Comparative analysis of functional state and working capacity on veloergometer of average training level women of age 25–35

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Summary

The article represents research of physiological indices (heart rate, tidal volume, respiratory rate, respiratory minute volume on AeT and AT energy supply level) and magnitude of working capacity on veloergometer at AeT and AT level of different somatotype women of age 25–35 of average training level. Using submaximal load-testing, values of the main physiological indices on AeT and AT level were established. They identify functional state and magnitudes of working capacity on veloergometer at AeT and AT’s level of people of asthenic (10 women), normosthenic (10 women), and hypersthenic (10 women) types. This research allowed establishing peculiarities of body functioning in general and cardiovascular system among different somatotypes during training load within aerobic limits of energy exchange. It was revealed that, in spite of subjects’ physical fitness homogeneity, people of asthenic type had higher capabilities of functional systems working in comparison with normosthenics and especially with hypersthenics (a number of physiological indices (relative tidal volume, relative respiratory minute volume) among somatotypes differs on significance level 0.05 (р < 0.05)). It was also established that asthenics' relative magnitudes of working on veloergometer in aerobic limits of body functioning (relative N on AeT and AT) were higher in comparison with other somatotypes, and normosthenics had higher absolute magnitudes (absolute N on AeT and AT).

The research results can be used for practical training subject matters in planning fitness and wellness training with different somatotypes women in general. Considering the latter, this individual approach should help them with negotiation of the plateau level in the training growth and would contribute to approach of very high level of fitness preparedness.

In general, in spite of homogeneity of asthenic, normosthenic, and hypersthenic women of age 25–35 types, their differences in functional state and working capacity on veloergometer were revealed. Established regularity should be considered during training planning with this cohesive.

Keywords: functional state, veloergometer, submaximal load-test, somatotype, fitness.

Introduction

In physical science much attention is given to research of functional state of a person during training process (Wilmore, Costill, 1997; Иорданская, 1999; Forman, 2010; Sherwood, 2011; Солодков, 2014). In spite of considerable amount of researches in this area, some sides are still poorly studied, especially research of functional state (indices that identify functional state: heart rate, tidal volume, respiratory rate, respiratory minute volume on AeT and AT energy supply level) in the ratio of physical loads capacity relativity to health-giving sphere of physical exercises application. The intensification of fitness and wellness training process and rapid development of fitness that are observed have influenced the need to identify and analyse functional state of different age-sex group people, practicing physical exercise within fitness and wellness training (Бурцева, 2015; Якубовский, 2015). Timeliness of the research consists of identification of physiological organism reactions to physical load of women of age 25–35 as an active users of fitness service from the perspective of affiliation with somatotype and fitness preparedness level that will contribute to the individualization of training process.

Research objectives: 1. To identify physiological indices of AeT and AT energy supply of different somatotype women of age 25–35 with average training level. 2. To establish working capacity on veloergometer, relative to AeT and AT energy supply of different somatotype women of age 25–35 with average training level. 3. To put together physiological indices and working capacity on veloergometer, relative to AeT and AT energy supply of different somatotype women of age 25–35 with average training level.
Methods and organization of the research

Research methods: analysis and generalization of scientific-methodical literature, spirometry (tidal volume, respiratory rate, respiratory minute volume), pulsometry (heart rate), stress-testing on veloergometer with submaximal incrementally increasing load (aerobic threshold – AeT, anaerobic threshold – AT), and mathematical statistics methods.

The research was carried out from February till March, 2016, in Belarusian National Technical University (Minsk). The research laboratory of Sporting Engineering Department served as the experimental platform. Women of age 25–35 with fitness training experience more than 6 months took part in the research. Using measuring method of wrist circumferences (based on the classification of M. V. Chernorutskii) and comparative standards of physical fitness of the total number of surveyed women (114), 10 subjects from each somatotype (asthenics, normosthenics, hypersthenics) with average level of physical fitness were picked out (Дорохов, 2002; Якубовский, 2016).

From the methods list that was used in the research as the main technique, stress-testing on veloergometer with submaximal incrementally increasing physical load had served in here. Based upon this method, the approach of scientists B. F. Vashlyaev and I. U. Sazonov was taken. It consisted in tidal volume measuring and its dynamics within subjects’ working that was carried out on veloergometer (the pace of pedalling – 60 rpm, capacity and duration of load’s step – 25 W and 2 min respectively) (Вашляев, 2013).

Within measuring activity, this equipment was used:
- IMPULSE ECU7 exercise bike;
- МАС2-ПК autonomous pneumograph;
- Pulsometer Polar, model RS400;
- Portable concentration meter of blood lactate “Akusport”.

In the course of completing incrementally increasing load on veloergometer by subjects, measuring order was chosen as follows: a) pulse rate that had been measured continuously during the whole working was entered in the protocol at the end of every second minute of test before blood lactate and tidal volume measurement; b) estimation of blood lactate concentration was carried out 30 s before finishing each step of working and before tidal volume measuring; c) tidal volume measuring was carried out during last 15 s of each 2 min of working step; d) test stopped if specific tidal volume was increasing sharply, indices of lactate were more than 4 mmol/L, and pulse rate was more than 180 bpm (Mezzania, 2009).

Results and discussion

While testing on veloergometer, AeT and AT energy supply for subjects was determined relatively by a number of physiological indicators – heart rate, tidal volume, respiratory rate, respiratory minute volume (Table 1). The subjects’ somatotype was taken as a basis for the research, which, according to experts and as shown by the present study, is characterized by differences in the weight-height values among types (asthenics, normosthenics, hypersthenics), so they were calculated in both absolute and relative values of physiological parameters (Carter, 2002; Van Praagh, 2007). This approach allowed to clearly represent the behaviour of functional processes of the subjects of different somatotype during work.

It has been revealed that the results of functional system activity of different somatotype people on threshold values of aerobic mechanism of energy supply is heterogeneous. So, considering the heart rate on the level of AeT and AT, it is worth noting that the most expressed differences are observed between asthenics (132.8 ± 6.2 and 169.5 ± 7.1 bpm) and hypersthenics (125.8 ± 6.2 and 157.5 ± 6.5 bpm) – 7 and 12 bpm respectively. The ratio of the results points at the predominance of asthenics over hypersthenics on the capability of cardiovascular system functioning within the limits of aerobic energy supply, the ability to cope with significant loads during economy mode of body function (Prosser, 1994; Edward, 1995; Marc, 2014).

Analysis results of the relative respiratory minute volume on AT level among persons of different somatotype allowed to set the feature of the achieving process by means of increasing the respiratory rate or depth and, as a result, a preferential increase value of respiratory rate or tidal volume. So, when comparing the relative tidal volume and the respiratory rate on AT level of asthenics (1), normosthenics (2), and hyperssthenic (3), it was revealed that the relative respiratory minute volume of different somatotype had been achieved in different ways: 1) 24.7 mL (relative tidal volume) × 22.1 (tidal
volume) = 545 mL/min (relative respiratory minute volume); 2) 243 mL × 20.7 = 503 mL/min; 3) 15.0 mL × 26.1 = 392 mL/min. Asthenics and normosthenics reach the level of AT due to the parallel increase of the respiratory rate and relative tidal volume with the priority of the last one. In turn, hypersthenics, compared to the other two somatotype on the level of AT, are observed with high value of the respiratory rate and low relative tidal volume (relative tidal volume on AT level is even lower than AeT – 15 and 15.1 mL, respectively). The relation of results again points at the ineffective functioning of the respiratory system of hypersthenics in comparison with other somatotypes (Green, 1993).

### Table 1

<table>
<thead>
<tr>
<th>Somatotype</th>
<th>Asthenic</th>
<th>Normosthenic</th>
<th>Hypersthenic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight, kg</td>
<td>53.1 ± 3.9</td>
<td>59.5 ± 4.2</td>
<td>65.8 ± 4.8</td>
</tr>
<tr>
<td>Height, cm</td>
<td>159.7 ± 4.4</td>
<td>163.9 ± 4.5</td>
<td>167.2 ± 5.1</td>
</tr>
<tr>
<td>State</td>
<td>Resting</td>
<td>AeT</td>
<td>AT</td>
</tr>
<tr>
<td>Heart rate, bpm</td>
<td>75.2 ± 3.9</td>
<td>132.8 ± 6.2</td>
<td>169.5 ± 7.1</td>
</tr>
<tr>
<td>Absolute tidal volume, mL</td>
<td>522.4 ± 37.7</td>
<td>1280 ± 45.8</td>
<td>1310 ± 52.3</td>
</tr>
<tr>
<td>Respiratory rate, time</td>
<td>11.1 ± 1.8</td>
<td>22.1 ± 3.5</td>
<td>12.3 ± 1.5</td>
</tr>
<tr>
<td>Absolute tidal volume, mL</td>
<td>9.8 ± 0.7</td>
<td>24.1 ± 0.9</td>
<td>17.28 ± 0.62</td>
</tr>
<tr>
<td>Absolute respiratory minute volume, L/min</td>
<td>5.79 ± 0.42</td>
<td>17.28 ± 0.62</td>
<td>13.5 ± 1.9</td>
</tr>
<tr>
<td>Relative respiratory minute volume, L/min</td>
<td>0.109 ± 0.007</td>
<td>0.325 ± 0.012</td>
<td>0.545 ± 0.022</td>
</tr>
</tbody>
</table>

Note: the results that have significant difference at the significance level of 0.05 are typed bold

Research of the working capacity on veloergometer of studied cohesive relatively AeT and AT energy supply allowed to establish the differences in capability of physical load negotiation that was carried out within AeT energy supply by asthenics, normosthenics, and hypersthenics (pictures 1 and 2).

So, the differences in absolute and relative values of working capacity on veloergometer with the threshold values of aerobic energy supply (absolute N and relative N on AeT and AT) between asthenics and normosthenics were 5 and 0.1 W, 5 and 0.2 W, between asthenics and hypersthenics – 7.5 and 0.4 W, 10 W and 0.7 (p < 0.05), between normosthenics and hypersthenics – 12.5 and 0.3 W, 15 W and 0.5 (p < 0.05). The final ratio of results points at the advantage of asthenic type over the other somatotype, especially hypersthenic; the development of relative working capacity on veloergometer with AeT and AT.
At the same time shows normosthenics to have the highest absolute values. The first case can be explained by the integrative coherence of organs functioning and body systems of asthenics during negotiation of massive physical load; and the second case is existence of normosthenics’ capabilities for negotiation of heavy physical loads on AeT energy metabolism (Harms, 2000; Silva, 2013).

Overall, the obtained results were put into comparative research method, which allowed to establish general and distinctive features of persons of different somatotype in relation to their physiological and capacity indices on the level of AeT and AT.

The asthenic type of a person is characterized mainly by a higher physiological and capacity parameter (mostly relative values) of AeT and AT compared to the other two somatotypes. This feature is expressed the most in establishing the percentage difference of the relative tidal volume, relative respiratory minute volume, and relative N on AT – asthenic-normosthenic – 1.6 %, 7 %, and 7.7 %; asthenic-hypersthenic – 39.3 %, 29.1 %, and 26.9 %.

The surveyed cohesion, relating to normosthenic type, is characterized by pronounced predominance in the studied indices over hypersthenics and little lag when compared to asthenics. Therefore, putting together indices of respiratory minute volume and relative respiratory minute volume N and relative N on AT level between participating in the experiment normosthenics (1) and hypersthenics (2) and normosthenics (1) and asthenics (3), we obtain the following percentage difference: 1–2 – 13.9 % and 38.3 %; 10.5 % and 20.8 %; 1–3 and 3.4 % and 1.6 %; 3.5 % and 7.6 %.

The analysis of the obtained results revealed that hypersthenics’ capability to negotiate working on relatively long duration in the aerobic zone of energy supply is lower in comparison with normosthenics’ and especially asthenics’ capabilities.

In our opinion, an unresolved issue within this research is the absence of comparative norms for different somatotype women of age 25–35 with average training level on veloergometer of aerobic and anaerobic threshold energies: asthenic – 90 and 1.7 W (AeT), 137.5 and 2.6 W (AT); normosthenic – 95 and 1.6 W (AeT), 142.5 and 2.4 W (AT); hypersthenic – 82.5 and 1.3 W (AeT), 127.5 and 1.9 W (AT).

3. Analysis of functional indices and working capacity on veloergometer, relative to aerobic and anaerobic thresholds of different somatotypes women of age 25–35 with average training level, allowed to establish next aspects:

A) Asthenic type of a person is characterized by more optimal high physiological indices (heart rate, relative tidal volume, respiratory rate, relative respiratory minute volume) as compared to other somatotypes. It makes it clear that heart rate values on anaerobic threshold are as follows: asthenic – 169.5 bpm, normosthenic – 166.4 bpm, and hypersthenic – 157.5 bpm. In general, we can make a conclusion that more effective functioning of cardiorespiratory system is corresponding to asthenics as compared to normosthenics and especially to hypersthenics.

B) Taking under consideration the results of working capacity on veloergometer among studied somatotypes, we obtain that the asthenics’ relative magnitudes (relative N on aerobic and anaerobic thresholds) are higher as compared to the others, and normosthenics have higher absolute magnitudes (absolute N on aerobic and anaerobic thresholds). These results point out the predominance of asthenics over the others in working efficiency that is made within aerobic threshold energy; it also points out

Conclusions

1. During the testing, women of age 25–35 with average training level on veloergometer established levels of AeT and AT, more particularly, a number of physiological indices (heart rate, tidal volume, respiratory rate, respiratory minute volume) that defined them. Particular importance and informativity for the planning of training have the indices of heart rate and the relative respiratory minute volume on AeT and AT: asthenic – 132.8 bpm and 0.325 L/min (AeT), 169.5 bpm and 0.545 L/min (AT); normosthenics – 131.7 bpm and 0.313 L/min (AeT), 166.4 bpm and 0.503 L/min (AT); hypersthenics – 125.8 bpm and 0.268 L/min (AeT), 157.5 bpm and 0.392 L/min (AT).

2. Submaximal load-testing of different somatotypes women of age 25–35 with average training level allowed to establish the magnitudes of working capacity (absolute N and relative N) on veloergometer of aerobic and anaerobic threshold energies: asthenic – 90 and 1.7 W (AeT), 137.5 and 2.6 W (AT); normosthenic – 95 and 1.6 W (AeT), 142.5 and 2.4 W (AT); hypersthenic – 82.5 and 1.3 W (AeT), 127.5 and 1.9 W (AT).

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to the potential high capability of normosthenics’ vegetative function.

C) Putting together physiological indices with magnitudes of working capacity on veloergometer among subjects – asthenics, normosthenics, and hypersthenics, – we obtain the results, showing that the somatotypes with notable predominance on one of the indices (in physiological ones (heart rate on the level of anaerobic threshold)) for the most part are characterized by predominance over the other somatotypes on others indices (directly in magnitude of working capacity (relative N on AT)).

REFERENCES

moterų organizmo ir jų širdies ir kvėpavimo sistemos funkcionavimo ypatumus atliekant aerobinio pobūdžio fizinį krūvį.

Išryškėjo, kad nepaisant panašaus tiriamųjų fizinio parengtumo lygio, astetinio tipo moterys pasižymi statistiškai patikimai (p < 0,05) didesniu funkciniu pajegumu, palyginti su normosteninio ir hipersteninio tipo moterimis (KT, MKT). Taip pat buvo nustatyta, kad santykinis darbo, atliekamo veloergometru, galingumas energiją gaminant aerobiniu būdu didesnis buvo asteninio tipo moterų, palyginti su kitų somatinių tipų tiriamo- siomis, tačiau absoliutusis galingumas ties AS ir AnS ribomis didesnis buvo normosteninio tipo moterų.

Tyrimo rezultatai gali būti taikomi planuojant sporto treniruočių, taip pat ir įvairių somatinių tipų moterų sveikatingumą didinančių pratybų turinį. Moterų fizinio rengimo pratybų individualizavimas leistų padidinti organizmo adaptaciją prie fizinį krūvių ir pasiekti geresnių fizinio parengtumo rezultatų.

Raktažodžiai: funkcinė būklė, veloergometras, submaksimalus fizinis krūvis, somatotipas, aerobinė apykaita.