Analysis of the cardiovascular system performance in long-living individuals

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Abstract
The paper presents some interesting data and findings on the study of the performance of the cardiovascular system in long-living individuals aged over 90. In this case, highland area individuals of this class are compared with those in flatland areas. For the purpose of the study, the cardiometric technology has been used that allows identifying age-related features in the said long-liver cohorts. The conclusions thereupon reveal the features of an individual age-related state, the assessment of which may find practical applications by researchers involved in gerontology.

Keywords
Gerontology, Cardiovascular system, Hemodynamics, Metabolic processes, ECG, RHEO, Stress index

Materials and methods
Individuals aged 90 to 100 years have been examined by us as follows: one group of them lived in a mountain region, 1200 m above sea level, in Costa-Rica, and another group covered long-livers in flatlands in the South of Russia. To carry out the comparative studies, the following most informative parameters have been analyzed by us:

1. Metabolic processes in cardiac muscles: lactate, phosphocreatine and oxygen concentration parameters (in conventional units).
2. Hemodynamics: SV (stroke volume) percentage of the early diastole PV1 volume; parameter RV1 in %. PV1 is the volume of blood entering the heart ventricle in the early diastole (ml);
PV2 is the volume of blood entering the heart ventricle in the atrial systole (ml);
PV5 is pumping function of the aorta (ml).

An important aspect is the measurement of the above listed parameters during the orthostatic test. All the measured data have been summa-
rized in a table given below herein (see Table 1). The paper presents the relevant cardiometric ECG and Rheographic records. In total, 8 long-living persons have been covered by the studies. Results of examination of long-living individuals with the use of cardiometric technology Taking into account the fact that classical cardiology cannot provide a comparative analysis of any age-related changes in a healthy heart, we offer fresh cardiometric criteria which are capable of revealing new, previously unknown, dynamics of age-related changes in the performance of the cardiovascular system in human subjects. Table 1 below herein contains examination data obtained in our above-mentioned studies on the heart performance covering the long-liver cohorts. Figures 1 to 8 given below in the paper display some recorded ECG and Rheo curves which have been used as the main sources of the analyzed information pertaining to the comparison studies.

Table 1. Data on metabolism, hemodynamics and system indicators of long-livers

<table>
<thead>
<tr>
<th>№</th>
<th>ID name of long-liver</th>
<th>Country</th>
<th>Year of birth</th>
<th>Lactate (3–7)</th>
<th>O₂ (0.5–0.55; 0.6–0.65; 0.7–0.85)</th>
<th>PCr</th>
<th>RV1 (60%)</th>
<th>PV1</th>
<th>PV2</th>
<th>PV5</th>
<th>Stress Index (150–300)</th>
<th>Ortho-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>X1, Costa-Rica</td>
<td>1925</td>
<td>39.6</td>
<td>0.16</td>
<td>0.16</td>
<td>0.36</td>
<td>norm</td>
<td>norm</td>
<td>+4%</td>
<td>+13%</td>
<td>221</td>
<td>Lying</td>
</tr>
<tr>
<td>2</td>
<td>X2, Costa-Rica</td>
<td>1915</td>
<td>12.68</td>
<td>0.07</td>
<td>1.81</td>
<td>norm</td>
<td>norm</td>
<td>norm</td>
<td>+9%</td>
<td>norm</td>
<td>Lying</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>X3, Costa-Rica</td>
<td>1926</td>
<td>7.21</td>
<td>0.28</td>
<td>1.99</td>
<td>2.59</td>
<td>norm</td>
<td>-24%</td>
<td>-90%</td>
<td>-76%</td>
<td>528</td>
<td>Lying</td>
</tr>
<tr>
<td>4</td>
<td>X4, Costa-Rica</td>
<td>1919</td>
<td>10.61</td>
<td>0.07</td>
<td>1.05</td>
<td>58.24</td>
<td>norm</td>
<td>norm</td>
<td>12%</td>
<td>norm</td>
<td>221</td>
<td>Lying</td>
</tr>
<tr>
<td>5</td>
<td>X5, Costa-Rica</td>
<td>1923</td>
<td>5.44</td>
<td>0.52</td>
<td>6.50</td>
<td>48.97</td>
<td>norm</td>
<td>norm</td>
<td>+1%</td>
<td>norm</td>
<td>931</td>
<td>Lying</td>
</tr>
<tr>
<td>6</td>
<td>X6, Russia</td>
<td>1928</td>
<td>7.80</td>
<td>0.05</td>
<td>1.82</td>
<td>71.59</td>
<td>norm</td>
<td>norm</td>
<td>1%</td>
<td>norm</td>
<td>128</td>
<td>Lying</td>
</tr>
<tr>
<td>7</td>
<td>X7, Russia</td>
<td>1924</td>
<td>1.76</td>
<td>0.77</td>
<td>4.03</td>
<td>45.35</td>
<td>norm</td>
<td>norm</td>
<td>5%</td>
<td>norm</td>
<td>829</td>
<td>Lying</td>
</tr>
<tr>
<td>8</td>
<td>X8, Russia</td>
<td>1926</td>
<td>22.14</td>
<td>0.43</td>
<td>2.39</td>
<td>70.63</td>
<td>norm</td>
<td>norm</td>
<td>0%</td>
<td>norm</td>
<td>239</td>
<td>Lying</td>
</tr>
</tbody>
</table>

Note: Lactate, oxygen (O₂) and phosphocreatine (PCr) concentration indices are given in the table in conventional units.
Figure 2. ECG and Rheo of X2; A: lying position and B: sitting position (year of birth: 1915)

1. Ca++ deficit;
2. Coronary blood flow is weakened;
3. Low level of oxygen concentration;
4. Load on atria (PV2) detected.
Figure 3. ECG and Rheo of X3; A: lying position, B: sitting position, and C: standing position (year of birth: 1926)

1. Endocarditis;
2. Coronary blood flow is reduced. It affects hemodynamics and is reflected in blood volume deficiency in the early diastole (PV1).
Load on atria (PV2) detected.
В)
Figure 4. ECG and Rheo of X4; A: lying position, and B: sitting position (year of birth: 1919)
1. Ca++ deficit;
2. Extrasystole due to the increased number of fibroblasts in cardiac muscle (danger!)
3. The aorta is dilated;
4. Very low level of oxygen concentration in muscle cells detected;
5. Low level of phosphocreatine concentration detected;
6. Low stress index indicating severe state;
7. Nevertheless, hemodynamics is O.K.

А)
Figure 5. ECG and Rheo of X5; A: lying position, B: sitting position, and C: standing position (year of birth: 1923)
1. The aorta is dilated;
2. High diastolic pressure is detected;
3. Coronary blood flow is insufficient;
Consequence: the early diastole blood volume percentage referred to stroke volume is reduced (RV1);
4. All other indicators are O.K.
Figure 6. ECG and Rheo of X6; A: lying position, and B: sitting position (year of birth: 1928)

1. Very low level of oxygen concentration in cardiac muscle cells;
2. The IVS contractility is significantly reduced.
1. High stress index indicates over-tension of the organism as a whole;
2. Low level of lactate concentration is an indication of weakness of myocardium. Nevertheless, the hemodynamic parameters are within the norm.

1. Increased level of lactate concentration detected;
2. Other parameters are within the norm.
Upon analysis of the above mentioned cardiometric data, it has been found that no common pronounced problem of aging is available in the examined cohorts of the long-living individuals. A reduced coronary blood flow was detected in three long-livers. A decreased level of oxygen concentration in blood was identified in two individuals of the said class. Other parameters should be treated as individual peculiarities for each of the examined persons.

It should be noticed that the comparative analysis of Costa-Rican long-living subjects, who live in the regions 1200 m above sea level, and the Russian long-livers from Russian flatlands is worthy of being discussed.

So, the highland long-living persons show a dilation of the aorta. It should be attributed to hypoxia, a consequence of which is an increased carbon dioxide level in the organism that results in the dilation of blood vessels. It leads to a disbalance in hemodynamics, especially under physical loads. Evidence supporting this fact is demonstrated in Table 1 given above herein. Actually, observed is insufficiency of blood filling in the aorta that produces a deficit in the coronary blood flow.

Conclusions
1. The amplitude of cardiac muscle contraction reduces with age. It is related to a depletion of the total ATP energy resources in general.
2. The detected changes in the performance of the cardiovascular system of the long-living subjects show their individual peculiarities.
3. It has been found that the primary cause of hemodynamic changes in the long-livers is abnormal respiration which is responsible for alterations in the balance between oxygen and carbon dioxide in blood.
4. All other changes detected in the studies should not be classified as those age-related, since they are also often reported for middle-aged individuals.
5. The cardiometric technology makes possible to issue the proper recommendations on how to maintain the cardiovascular system in a healthy state for a long period of life that may be used as useful strategy to prolong a healthy life.

Statement on ethical issues
Research involving people and/or animals is in full compliance with current national and international ethical standards.

Conflict of interest
None declared.

Author contributions
The authors read the ICMJE criteria for authorship and approved the final manuscript.

References