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Editorial

Children's Sports Physiology—The Early Studies

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The purpose of this editorial is to summarize the main findings of early studies in the field of children's sports physiology. The Scopus and PubMed databases were searched on 12 December 2022 using the keywords children, sport, or exercise for studies prior to 1970 to identify English literature. It was interesting to note that these early studies focused on topics that are still considered by exercise physiologists today. For example, an important topic in the early studies was the differences in cardiorespiratory (CRF) and neuromuscular physical fitness [1–4] by sex and age. Master [1] described an exercise test of myocardial function, including climbing, and developed normative data by sex and age, concluding that children were more efficient. He reported an age trend in which there is a sharp increase until puberty, and from there, the increase in performance is attenuated until the age of 20 [1]. Elsewhere, Shaffer [4] examined junior high school girls using the Kraus–Weber test (i.e., a fitness battery consisting of muscle strength and flexibility tests) and showed that neuromuscular fitness was correlated with intelligence and improved after appropriate exercise interventions. Moreover, Ono et al. [2] tested children aged 6–14 years on a wide range of fitness components. The authors observed (a) a similar CRF (3 min step test) between girls and boys except at the age of 12 and 13, in which boys scored better; (b) a lower CRF in children compared to adults; (c) an increase in the vertical jump with age in boys and smaller age-related differences in girls; and (d) an increase in the number of pull-ups and duration of hanging from the bar with age in boys, decreasing after the age of 12 in girls. Based on these findings, the authors concluded that the difference in motor ability between the genders becomes eminent from the age of 13 [2]. Alderman [3] investigated CRF (physical work capacity at a heart rate of 170) using a longitudinal study design (testing on two different occasions, 1 year apart) in children aged 10 to 14 years and observed an overall increase in CRF.

Another topic of scientific interest was the question of optimal exercise intensity for children and adolescents [5–7]. Malina had previously identified the research gap on the effect of exercise on growth and pointed out that most of the research has focused on animal studies [5]. He suggested that this knowledge would allow us to determine which sports and exercises are ideal for children [5]. In addition, Reichert [6] examined the intensity of competition that should be developed in athletics for children under the age of 13. He stated that a child who is induced to participate in highly competitive sports that imitate adult patterns is subjected to severe physical and emotional strains, and this can profoundly affect his subsequent physical growth and social development [6]. Furthermore, Maksim [7] suggested that a sports program for children should be one that contributes to their entire physical fitness, which includes physical, mental, emotional, moral, social, and spiritual values. The author stated that sports such as boxing and football should be avoided due to the physical risks [7]. Likewise, Hein [8], while acknowledging the importance of sports in the education of young children, highlighted the need for optimal exercise intensity to avoid emotional stress and undue risk of physical deformity.

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In addition to the previously mentioned studies that examined physiological characteristics in healthy children, other research has been carried out in patients [9,10]. For instance, Scherr and Frankel [10] examined the effectiveness of a training program that includes basic breathing techniques and postural exercises for swimming and self-defense in children with bronchial asthma. They found that, with due attention to bronchial asthma as an allergy and with the collaboration of the patient, parent, physician, and physical instructor, the results obtained were beneficial for the children, both in combating the disease and in improving the adjustment of personality. Abe et al. [9] investigated the effect of a 4-week training program, including right elbow flexion exercises and lifting 1/2 one-repetition maximum weight, on patients of progressive muscular dystrophy. They showed an increase in muscle strength, but after four weeks of detraining, muscle strength returned to baseline levels. Ono et al. [11] studied the ponderal index and CRF and found that a circuit training program reduced the ponderal index, and the magnitude of the decrease was greater in children trained for longer periods, while the training effect was more pronounced in children with a lower ponderal index. In addition, CRF was higher in children with an average ponderal index than in those with a low or high ponderal index [11]. A summary of the topics of children's sports physiology considered in the first studies can be seen in Table 1. Researchers in these fields are encouraged to study and, if suitable, cite these studies.

Table 1. Topics of children's sports physiology in the first studies (English literature) carried out before 1970.

Topic	Study
Sex- and age-related differences in CRF and neuromuscular fitness	[1–4]
Effect of exercise intensity and sport on growth	[5–8]
Exercise in patients and weight control	[9–11]
Other aspects (differences between rural and urban children; effect of equipment on sport skills; physician's role in sports preference)	[12–15]

CRF, cardiorespiratory fitness.

Other aspects examined in early studies of children's sports physiology include differences between rural and urban children [14,15], the effect of equipment on sports skills [13], and the role of physicians in sports preference [12]. Tamura et al. [14,15] compared rural and urban children and found no differences in physical development, such as body height, body weight, chest girth, and sitting height. However, the running ability of rural children was slightly lower than that of the average child for sprint running (50 m), in which maximum power must be exerted in a short period of time. On the other hand, their running ability was well above that of the average Japanese child for long-distance running (1500 m for boys and 1000 m for girls), in which one must provide an all-out effort to perform endurance work over a long period of time. Wright examined the effect of using lightweight and heavyweight plastic equipment on sports-type skills in children aged 7 and 8 years old and concluded that the learning of sports-type skills may be facilitated by the use of lightweight equipment in children with limited strength [13]. Logan [12] highlighted the physician's role in assessing a child's readiness for a specific sport. He reported that certain contact sports, especially when the competition is intense, are too severe for immature children. On this basis, the physician can ensure the proper choice of sports to protect the child from injury and exploitation. Cooperation between the physician and coach is important to this end.

A preliminary remark should be made that Russian science in the period before 1970 was practically not integrated into the world flow of scientific information, and the vast majority of publications by Russian authors until the mid-1970s were inaccessible to the world reader. It was only in the 1970s that Russian journals began to appear, fully or partially translated into English, and were entered into libraries and electronic databases around the world. However, a huge amount of research from the 1950–60s is not available for study by non-Russian-speaking researchers. These scientific works contain interesting facts and productive scientific concepts that deserve to be circulated in scientific communities today; furthermore, they may partially explain the excellence of the USSR in sports during this period (Figure 1).

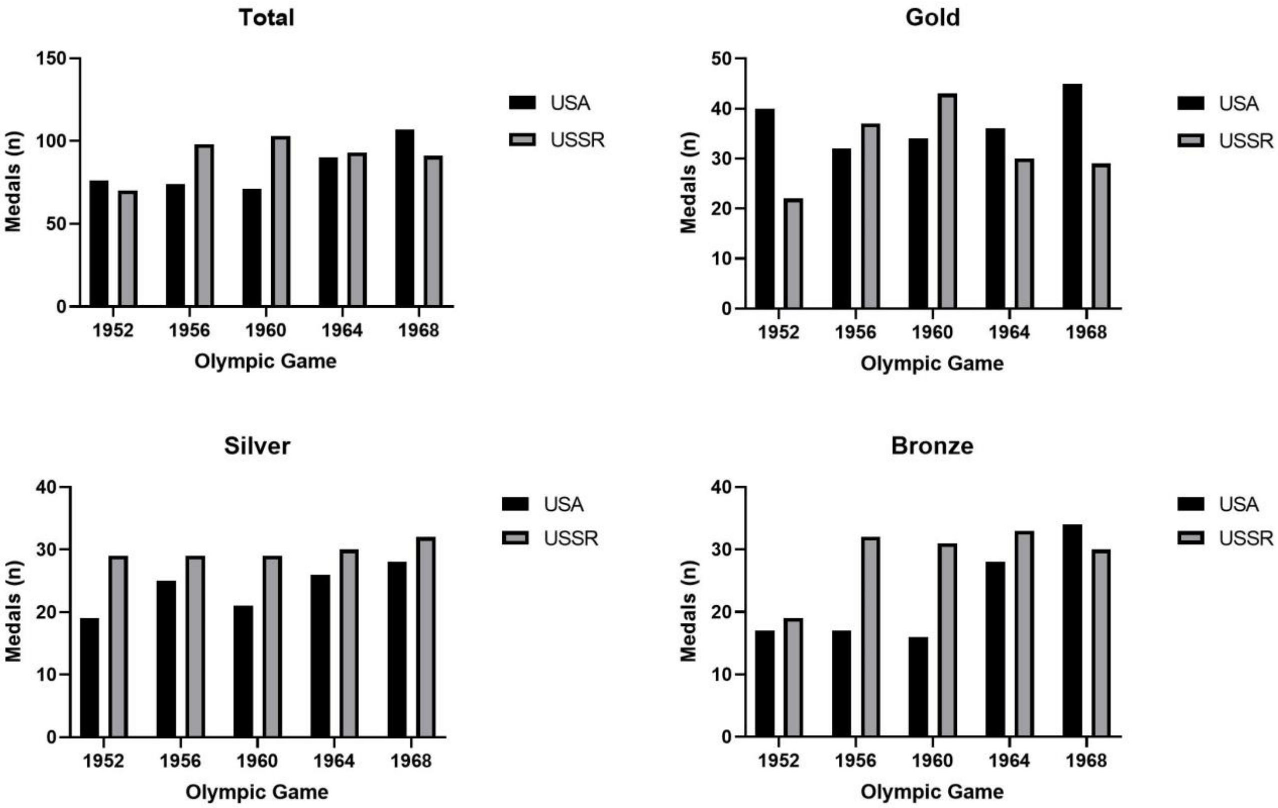

Figure 1. Medals in the Olympic Games from 1952 to 1968 [16].

Markosyan et al. [17] studied the reaction of the blood coagulation system to a dosed cyclic physical load at a power of 60% of the maximum, and the duration of the load was 20 minutes. The subjects were teenagers 13–14 years old, boys 16–18 years old, and adults 22–25 years old. The rate of blood clotting decreased 5 minutes after the exercise to approximately the same extent in all subjects (25%), and its recovery was the fastest in adults and slower in adolescents. Based on these and other data characterizing the work of the blood coagulation system during physical exertion, Markosyan et al. developed a theoretical concept of age-related increases in the biological reliability of the body [18].

One of the first measurements of maximum oxygen consumption (MOC) in boys of school age was performed by Efremov [19], who showed that there is a direct proportional relationship between the level of the MOC and the motor fitness of the subjects.

Korol [20] studied the age-related features of the interaction of the functions of external respiration and blood circulation during intense muscular activity. The load was set by running in place at a pace of 70% of the maximum. The study showed that the nature of the adaptive reactions of the function of external respiration and blood circulation changes with age. In the older age groups, an intensification of functions occurs due to an increase in volumes (the stroke volume of the heart and respiratory volume), while in the younger groups, an increase occurs due to heart rate and respiratory rhythm.

In the work of Bukreeva [21], the age-related development of movement speed in the different joints of the upper and lower extremities in subjects from 7 to 15 years old was analyzed. It is shown that the maximum rate of movements in all joints increases with age, and this increase proceeds unevenly. A strong increase takes place from 7 to

9 years of age, whereas there is a decrease in growth from 10 to 11. From 11 to 13 years of age, growth again increases significantly, slowing down from 14 to 16 years. In girls after 14 years of age, growth may completely stop. Comparison by gender shows that at a younger age (7–9 years) in boys, the maximum rate of movements is higher than in girls, and at 10–12 years the differences are smoothed out; at 13–14, girls are ahead of boys in terms of the pace of movements in most joints. By the age of 16, the pace of movements in boys again becomes higher than in girls, and in adult men it is much higher than in women.

Gas exchange during 50 m and 100 m runs and during the recovery period was studied by Ya.E. Egolinskiy [22] in children aged 8, 12, and 16, as well as in two adults. The author showed that the initial stages of the recovery process after a running load proceeded more quickly in the younger-aged subjects; moreover, they also had lower oxygen demand per 1 kg of body weight, although their oxygen consumption at a distance of 100 m was higher than that of the others. The percentage of oxygen absorption in children was lower than in adults. In general, the dynamics of recovery processes are faster in children of younger age groups compared with older children and adults. Based on the results obtained, the author concludes that the metabolic processes in children aged 8–12 are adequate to the energy demand of the body during a running load.

A number of studies aimed at assessing the impact of physical sports activity on the functioning of the leading physiological systems of the body were carried out by researchers from the Research Institute of Physical Education and School Hygiene of the Academy of Pedagogical Sciences of the USSR in the conditions of all-union competitions for young athletes. These studies covered the blood system [23], with a special focus on blood coagulation reactions [24]; the nervous system [25]; the cardiovascular system [26]; and thermoregulatory processes [27], as well as the multidirectional changes in physiometric parameters under the influence of various sports loads, including modality [28]. The results of these studies made it possible to formulate an idea of myogenic thrombocytosis [24], as well as to propose hygienic criteria for exercise tolerance by young athletes [28].

One of the major scientific generalizations regarding the ontogenesis of motor abilities belongs to Farfel [29,30], and it is based on the experimental studies of his colleagues and graduate students. By studying the various aspects of motor function, Farfel [29] came to the conclusion that many motor abilities, such as the speed of movements and their accuracy, coordination, muscle feeling, etc., except for strength and general endurance, reach a high level of development in the range of 13–15 years, that is, even before the completion of puberty. Additionally, motor function development is most effective at the age when motor qualities show the greatest growth in the process of natural development, that is, again, up to 13–15 years. Farfel [30] notes that "it is difficult to name any movement (unless, of course, it requires exceptional strength or endurance), which could not be taught to a boy or girl of 12–13–14 years old".

In the works of the world-famous scientist Bernshtein [31], ideas about the levels of movement construction were experimentally and theoretically substantiated, starting from the most primitive level A, which involves the formation of skeletal muscle tone, to the highest level E, where intellectual motor acts are formed that are associated with speech, writing, etc. Bernstein believed that the development of movement in ontogenesis proceeded from the bottom up in accordance with the levels he singled out. This concept was further developed in the works of many physiologists, psychologists, and biomechanics around the world.

In 1967, under the editorship of Kuznetsova [32], a collection of articles called "Development of the motor qualities of schoolchildren" was published, which presents studies on age-related development and methods of training speed of movements in children and adolescents [33], static endurance [34], the strength and endurance of the respiratory muscles [35], and speed–strength qualities [36], as well as balance functions [37]. These studies formed the basis for the development of physical education systems at schools, as well as training programs for young athletes in various sports.

In conclusion, the early studies in the field of children's sports physiology made a major contribution to the scientific literature. Moreover, it was interesting to highlight that similar research questions were examined by researchers in both English and Russian literature, and our editorial attempted to present a sample of both English and Russian literature in this field.

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