial			
	1 st min	2 nd min	3 rd min	Total	1 st min	2 nd min	3 rd min	Total
Circum-puberty	851 ±107	863 ±97	879 ±133	2600 ±331	986 ±169*	894 ±152	893 ±37	2973 ±413*
Post-puberty	968 ±120	968 ±110	1016 ±79	2952 ±482	1054 ±112*	1053 ±68*	1084 ±356*	3176 ±232*
p	0,052	n.s.	0.029	0,038	n.s.	0,024	0,005	0,034

*Significant difference (p<0.05) between ordinary and competition trials by paired t-test
p - probability of difference between groups by t-test for independent samples
n.s. – non significant

increased in both groups. Neither total work output nor its increase by enhanced motivation correlated with the peak VO₂.

Heart rate. A significant motivation effect on heart rate was found in circum puberty girls during the second and third minute of exercise (p<0.05) despite the lack of increased work output during these minutes. In post puberty girls the mean heart rates were slightly higher in competition trial but the differences were not significant. Individual analysis showed that in the competition trial peak heart rates were not elevated in those three girls of the post puberty group who did not show the motivation effect on the work output. Peak heart rate did not correlate with the aerobic power.

Ratio work output / heart rate. In both trials the ratio was significantly higher in post pubertal girls (Fig.1). The motivation effect on the work output increased the ratio during the first minute in both groups and during the second and third minutes only in post pubertal girls.

Ratio of the total work output to peak heart rates was significantly higher in the post puberty group but differences between ordinary trial and competition trial were not significant in any groups (Table 2).

Discussion

In accordance with results of Wilmore (19) the obtained results evidenced that the enhanced motivation in competition situation increases the work output in cyclic

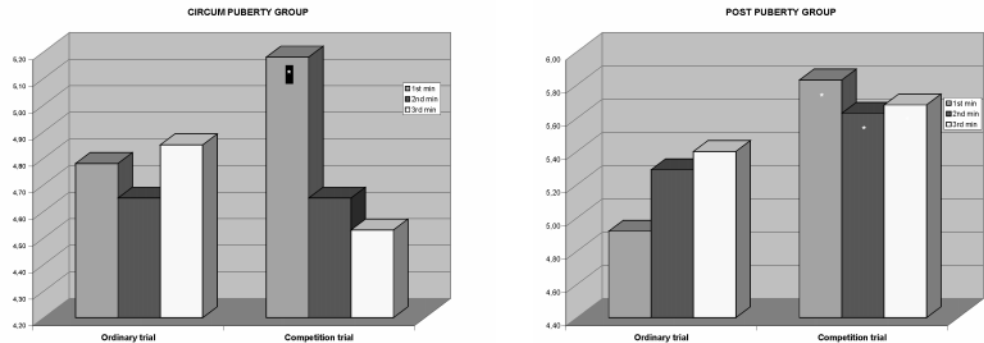


Fig.1. Ratio between work output during a minute and heart rate at the end of the minute. Asterisks denote statistically significant difference (p<0.05) between ordinary and competition trials by paired t-test. In all cases the ratios of the post puberty group (B) were significantly (p<0.05) higher in comparison to the circum puberty group (A) by one-way ANOVA for independent sample.

Table 2. Heart rate at the end of every minute of exercise and the ratio of work output / peak heart rate (means SD)

	Ordinary trial				Competition trial			
Group	1 st min	2 nd min	3 rd min	Ratio	1 st min	2 nd min	3 rd min	Ratio
Circum-puberty	178 ±19	187 ±10	192 ±8	13,5 ±2,0	185 ±13	192 ±8*	197 ±7*	14,2 ±2,4
Post-puberty	177 ±12	183 ±10	188 ±10	15,8 ±1,7	183 ±10	187 ±10	191 ±10	16,8 ±1,3
p	n.s.	0,009	n.s.	0,031	n.s.	n.s.	n.s.	0,025

*Significant difference ($p < 0.05$) between ordinary and competition trials by paired t-test

p – probability of difference between groups by t-test for independent samples

n.s – non significant

exercise. The same was demonstrated by Davidenko et al. (1) who used a payment for enhancing the motivation. The present results showed that in post puberty girls the motivation effect on work output was evident during the exercise in all three minutes whereas in circum puberty girls the increased work output was found only during the first minute of exercise. On the one hand, it is possible that post puberty girls distributed their working capacity in a wiser manner. On the other hand the reason of the difference between groups might be related to a maturation dependent distinction in action of factors limiting work capacity. Since the performance of three-minute all-out exercise should depend in a great extent on the anaerobic capacity, the developmental difference in this quality might be decisive. In late adolescence a substantial improvement of anaerobic glycolytic capacity appears (see ref.16). In present results the essential contribution of anaerobic capacity was indirectly indicated by the lack of significant correlation between work output and peak aerobic power.

The competition situation results in also exaggerated heart rate responses (11, 12, 13). In the present experiment this manifestation was evident during the second and third minute of exercise in circum puberty girls when work output was not increased. At the same time, this result indicates that the enhanced cardiac response was not a

simple consequence of increased work rate. The same was pointed by the increased ratio work output / heart rate.

In exercise, the initial adjustment of heart activity is related to the effect of the central motor command (2) and feedback influence from the muscle proprioceptors (9). In the course of exercise an additive influence will be exerted by muscle metaboreceptors. (9). The latter depends on contribution of anaerobic energy production and should be significant in such a kind of exercise as 3-min all-out cycling. The enhanced contribution of anaerobic energy production might be responsible for the both gradual increase of heart rate during the used exercise test and in condition of the enhanced motivation. However, alternatively, the motivation effect on heart rate might be related to shift in sympathetic/vagal balance controlled by hypothalamic centers. The obtained results provided an opportunity to suggest that circum puberty girls are more sensitive to the influences on heart rate control mechanisms.

Comparison of the two groups of girls showed the superiority of post pubertal adolescents by higher work output and lower exercise heart rate. Previous studies demonstrated reduced mass-related peak VO_2 (6) and of performance in Cooper 12-min running test (18) in girls of advanced sexual maturation. It was in obvious relationship to pronounced gain of body mass in this age.

The probable reasons of the difference between these and present results is that performance on bicycle ergometer is not influenced by body mass, and that in 3-min all-out exercise the performance depends both on aerobic and anaerobic energy metabolism.

In conclusion, the effect of enhanced motivation is manifested by increased work output during short term all-out exercise and exaggerated increase of exercise heart rate whereas the increase of exercise performance is relatively more pronounced than enhanced heart rate response. However, heart rate continued to increase despite the reduction of work output in circum puberty girls. This group of girls is less capable to maintain the motivation effect on the performance during exercise.

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