

Economics and Human Biology. Active acceleration in pediatric growth and development: explanation provided by economic theory

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Abstract. Currently, health of the pediatric population is in the focus of attention of research studies describing the long-term dynamics of physical development and processes of acceleration and deceleration in growth and development in various countries and regions of Russia. The aim of the study is to validate a hypothesis explaining acceleration – deceleration in growth and development of the pediatric population. The authors performed an analytical investigation based on the archival and proper data on the physical development of the child population in Moscow, which is a point of long-term observation of the growth and development of the pediatric ages. The study included 7484 people in total. To analyze the impact of economic factors, the publicly available data of international organizations, such as the World Bank, and literature data were used.

Key words: children and adolescents, acceleration, deceleration, physical development, puberty, risk factors, economic theory.

Introduction

Physical development of children and adolescents is a criterion of the state of health including the assessment of harmony and the level of biological development (1-6). There exists a wide range of fundamental studies devoted to the investigation of physical development of the pediatric population, describing the long-term dynamics of physical development and acceleration and deceleration in the growth and development in various countries and regions of Russia (6-13).

Acceleration is defined as the fast rate in the growth and pubertal development of children and adolescents compared to previous generations (14). Deceleration (several authors use the term retardation) is the process of reverse acceleration, i.e., the slow rate in the growth and maturation of the body (15). Publications also use the term “secular trend” adopted in the fields of economy and sociology, where “secular”

means “long-term, long-lasting”. A secular trend can be defined as changes in the average size or body shape of individuals in a population from generation to generation (16).

The history of the study of acceleration process dates back decades: back in the 19th century the German physician E. Koch put forward a “heliogenic” hypothesis and the French economist, physician, and statistician L.R. Villerme regarded as of paramount importance to the influence of socio-economic factors (16).

Modern researchers agree that the reasons and mechanisms responsible for the acceleration in the growth and pubertal development of the children population remain insufficiently studied and describe only the influence of individual factors on the course of the acceleration - deceleration processes (17). One of the few fundamental works on this issue published by a RAMS corresponding member B.A. Nikityuk sum-

marizes Russian and foreign experience in studying manifestations and effects of acceleration reporting the following: «Acceleration is a mysterious phenomenon of our time. The problem of acceleration is inexhaustible» (18). According to B.A. Nikityuk, there are three levels of implementation of acceleration: ecological and biological, genetic and socio-economic (18).

The age for menarche in girls, being an informative parameter of puberty, plays a significant part in the analysis of the processes occurring in the physical development of the child population; the age of pollution in boys is difficult to record and it is not a sufficiently informative parameter. The age of menarche was traditionally analyzed considering climatic and geographical differences (north-south, east-west), industrialization and urbanization, etc. (19-20). However, it has been shown that the age of menarche is not so much influenced by climatic and geographical factors (if they are not extreme) in representatives of various ethno-territorial groups as, for example, GDP per capita (21).

Considering the fact that physical development of the pediatric population is often investigated within the framework of preventive medical research and extensive statistical material formalized as numerous databases has been obtained, it is appropriate to theoretically understand scientific and practical significance of the accumulated data and formulate a hypothesis providing explanation of the activity of acceleration – deceleration processes in the growth and development of the pediatric population and their role in shaping the health of the younger generation.

The aim of the study is to validate a hypothesis that provides an explanation of the activity of acceleration – deceleration processes in the growth and development of the pediatric population.

Materials and methods

The authors analysed archival sources and proper data on the physical development of the pediatric population in Moscow, which is a point of long-term observation of the growth and development of the pediatric population. The data were obtained using standard anthropometric methods and instrumentation and

works published in the scientific literature between the 20th century and the beginning of the 21st century. This large chronological span is necessary as a 100-year observation period is required to explain the causes and mechanisms of the acceleration process (22-23).

The sample counts 7484 subjects. Inclusion criteria were the age of 14-17 years old, living in Moscow. The exclusion criteria were other ages and sex groups, living in other regions.

Additionally, using the status quo method (retrospectively), the age of menarche was studied in 893 female students of various ethnicity born between 1995 and 2000, studying at Moscow Universities, 20% of the girls had been living in Moscow for less than 5 years. Inclusion criteria were a signed voluntary informed consent, belonging to the studied age and sex group, living in Moscow, a correctly completed questionnaire. The exclusion criteria were other ages and sex groups, living in other regions, absence of the correctly completed voluntary informed consent and questionnaire. Based on the results, a “Database for the study of menstrual function in adolescent girls (born between 1995 and 2000)”, a database registration certificate 2020622018 dated 23.10.2020 was issued.

The study was conducted in Moscow, since the capital is the center of innovation, there is a concentration of economic activity, and the effect of most economic factors is expressed there (24).

To analyse the influence of economic factors, the publicly available data of international organizations, such as the World Bank, as well as literature data were used. The authors analyzed the most informative economic parameter – gross domestic product (GDP) per capita, — since it considers not only the market value of all final goods and services that have been produced by all sectors of the economy for a year in the country for consumption, accumulation and export, regardless of the nationality of the factors of production used, but also the population of the country (25).

The study participants were not exposed to any hazards; their rights were not violated in accordance with the requirements of biomedical ethics approved by the Declaration of Helsinki by the World Medical Association (2013).

Statistical data were processed using the statistical analysis package Statistica 10.0 (StatSoft, USA).

Results

Physical development of the child population of Moscow in the time interval 1925 - 2012 was analyzed for boys and girls, aged 14-17, i.e., during the period when the processes of growth and development are close to their completion (Figures 1, 2, 3). Acceleration of growth processes from generation to generation was recorded: at the beginning of the 21st century, in all age and sex groups, Moscow boys and girls reliably ($p \leq 0.05$) exceeded their 20th century peers in body length, body weight and chest circumference parameters. By the time the growth processes are completed, the difference in body length for boys is more than 16 cm, for girls - more than 10 cm, notably, modern seventeen-year-old girls are 3.5 cm taller than boys in 1925. The difference in body weight for boys is 16.5 kg, for girls - more than 6 kg, for chest circumference - more than 10 and 6 cm, respectively.

The cyclical nature of changes in the physical development of Russia's pediatric population is described in the scientific literature and can be schematically represented as follows: overcoming the post-war slowdown in the growth and puberty of children and adolescents in the 1950s, beginning of the process of acceleration in growth and pubertal development in the 1960s, and its continuation in the 1970s, with a peak in the mid-70s, beginning of the deceleration process with the phenomena of gracilization in the early 1980s and the activity of the deceleration process until the early 2000s, beginning of the acceleration process in the first decade of the 21st century. The cyclical nature of these changes is most clearly demonstrated by considering the most informative parameter of the pubertal period - the age of menarche in girls and its significant shifts ($p \leq 0.05$) over the observation period (Figure 4).

An analyzed period was characterized by global socio-economic transformations at the global level, which also affected Russia. Thus, Kondratiev theory of economic cycles is widely known in economics; it describes large cycles («long waves») with a duration of 48-55 years and having a downward and upward wave. Currently, five Kondratiev cycles have been described, and their duration today is reduced to 40 years, the fact being associated with the intensification of scien-

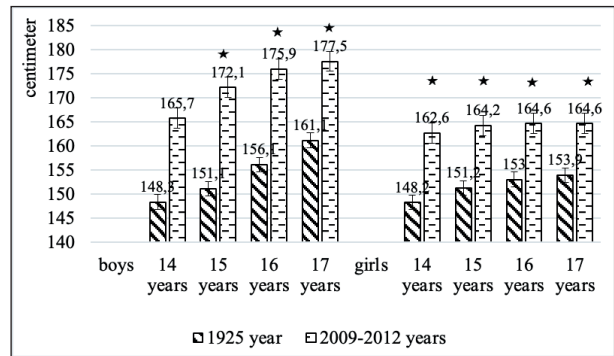


Figure 1. Body length of Moscow boys and girls, aged 14-17, at the beginning of the XX century and the beginning of the XXI century, cm; black star = $p \leq 0,05$.

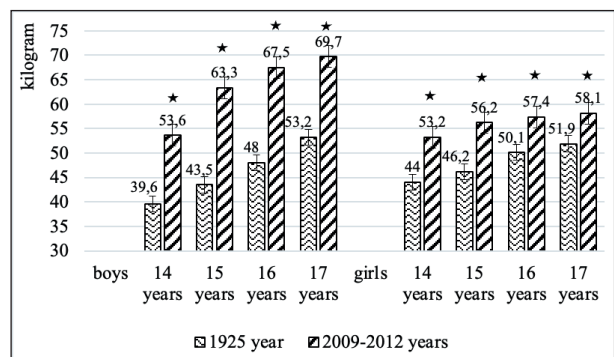


Figure 2. Body weight of Moscow boys and girls, aged 14-17, at the beginning of the XX century and the beginning of the XXI century, kg; black star = $p \leq 0,05$.

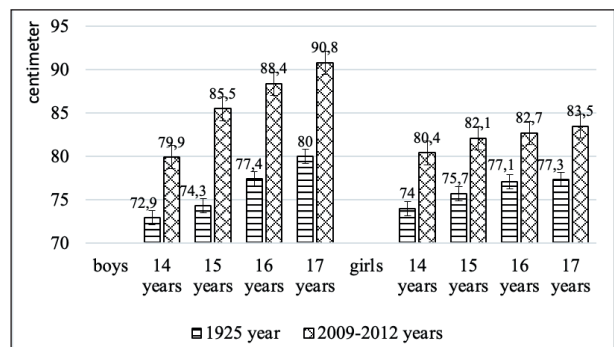


Figure 3. Chest circumference of Moscow boys and girls, aged 14-17, at the beginning of the 20th century and the beginning of the 21st century, cm; black star = $p \leq 0,05$.

tific and technological progress. It is possible to put forward a hypothesis about the influence of economic cycles on the change in parameters of the physical development of the pediatric population. The observation period chosen for the study coincides with the 4th

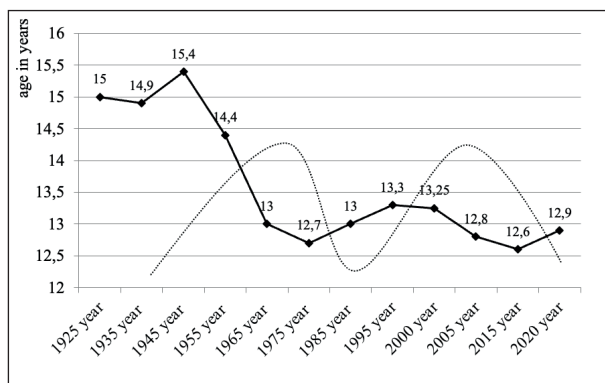


Figure 4. The age of menarche in Moscow girls at the beginning of the 20th century and the beginning of the 21st century in years and a schematic representation of Kondratiev 4th and 5th major economic cycles.

cycle of Kondratiev theory (according to various estimates, the cycle falls between 1936–1940 and 1980–1985, the cycle is associated with the development of the fourth technological paradigm, based on the automotive industry, non-ferrous metallurgy, petrochemistry) and the 5th cycle of Kondratiev theory (according to various estimates, the cycle falls between 1985 and 2020, the cycle is associated with the development of the fifth technological order and the predominance of mobile communications, information technology, software, digital networks and the Internet (26–27).

If the age of menarche in Moscow girls and major economic cycles of Kondratiev theory are compared, then it is possible to trace cyclical changes in parameters and their location in antiphase (Figure 4). Thus, children born on the upward wave 4 of Kondratiev major economic cycle made up the generation of “accelerators”, and children born on the downward wave that coincided with the oil crises (spike in oil prices) 1975–1980 – the generation of “decelerants” (“retardants”), which completely coincides with the previously described scheme.

To further analyze the impact of economic cycles on the age of menarche in girls, we used the GDP per capita value in the year of birth of girls, 1990–2000, which coincides with Kondratiev 5th major economic cycle (Table 1).

In 1990 in the USSR, GDP per capita was 3492.17 USD, which is the highest value for the reviewed period. The average age of menarche in Moscow girls born in 1990 was 147.25 ± 14.83 months,

Table 1. Data on the menarche age of Moscow girls and the GDP per capita in the girl’s year of birth

Year of birth/ year of observation	Average age of the onset of menarche in Moscow girls, months.	GDP per capita, USD (in the year of birth) ¹
1990/2010	147,25	3492,71
1995/2015	152,20	2665,78
1996/2016	147,57	2643,90
1997/2017	152,07	2737,56
1998/2018	154,51	1834,85
1999/2019	154,86	1330,75
2000/2020	154,61	1771,59

¹Source: World Bank Open Data [Electronic resources] – Available at: <https://data.worldbank.org/>, (date of access 30.04.2021).

that is, menstruation should occur in the interval from 11 years 0 months to 13 years 5 months.

In 1995 in the Russian Federation GDP, per capita was 2,665.74 USD, that is, 819.37 USD less than in 1990 in the USSR. The average age of menarche in Moscow girls born in 1995 was 152.20 ± 12.14 months, that is, menstruation should occur in the interval from 11 years 7 months to 13 years 7 months. It can be noted that with a decrease in GDP per capita, there is a significant increase in the age of menarche in girls ($p \leq 0.05$).

In 1998, the Russian Federation experienced one of the most severe economic crises in the entire history of the country. On August 17, 1998, the Central Bank and the Russian Government announced a technical default on the main types of government securities. For the first time in the global history, the state declared a default on domestic debt denominated in the national currency. These circumstances had an impact on GDP per capita, which amounted to 1,834.85 USD. The average age of menarche among Moscow girls born in 1998 was 154.51 ± 15.35 months, which is significantly higher than in 1990 ($p \leq 0.02$). Menstruation should occur between 11 years 6 months to 14 years 1 month.

In 1999 there was a further decline in GDP per capita, while the average age of menarche in Moscow girls increased and amounted to 154.86 ± 13.22 , which was significantly higher than the 1990 value ($p \leq 0.01$). Menstruation should occur between 11 years 8 months and 14 years 0 months.

Figure 5 demonstrated cyclical changes of the abovementioned parameters and their location in antiphase.

To state links between the age of menarche in girls and economic parameters, a nonparametric method was applied (since GDP per capita does not have a normal distribution), namely, Spearman's rank correlation coefficient, which was -0.89 at $p \leq 0.05$; this indicated high correlations between the parameters.

Discussion

Changes in the parameters of physical development of children and adolescents are cyclical in nature, body length changes in time along a sinusoid, periods of "rise" are replaced by periods of "decline". Moreover, the waves of the "first" (longer duration) and "second" (shorter-term) order are distinguished. Heliophysical factors (natural geomagnetic field of the Earth, magnetic storms, sunspots, etc.) affect the human body. Comparison of body length and weight with fluctuations in geomagnetic activity demonstrates that the major wave with a period of about 80 years for both curves is in antiphase - during the calm sun, the growth processes are activated. Puberty is also associated with geomagnetic activity that occurs in the girl's year of birth. In girls born in a year of increased geomagnetic activity, puberty occurs later. Against the background of 80-year cycles, there are cycles with a length of about 11 years. (18).

Similar findings were published by G.G. Koche-

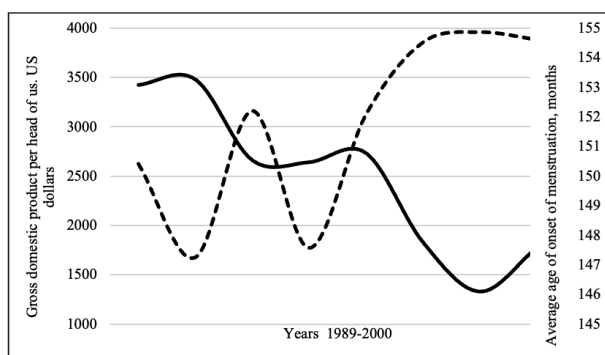


Figure 5. Menarche age in Moscow girls and GDP per capita in the year of birth for 1990-2000. Black line = GDP per capita in US dollars.

masov, who links acceleration and retardation with the Earth's rotation rate characterized by periods of deceleration and increase (28).

It seems natural that the first hypotheses explaining the processes of acceleration - deceleration were heliophysical, radio wave, selective-urban and nutritional (18).

Later, RAMS Academician Lisitsyn combined main theories of acceleration into several groups: physicochemical (heliogenic, radio wave, cosmic radiation, increased concentration of carbon dioxide); the influence of individual factors of living conditions (alimentary, nutritive, increased information); genetic (cyclical biological changes, heterosis); the theory of complex factors of living conditions (urban influence; a complex of socio-biological factors) (29).

However, cyclical processes are characteristic not only of heliophysical factors, but also of the world economy. According to Kondratiev's theory of economic cycles, there are small cycles lasting 8-10 years (according to other sources, 7-11 years) and large cycles, lasting 48-55 years, small cycles are superimposed on large ones. Moreover, some economists believe that there is a relationship between Kondratiev's 55-year long wave, which is nothing more than an 11-year solar cycle repeated 5 times (30).

In literature there is data indicating the relationship between the parameters of the physical development in children and adolescents and economic factors. There is a point of view that the acceleration processes are suspended in economically developed countries since there is a full implementation of the genetically determined limit of body length in favorable socio-economic conditions. Data has been obtained that, simultaneously with the growth of GDP per capita, the living conditions of different groups of the population are leveled, socio-economic differences are smoothed out and, therefore, the acceleration processes are stabilized (31).

In Poland, in 1985-1986, 2005-2006 and 2015-2016, a study was performed that included 11,671 girls aged 10-16 years, which demonstrated that the age of menarche was determined by the level of education of parents and the number of children in the family, as well as by the general parameter of social economic status (32).

In 1982-1983 and 2005-2011 the intergenerational differences in anthropometric parameters of boys aged 7-16 from middle-class families were studied in Kolkata, India. Modern boys have more favorable general conditions of development, this is probably due to socio-economic progress in India in recent decades (33).

In 1985-2015 trends in anthropometric parameters in children and their relationship with economic development during the period of rapid urbanization were analyzed in Guangzhou, China. As GDP per capita (in USD) approached 25,000, the urban-rural gap narrowed and disappeared, thus, inequality in growth has gradually decreased with economic development (34).

In Slovenia their trends were recorded towards an increase in body length in boys and an earlier onset of puberty in adolescents of both sexes in 2013 compared with those in 1993 as a result of socio-economic transformations that the country experienced in the period from 1991 to 2013 (35).

At the same time, the work of RAS Academician Velichkovsky and co-authors demonstrated a pronounced negative impact of economic crises, socio-political crises on the total body size (36).

Thus, the impact of the country's economic development on the physical development of children and adolescents is beyond doubt. The works of leading economists and demographers' evidence that urbanization, migration processes and the associated possibility of heterosis, socio-economic transformations, information loads, changes in diet, etc. are directly related to the economic development of the country (37-40).

Therefore, the authors have proposed to combine individual theories explaining the processes of acceleration - deceleration in the growth and development of the child population into a single economic theory.

Temporary deceleration in the growth and pubertal development of children and adolescents in the context of socio-economic well-being should not give causes for concern; sustained deceleration can be considered as a result of socio-economic ill-being and evidence possible problems in the formation of health of the younger generation. It has been stated that children born during the years of economic crisis constitute a "risk group" in relation to growth and development processes and the formation of health.

Conclusions

The authors propose to combine individual theories explaining the processes of acceleration - deceleration in the growth and development of the child population into a unified economic theory.

Temporary deceleration in the growth and pubertal development of children and adolescents in the context of socio-economic well-being should not give cause for concern; sustained deceleration can be considered related to socio-economic ill-being and evidence possible problems in the formation of health of the younger generation. It has been stated that children born during the years of economic crisis constitute a "risk group" in relation to growth and development processes and the formation of health. In summary these are the results of our study:

1. The authors have proposed an economic theory providing explanation for active acceleration in pediatric growth and development;
2. Children born during the years of economic crisis constitute a "risk group" in terms of growth and development processes and the formation of their health status;
3. Since physical development of the pediatric population is considered as an informative criterion of health status, and reflects the impact of economic development, it is necessary to monitor the parameters of physical development and enter information on these parameters in the databases of Rosstat (or the Ministry of Health, Rospotrebnadzor).

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