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AGE-RELATED FEATURES OF THE CARDIAC OUTPUT IN BASIC POSE CONDITIONS (STANDING/LYING)

L.R. Dilenyan, I.V. Bocharin, A.V. Zaripova, A.K. Martusevich

*The **aim of the work** was to show the dynamics of cardiac output (CO) in standing and lying positions in postnatal ontogenesis.*

***Material and methods.** The data were obtained on the basis of an observational study in 1944 people (1308 men and 636 women). The following age groups were: up to 8 years (n=55), 9-14 years (n=68), 15-21 years (n=226), 22-35 years (n=326), 36-55 years for women and 36-60 years for men (n=658), up to 70 years (n=413) and over 70 years (n=198). The study was performed standing up and after 15-20 minutes in the supine position on the complex of the expert diagnostic system "ANTHROPOS-CAVASCREEN" based on rheography.*

***Results.** Our data justify the identification of the type of dynamic organization of blood circulation in humans by the anthropo-physiological ratio of CO in standing/lying positions. The transition to a hyperkinetic state in orthostatics is a manifestation of adaptation to the gravitational (hydrostatic) factor of blood circulation to ensure the circulatory state of the cardiovascular system in the most constant and relevant for human life conditions of upright walking. The obvious direction of such adaptation is the centralization of blood circulation in the standing position and the formation of a hyperkinetic state of the pumping function of*

the heart. This orientation reflects the strained state of the cardiovascular system in the anti-gravity support mode, which not only limits the functional reserve for cardiac output in the standing position, but also clearly associated with the growth of both problematic circulatory conditions and nosological states formed on this basis.

Keywords: *age; cardiac output; heart mass; pose conditions; standing; lying*

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ВОЗРАСТ-ЗАВИСИМЫЕ ХАРАКТЕРИСТИКИ СЕРДЕЧНОГО ВЫБРОСА В ОСНОВНЫХ ПОЗНЫХ СОСТОЯНИЯХ

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Целью работы *была оценка динамики сердечного выброса (СВ) в положении стоя и лежа в постнатальном онтогенезе.*

Материал и методы. *Данные были получены на основе наблюдательного исследования 1944 человек (1308 мужчин и 636 женщин). Выделяли следующие возрастные группы: до 8 лет (n=55), 9-14 лет (n=68), 15-21 год (n=226), 22-35 лет (n=326), 36-55 лет для женщин и 36-60 лет для мужчин (n=658), до 70 лет (n=413) и старше 70 лет (n=198). Исследование проводили стоя и через 15-20 минут в положении лежа на спине на комплексе экспертной диагностической системы "ANTHROPOS-CAVASCREEN" на основе реографии.*

Результаты. *Наши данные обосновывают идентификацию типа динамической организации кровообращения у человека по антропофизиологическому соотношению СВ в положении стоя/лежа. Переход в гиперкинетическое состояние в ортостатике является проявлением адаптации к гравитационному (гидростатическому) фактору кровообращения для обеспечения циркуляторного состояния сердечно-сосудистой системы в наиболее постоянных и актуальных для жизни человека условиях прямохождения. Очевидным направлением такой адаптации является централизация кровообращения в положении стоя и формирование гиперкинетического состояния насосной функции сердца. Такая ориентация отражает напря-*

женное состояние сердечно-сосудистой системы в режиме антигравитационной поддержки, что не только ограничивает функциональный резерв сердечного выброса в положении стоя, но и явно связано с ростом как проблемных состояний кровообращения, так и нозологических состояний, сформированных на этой основе.

Ключевые слова: *возраст; масса сердца; позные условия; положение стоя; положение лежа*

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Introduction

Interaction with the Earth's gravity is a permanent factor of the external environment [1-3], which has a systemic gravitational effect on blood circulation [2-5]. It manifests itself in the characteristic human stage adaptation to the conditions of upright walking throughout postnatal ontogenesis [1, 4, 6, 7].

In clinical practice, as a rule, diagnostic studies of cardiac output (CO) are performed in the supine position [8, 9], that is, in conditions of minimal manifestation of the gravitational influence on blood circulation, which affects the reference values of the studied indicators [1, 3]. At the same time, there are practically no standards and diagnostic approaches that take into account the typical human daily rhythm of natural body positions [2, 3, 5]. Given the fact that the CO indicators in the standing position in postnatal ontogenesis are not sufficiently represented in the literature, this was the basis of this work [3, 5, 8].

That is why the aim of this study was to show the dynamics of CO in standing and lying positions in post-natal ontogenesis.

Material and research methods

The data were obtained on the basis of an observational study in 1944 people (1308 men and 636 women). The only limiting condition for forming such a sample was the exclusion of patients with acute conditions or exacerbation of chronic diseases from its composition. The samples were formed in accordance with our proposed classification of stages of ontogenetic adaptation to Earth's gravity in the process of formation and life activity in typical human conditions of upright walking. The following age groups were identified (in total for men and women) [10, 11]: up to 8 years (n=55), 9-14 years (n=68), 15-21 years

(n=226), 22-35 years (n=326), 36-55 years for women and 36-60 years for men (n=658), up to 70 years (n=413) and over 70 years (n=198).

The study was performed standing up and after 15-20 minutes (outside of the transition States of hemodynamics) in the supine position on the hardware and software complex of the expert diagnostic system "ANTHROPOS-CAVAS-CREEN" based on rheography [1, 8, 12].

The study was approved by Local Ethic Committee of Privolzhsky Research Medical University (2018).

The results were processed using the Statistica 6.0 program. The normality of the distribution of parameter values was evaluated using the Shapiro-Wilk criterion. Taking into account the nature of the attribute distribution, the Kraskal-Wallace H-test was used to assess the statistical significance of differences. Data was presented in the format M±m. The differences were considered significant at a significance level of $p<0.05$. We calculated the true level of statistical significance of differences in the average values of indicators.

Results and Discussion

Load voltage anti-gravity nature of cardiovascular system in the process of the growth formation of bipedalism defines the need for structural and functional capacity of the heart and circulatory system for the implementation of the basic ontogenetic adaptation to planetary gravity man as upright beings [4, 7, 8]. The dynamics of heart growth is compared with the stages of adaptation to Earth's gravity and shows the process of becoming a structural transformation link (Fig. 1, above).

The highest rate of increase in heart mass is observed at the time of the child's transition to independent standing (stage 1). This speed remains high during stages 2 and 3. After the completion of the formation of erectness (stage 3), the increase in heart mass decreases slightly, but in the puberty period it increases again. The marked phase character can be traced by the age dynamics of the rate of change in the specific mass of the heart (Fig. 1, below), showing the stage features of the relationship between the formation of erectness and the structural development of the heart proper.

In general, the dynamics of increasing heart mass reflects the body's adaptive request to the circulatory system, which is clearly addressed, first of all, to certain age dates of becoming upright. Much less pronounced such a request is implemented on 5, reflecting, in contrast to the growth process at the initial stages, the manifestations of functional hypertrophy of the heart.

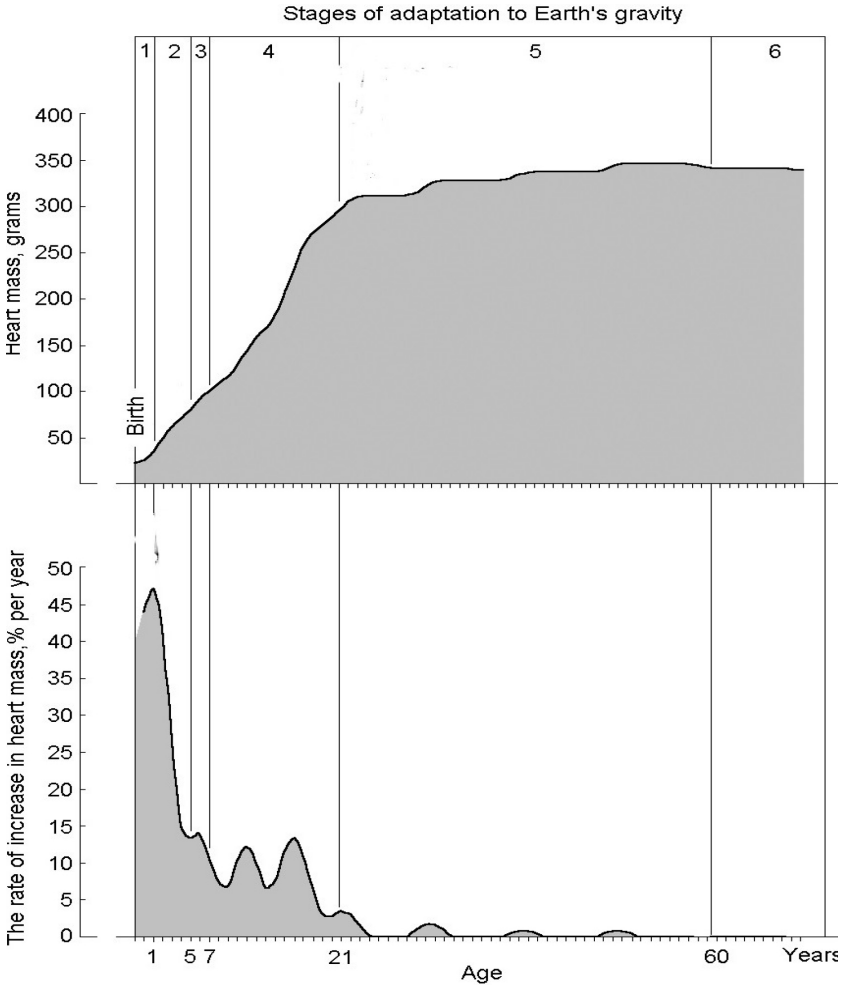

Fig. 1. The growth of the heart in accordance with the stages of adaptation to earth's gravity in the process of ontogenetic formation of upright walking in humans. It is given according to Yu.A. Vlasov (1992) [7], combined with periodization according to our "anthropogenetic model"

According to the structural formation of the heart, its functional capabilities are also formed. The increase in heart mass is accompanied by an increase in the minute volume of the heart (Fig. 2, top).

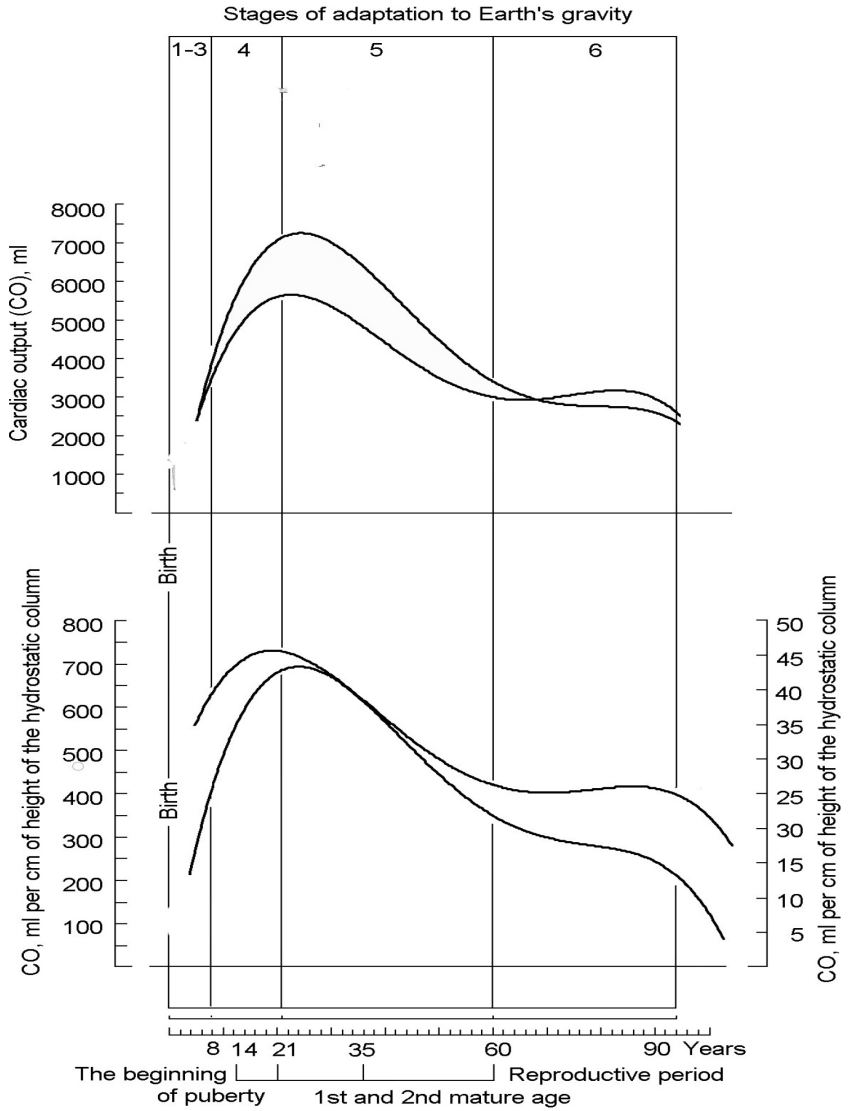

Fig. 2. Ontogenetic dynamics of cardiac output (CO) combined with the stages of adaptation to earth's gravity in the process of becoming upright in humans. It is given according to Yu.A. Vlasov (1992) [7] combined with periodization according to our "anthropogenetic model"

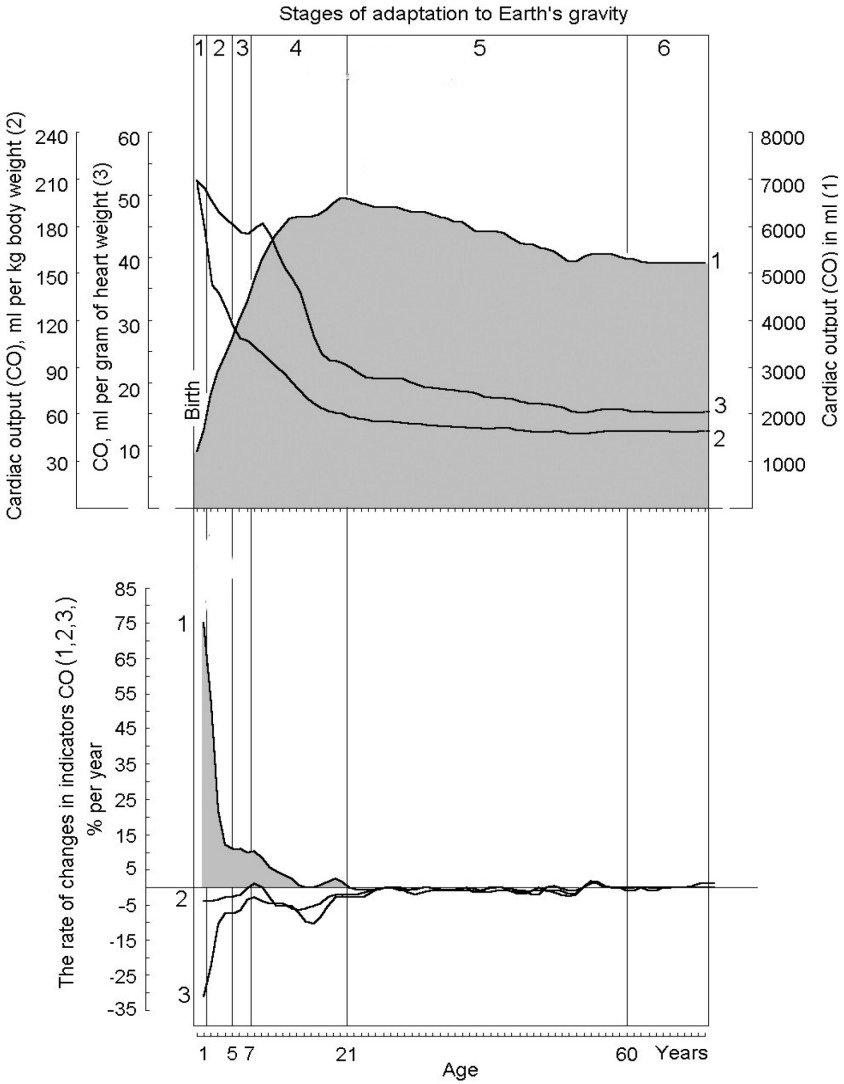

Fig. 3. Anthropophysiological characteristics of age-related dynamics of cardiac output (high picture) и "hydrostatic index" of cardiac output at human in lying positions (CO / 10 sm) and standing (CO / 70% of growth) in accordance with the stages of adaptation to earth's gravity in the process of becoming upright. Body position indicates by arrows

Moreover, the highest rate of its growth is at the 1, 2 and 3 stages of the formation of the erect walk (Fig. 2). In contrast to changes in heart mass, the rate of increase in CO will decrease. Little changes in puberty and other age periods. The lag in increasing the CO in comparison with the body weight and, especially, with the heart weight is reflected in the decrease in the corresponding specific indicators – CO per kg of body weight and CO per gram of heart weight. For these indicators, the most pronounced changes are as for their overall level (Fig. 3, above), and by the rate of change (Fig. 2, at the bottom) are marked at the main stages of the formation of erect walking.

It should be noted that not even the majority, but almost all the data in the literature, including those used [7], for the above characteristics of the age dynamics of the CO, were obtained by traditional measurement of cardiac output in the supine position. And even with this restriction, the most expressive age-related CO are combined with the main stages of the formation of erectness and the corresponding manifestations of adaptation of the cardiovascular system to the gravitational factor of blood circulation. Given that for a person, the most relevant conditions of life are certain forms of upright walking, it is necessary to characterize the age dynamics of the state of the cardiovascular system, including the cardiac output, and the conditions of the vertical position of the body.

In accordance with the anthropophysiological approach, a general analysis of the age-related dynamics of cardiac output was carried out (men and women in total) when determining the CO by standing and lying position. Figure 3 shows data on the age dynamics of the direct value of the CO (top) and indexed (bottom) by body weight-the systolic index (SI).

When comparing the dynamics of absolute values of CO (in ml) according to their own data in the supine position (Fig. 3) and according to the literature [8, 9], which are also obtained in the supine position (Fig. 2), there is a practical coincidence of the maximum increase in cardiac output at the time of completion of growth (by 21 years). The entire subsequent dynamics of the progressive decline in CO values was essentially similar. Especially clearly age-related decrease in cardiac output in the supine position is determined by the systolic index (SI, ml / kg).

A noticeably steeper decrease in the CO level according to our data is due to the fact that the available data [8, 9] were obtained from samples of practically healthy people. We used an observational, clinically unrefined sample that included chronic diseases in remission. And it is quite natural that since the accumulation of such persons in older age samples, the corresponding depression of the pumping function of the heart was more pronounced. Whereas age samples at the definitive stage of postnatal ontogenesis were more homo-

geneous and less nosologically burdened in their composition, both according to our data and available data [2-5].

As for the CO values in the standing position, we also used our own data. In the first approximation, the nature of the dynamics of the CO and SI level curve in the standing position corresponds to that in the lying position. However, when comparing the curves, there are fundamental differences in the age dynamics of cardiac output standing and lying down. This can be seen by the gap between the curves at different stages of age dynamics and by the cross-section of the curves at post-productive age (over 60 years), which indicates the informative value of the anthropophysiological ratio for the CO (standing/lying) in the characteristic of the dynamic organization of blood circulation (Fig. 3).When comparing the curves of age-related dynamics of cardiac output, there are fundamental differences in the dynamics of CO in standing and lying positions. In figure 3 (above), we can be seen by the gap between the curves at different stages of age dynamics and by the cross-section of the curves in the post-productive age (over 60 years), which indicates the special informative significance of the anthropophysiological ratio for CO (standing/lying) in the typological characteristic of the dynamic organization of blood circulation [8]. The anthropophysiological correlation is even more pronounced when analyzing the age dynamics of the "hydrostatic index" of cardiac output (Fig. 3, at the bottom). The latter was calculated in relation to the IOC height of the hydrostatic column, which is conventionally accepted for the lying position in 10 cm, and standing-70% of the length of growth.

Conclusion

These data justify the identification of the type of dynamic organization of blood circulation in humans by the anthropophysiological ratio of CO in standing/lying positions [8, 10]. The transition to a hyperkinetic state in orthostatics, on the one hand, is a manifestation of adaptation to the gravitational (hydrostatic) factor of blood circulation to ensure the circulatory state of the cardiovascular system in the most constant and relevant for human life conditions of upright walking. The obvious direction of such adaptation is the centralization of blood circulation in the standing position and the formation of a hyperkinetic state of the pumping function of the heart. This orientation reflects the strained state of the cardiovascular system in the anti-gravity support mode, which not only limits the functional reserve for cardiac output in the standing position [10], but also clearly associated with the growth of both problematic circulatory conditions and nosological states formed on this basis.

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