VESTIBULAR STIMULATION AND CARDIOVASCULAR CHANGES IN 10-12-YEAR-OLD RHYTHMIC GYMNASTS

INTRODUCTION

Rhythmic gymnastics is a sport that develops a variety of motor abilities (whole-body coordination, dynamic balance and static balance, sense of kinaesthesia, whole-body movement time, and eye-hand coordination), and perceptual abilities (whole-body reaction time, anticipation of coincidence, and depth perception) (Kioumourtzoglou et al. 1997; Pavlova and Alexandrova 2001). Some up-to-date studies have considered the physiological and anthropometric determinants of rhythmic gymnastics, and also flexibility, explosive strength, aerobic capacity, body dimensions, and anaerobic metabolism (Pavlova and Alexandrova 2001; Douda et al. 2008; di Cagno et al. 2008). Gymnasts start training at a very young age. It is known that the function of vestibular sensitive system differs slightly from those of adults (Gavriiski et al. 2006). The beginning of puberty growth and development in girls is at about the age of 11-12. Characteristic feature for this age group is asynchronous development of heart and blood vessels, and uncompleted functional and morphological development (Wilmore and Costill 1999; Gavriiski et al. 2006). The rhythmic gymnastics impacts permanently on the balance that is complex-conditioned by different functional systems. Naturally, the vestibular sensitive system plays an essential role for stable static and dynamic equilibrium of the gymnast’s body. From the accessible published data, the information about cardiovascular changes affected by vestibular stimulation was not obtained. The results of our previous study show improvement of the assessment for the vestibular stability of 9 to 12-year-old rhythmic gymnasts subjected to Losanov-Baychenko Test (Pavlova and Alexandrova 2001). With a view to the asynchronous development in this age period, it is important to study that sort of vestibular and autonomic reactions. Therefore, the aim of the present study is to elucidate the controlled vestibular stimulation effect on cardiovascular function and evaluate the vestibular stability through Losanov-Baychenko Test in 10-12-year-old rhythmic gymnasts.

METHODS

Eleven rhythmic gymnasts, 10-12 years old (training experience 2-4 years), from two rhythmic gymnastics sports clubs participated in this study. The girls
were subjected to Losanov-Baychenko Test (Gandelsman 1968; Bitchev et al. 1998). The following experimental protocol was applied: 3 min pre-vestibular stimulation measurements, 10 times controlled rotation in 20 s on Barani chair stimulating the semicircular canals, only one post-vestibular stimulation measurement. Heart rate (HR) and arterial blood pressure (RR) were monitored by Sport tester and the apparatus for automatic measurement. RR was also measured auscultatory to ensure double control. The assessments in degrees have been found on the basis of RR and HR difference values between pre- and post- Barani chair rotation by the Losanov-Baychenko Table. The highest degree is 5. In the original approach mean arterial pressure (MAP), pulse pressure (PP), systolic volume (SV), cardiac output (CO), and double product/rate-pressure product (RPP) were computed to examine the cardiovascular function using the Losanov-Baychenko Test. MAP, PP, SV, CO, and RPP values were calculated by the following equations:

1. Mean values for arterial pressure
   \[
   MAP (\text{mmHg}) = RRd + [0.333 \times (RRs - RRd)]
   \]
   \(RRd\) - diastolic blood pressure; \(RRs\) - systolic blood pressure

2. Pulse pressure
   \[
   PP (\text{mmHg}) = RRs - RRd
   \]

3. Systolic volume
   \[
   SV (\text{ml}) = 93 + 0.54 \times (RRs - RRd) - 0.47 \times RRd - 0.61 \times \text{age (in years)}
   \]

4. Cardiac output
   \[
   CO (\text{l.min}^{-1}) = SV \times HR
   \]
   \(HR\) – heart rate

5. Double product/rate-pressure product
   \[
   RPP = RRs \times HR
   \]
   Descriptive statistics, 2 Related Samples Tests (Wilcoxon T) and nonparametric correlations (Spearman’s Rho) were used for statistical analysis.

**RESULTS**

Descriptive statistics (Mean values±SD) of cardiovascular parameters heart rate (HR), systolic blood pressure (RRs), diastolic blood pressure (RRd), mean arterial pressure (MAP), pulse pressure (PP), systolic volume (SV), cardiac output (CO), and double product/rate-pressure product (RPP) pre- and post-vestibular stimulation are given in Table 1.
Table 1. Descriptive statistics of cardiovascular parameters pre- and post-vestibular stimulation

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre vestibular stimulation</th>
<th>Post vestibular stimulation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>HR [bpm]</td>
<td>88.18</td>
<td>8.04</td>
</tr>
<tr>
<td>RRs [mmHg]</td>
<td>103.64</td>
<td>15.05</td>
</tr>
<tr>
<td>RRd [mmHg]</td>
<td>63.27</td>
<td>9.68</td>
</tr>
<tr>
<td>MAP [mmHg]</td>
<td>76.71</td>
<td>11.21</td>
</tr>
<tr>
<td>PP [mmHg]</td>
<td>40.36</td>
<td>7.39</td>
</tr>
<tr>
<td>SV [ml.min⁻¹]</td>
<td>78.51</td>
<td>4.03</td>
</tr>
<tr>
<td>CO [l.min⁻¹]</td>
<td>6.92</td>
<td>.66</td>
</tr>
<tr>
<td>RPP</td>
<td>9196</td>
<td>1892</td>
</tr>
</tbody>
</table>

The comparison (2 Related Samples Tests - Wilcoxon T) of HR, RRs, RRd, MAP, PP, SV, CO, and RPP between before and after Barani chair rotation shows no significant differences (p>0.05).

The assessments obtained from the Losanov-Baychenko Table are 2.66±1.04 for all rhythmic gymnasts, and 2.06 ±0.37 (10yrs), 2.50±0.98 ((11yrs), 4.25±10 (12yrs) for gymnasts divided into age groups (Fig. 1).

Figure 1. Assessment according to rhythmic gymnasts age groups: 1 - 10 years old; 2 - 11 years old; 3 - 12 years old
This trend of assessment increase when comparing 10 to 12-year-old girls is similar to the reported data of rhythmic gymnasts in our previous research carried out in the field (Pavlova and Alexandrova 2001).

Significant correlations (NPar Spearman’s Rho) of the assessment, training experience and age have been considered (Fig. 2).

![Diagram showing correlations](image)

**Figure 2.** Correlations of the assessment with cardiovascular parameters RRs, RRd, MAP, PP, RPP pre-vestibular stimulation (VS), and positive correlation with age

The variable assessment correlates negatively with RRs, RRd, MAP, PP, and RPP measured before vestibular stimulation. Positive correlation was found according to age. The training experience has a negative correlation ($r = - .841$) with HR before rotation, and the age correlates positively ($r = .604$) with the assessment (at the 0.05 level of significance).

**DISCUSSION**

There are no published studies of children dealing with this topic, and especially for rhythmic gymnasts at the age of 10-12. Thus, the present findings are compared partially to some previous reports. Hemodynamic parameters of heart rate, systolic blood pressure and diastolic blood pressure have values like those of healthy children at the same age (Kasakova (1988; Oskolkova 1988; Wilmore and Costill 1999). The established insignificant differences from the comparison of cardiovascular parameters between pre- and post-vestibular stimulation show vestibular stability.
and slight impact on the autonomic hemodynamic indices. Similar effects but of repeated optokinetic stimulation on human autonomic function have been found in a published paper (Peters 2000). The assessment results from the rank test of Losanov-Baychenko in university students - athletes are higher than that of our subjects. (Pavlova et al. 1999; Pavlova et al. 2000). These outcomes and those obtained from a previous report (Pavlova and Alexandrova 2001) confirm the present findings and interpretation that the Losanov -Baychenko degree assessment depends on the age. The essential relationship of the training experience with pre-rotation HR is in keeping with the standpoint that regular sport training rises the cardiac activity effectiveness (Gavriiski et al. 2006). It is interesting that correlation structure of assessment is closely associated only with the cardiovascular parameters measured before vestibular stimulation and with the age as has already been debated. In this respect, it could be assumed that the gymnasts’ functional condition that refers to cardiovascular parameters together with the age is a reliable predictor for Losanov-Baychenko rank assessment. Undoubtedly, the applied original research approach in studying vestibulo-autonomic responses by Barani chair rotation and Losanov-Baychenko table degree assessment is a thorough analysis that could be suggested for exercise physiological study and testing in sports practice.

REFERENCES


The aim is to study the vestibular stimulation (VS) effect on cardiovascular function (CVF) and vestibular stability by Losanov-Baychenko Test (LBT) in rhythmic gymnasts (10-12 yrs). 11 girls performed LBT on Barani chair. Heart rate (HR), arterial blood pressure (RR), mean arterial pressure (MAP), pulse pressure (PP), systolic volume (SV), cardiac output (CO), and rate-pressure product (RPP) were studied and compared pre- and post- VS. The comparison shows insignificant differences (p>0.05) that are interpreted as having slight impact on CVF. The established assessments increase from 10 to 12-year-old girls. Interesting correlation of assessment was only found for the cardiovascular parameters measured pre-VS and for the age. In conclusion, this original research approach in studying vestibulo-autonomic responses and degree assessment could be suggested for exercise physiological study and testing in sports practice.

**Key words:** rhythmic gymnast, vestibular stimulation, Barani chair, cardiovascular function