PERSPECTIVES OF UKRAINIAN AND INTERNATIONAL RESEARCHERS ON THE "INFINITE TONE" PHENOMENON FOLLOWING PHYSICAL EXERCISE IN CHILDREN, ADOLESCENTS, AND YOUNG ATHLETES

СТАВЛЕННЯ УКРАЇНСЬКИХ І ЗАРУБІЖНИХ УЧЕНИХ ДО ФЕНОМЕНУ «НЕСКІНЧЕННОГО ТОНУ», ЯКИЙ З'ЯВЛЯЄТЬСЯ ПІСЛЯ ФІЗИЧНОГО НАВАНТАЖЕННЯ У ДІТЕЙ, ПІДЛІТКІВ І ЮНИХ СПОРТСМЕНІВ

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Abstracts

The study aims to summarize Ukrainian and international findings on the "infinite tone" phenomenon observed after physical activity in children, adolescents, and young athletes.

Material and methods. The study included 285 adolescent athletes: 174 soccer players (2nd–3rd class athletes), 65 male swimmers (2nd–3rd class athletes), 29 female swimmers (1st–3rd class athletes), and 17 handball players (2nd class athletes). Blood pressure was measured by the Korotkoff method using an aneroid sphygmomanometer. Physical performance was evaluated on a bicycle ergometer by measuring heart rate and blood pressure at rest, after two physical activities, and during the 5th minute of recovery.

Results. The "infinite tone" phenomenon was detected in 166 (58.2%) athletes after the second physical activity. Age did not significantly differ across groups, except for male swimmers, where the phenomenon was associated with a higher age. The phenomenon was most prevalent among swimmers (49.2%), followed by female swimmers (41.4%), soccer players (39.7%), and handball players (35.3%). PWC170/kg values showed no significant differences between athletes with and without the phenomenon. Overall, physical performance levels remained high, regardless of the presence of the "infinite tone".

Conclusions. The "infinite tone" phenomenon was observed in 35.3–49.2% of athletes involved in soccer, swimming, and handball after the PWC170 test and was independent of the sport type. Relative physical performance in athletes with the phenomenon did not differ from those without it, ruling out physical overexertion. International studies emphasize the method of measuring diastolic pressure and its connection with hypertension, whereas Ukrainian researchers assess the condition as unsatisfactory and recommend training in special medical groups.

***Key words*:** blood pressure, phases of Korotkoff sounds, "infinite tone" phenomenon, physical performance, young athletes.

Дослідження має на меті узагальнити результати досліджень українських та закордонних учених феномену «нескінченного тону», що спостерігається після фізичного навантаження у дітей, підлітків та молодих спортсменів.

Матеріал і методи. У дослідженні взяли участь 285 спортсменів-підлітків: 174 футболісти (спортсмени 2–3 класу), 65 плавців (спортсмени 2–3 класу), 29 плавчинь (спортсменки 1–3 класу) та 17 гандболістів (спортсмени 2 класу). Артеріальний тиск вимірювали за методом Короткова за допомогою анероїдного сфігмоманометра. Фізичну працездатність оцінювали на велоергометрі шляхом вимірювання частоти серцевих скорочень та артеріального тиску у стані спокою після двох фізичних навантажень та протягом 5-ї хвилини відновлення.

Результати. Феномен «нескінченного тону» був виявлений у 166 (58,2%) спортсменів після другого фізичного навантаження. Вік обстежених осіб суттєво не відрізнявся в різних групах, за винятком чоловіків-плавців, у яких особи із «нескінченним тоном» були достовірно старші, ніж особи без

цього феномену. «Нескінченний тон» був найбільш поширеним серед плавців (49,2%), наступними за ними були плавчині (41,4%), футболісти (39,7%) та гандболісти (35,3%). Визначені показники PWC170/кг не мали суттєвих відмінностей між спортсменами з «нескінченним тоном» та без нього. Загалом, рівень фізичної працездатності обстежених осіб залишався високим, незважаючи на наявність «нескінченного тону».

Висновки. Феномен «нескінченного тону» спостерігався у 35,3–49,2% спортсменів, які займалися футболом, плаванням та гандболом після тесту PWC170 і не залежав від виду спорту. Показники відносної фізичної працездатності у спортсменів із «нескінченним тоном» не відрізнялися від показників у спортсменів, які його не мали, що виключає вплив на появу «нескінченного тону» фізичного перенапруження. Закордонні дослідники наголошують на методі вимірювання діастолічного тиску та його зв'язку з гіпертонічною хворобою, тоді як українські дослідники оцінюють цей стан як незадовільний і рекомендують тренування у спеціальних медичних групах.

Ключові слова: артеріальний тиск, фази тонів Короткова, феномен «нескінченного тону», фізична працездатність, юні спортсмени.

Introduction. Measuring blood pressure during exercise testing, and especially during stress ECG, is a necessary addition to assessing heart rate, since abnormal responses can reveal hidden pathology. Given the complexity of measuring blood pressure during exercise, an accurate measurement technique using modern tonometers is necessary to ensure optimal clinical interpretation [29]. That is why, when measuring blood pressure in children and adolescents, and very rarely in young athletes, in order to avoid any errors, international authors, first of all, focus special attention on the devices for measuring it.

It is known that the main methods for measuring blood pressure include sphygmomanometers (mercury and aneroid) as well as automatic blood pressure monitors [30]. Automatic monitors that use the oscillometric method are quite widespread, but there are a number of questions regarding their accuracy due to the algorithm for its measurement [17]. There are recommendations for taking into account the characteristics of the target group being examined. For example, a number of hemodynamic changes common in pregnant women require specifically validated devices [7], and a study by Joukar et al., showed that the Omron HBP-1100-E automatic blood pressure monitor is not suitable for measuring blood pressure in the Iranian population [18]. Thus, despite the large number of validated automatic blood pressure monitors, Murthy et al., note that there are gaps in terms of geographic representation, including specific target populations and diseases/circumstances, as well as the range of upper-arm circumferences [21].

Such a relatively detailed description of the methods of measuring blood pressure is associated with reports questioning the existence of the phenomenon of the "infinite tone". Since 1984, there has been a point of view that the true diastolic pressure is almost never less than 50 mm Hg and the so-called "infinite tone" is actually an auscultatory phenomenon, in the presence of which the measurement of true blood pressure never has a zero value, and the dystonic type itself was considered an "atypical" reaction.

At the same time, a methodological problem was not excluded, the meaning of which is that listening to a zero tone during blood pressure measurement using the Korotkoff method is an auscultatory phenomenon, since positive values of diastolic pressure are observed when measuring pressure using other methods. Almost 40 years earlier, Wilburne, in 1945, having examined men aged 18 to 45, revealed "a previously undescribed cardiovascular syndrome, which in addition to the nervous element was characterized by transient zero diastolic brachial pressure (measured by indirect method), normal or elevated blood pressure in the popliteal fossa, and tachycardia. The clinical implications of this syndrome are obvious, especially in terms of its distinction from true aortic insufficiency". The author believed that this "syndrome is psychosomatic in nature, and although the actual diastolic pressure is probably not zero, it was most likely subnormal and caused by dilation of the peripheral vessels" [33].

The origin of Korotkoff sounds has been a subject of debate for over 100 years. These

arterial sounds are produced "by indirect measurement of blood pressure using an air-filled cuff, which is usually placed on the upper arm and initially inflated to a level exceeding the maximum or systolic blood pressure" [33]. By slowly releasing the pressure in the cuff, arterial murmurs can be heard with a stethoscope placed over the artery distal to the cuff, or with a microphone placed inside the cuff [12]. The murmurs appear as the cuff pressure approaches systolic, increase in amplitude, then generally decrease, and finally disappear when the cuff pressure is close to minimum or diastolic.

Korotkoff described three, and later five phases of arterial noise [13; 14; 24; 25]: appearance (K_I), softening (K_{II}), sharpening (K_{III}), muffling (K_{IV}) and disappearance (K_V). A more extensive description of the phases is given in the work of Beevers et al. [6], where phase K_I is clear tapping sounds, audible for at least two beats in a row (systolic blood pressure), phase K_{II} is a softening of the tapping sounds and the addition of a whistling sound, phase K_{III} is the return of the tapping sounds, as in phase K_I, but with an increase in their sharpness and intensity, phase K_{IV} is a sharp muffling of sounds with the appearance of softness and blowing, and phase K_V is the complete disappearance of all sounds (diastolic blood pressure), Figure 1.

Korotkoff suggested that the appearance of sounds is due to the opening and closing of the artery during cyclic changes in transmural pressure from positive to negative. This technique became known as the auscultatory method [13; 14]. However, the physical basis of this method remains poorly understood, especially the exact biophysical mechanism of sound generation. The temporal relationship of sounds with true systolic and diastolic pressure is also unclear.

The uncertainty in determining the end point of diastolic pressure, in particular, whether it should be taken as the point of muffling or the point of disappearance of the sound, is known as the "diastolic dilemma" [8; 25; 31]. The difference between diastolic pressure at muffling and disappearance of the Korotkoff sound (up to 10 mm Hg) is clinically significant, since it approaches the difference between nominally normal diastolic pressure (80 mm Hg) and the threshold for diagnosis and treatment (90 mm Hg). Thus, the choice of diastolic pressure end point may be biologically significant and potentially life-changing for patients [8; 24].

In international publications the following rule is accepted: if Korotkoff sounds are heard before zero pressure in the cuff, i.e. there is no K_V phase, then the value of diastolic blood pressure is taken to be the pressure in the cuff at

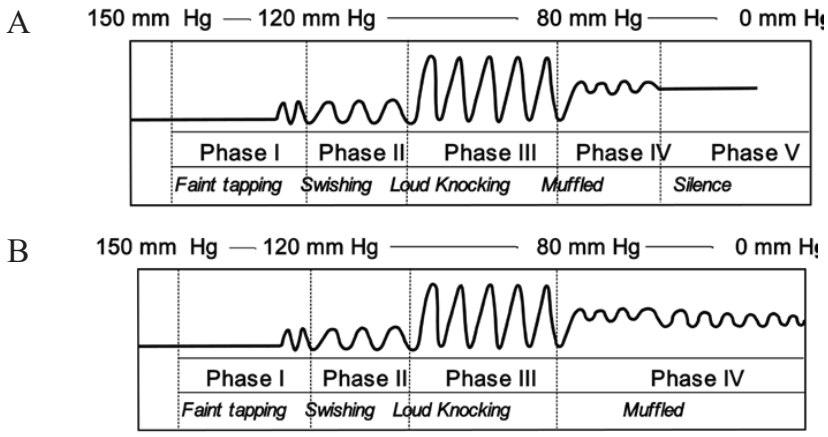

Fig. 1. Graphical representation of the Korotkoff sounds during the measurement of blood pressure (A) [6]; when the phenomenon of the "infinite tone" is observed, phase K_V is not detected (B)

the beginning of the K_{IV} phase (muffling of the tone) [10; 16; 19].

In the absence of a reliable theoretical basis for interpreting Korotkoff sounds, the clinical community relies on empirical studies comparing pressure recorded directly using intra-arterial catheters with simultaneous pressure measured by the auscultatory method. A working consensus has emerged, according to which in adults the point of disappearance of arterial noise (K_V) is the best indicator of diastolic blood pressure [24].

First of all, we consider it necessary to dwell on the reaction of blood pressure to physical activity in children and adolescents, since these changes are part of the physiological response to physical activity, which makes it possible to identify an increased blood pressure reaction in them. There are reports that testing dosed physical loads used to assess the condition of athletes and when interpreting blood pressure values require appropriate reference data [4]. The authors believe that under certain circumstances it is advisable to conduct such stress testing as a fairly non-invasive procedure that allows for expanding knowledge about the possible relationship between the presence of certain clinical conditions, the detection of an increased blood pressure response, and the risk of developing cardiovascular pathology and mortality in later life.

Wuestenfeld et al. believe that only a few studies have been devoted to the behavior of BP during physical exercise in children and adolescents, and even fewer publications have been published on the reactions of BP to bicycle ergometer loads in young elite athletes [34]. Having examined 739 young elite athletes (age 10–20 years, average 15.8 years, 442 males, 297 females) the authors determined the blood pressure percentiles of exercise tests on a bicycle ergometer. Upper limits for systolic blood pressure during exercise were obtained, which allows a more accurate assessment of its corresponding regulation, and echocardiographic studies demonstrated stress-induced cardiac adaptation in most of them, which correlates with higher stress blood pressure compared to individuals not involved in sports.

Thus, a review of the literature devoted to the study of the reaction of children and adolescents, as well as young athletes, to physical activity with the appearance of the "infinite tone" phenomenon, i.e. with the absence of the K_V phase, points to existing questions regarding the registration and interpretation of diastolic blood pressure in individuals with this phenomenon.

The aim of the study is to present modern data of Ukrainian and international researchers on the phenomenon of "infinite tone" that appears after physical activity in children, adolescents and young athletes.

Material and methods. A bicycle ergometry study was conducted on 285 athletes, including 174 male soccer players with a sports qualification of 2nd–3rd class (mean age: 15.8 ± 0.15 years), 65 male swimmers with a sports qualification of 2nd–3rd class (mean age: 15.0 ± 0.26 years), 29 female swimmers with a sports qualification of 1st–3rd class (mean age: 13.7 ± 0.25 years), and 17 male handball players with a sports qualification of 2nd class (mean age: 14.2 ± 0.29 years). The study was carried out in compliance with the main provisions of the Council of Europe Convention on Human Rights and Biomedicine (04.04.1997), the World Medical Association Declaration of Helsinki on Ethical Principles for Research Involving Human Subjects (2008–2013), and the Ministry of Health of Ukraine Orders No. 690 of 23.09.2009, No. 944 of 14.12.2009, and No. 616 of 03.08.2012. Each participant was informed of their rights and the possibility to withdraw from the study at any time without any explanation.

Physical performance was assessed on a Corival (Lode, Netherlands) bicycle ergometer following a standardized protocol [22; 23].

Measurements also included heart rate and arterial blood pressure at rest while seated on the ergometer (P_0, BP_0), after the first physical load (P_1, BP_1), after the second physical load (P_2, BP_2), and at the 5th minute of the recovery period (P_3, BP_3).

Since no automatic blood pressure monitors validated for professional athletes were available, blood pressure was manually measured using Korotkoff's method with

an aneroid sphygmomanometer (Romed, Netherlands) that had been calibrated according to the manufacturer's specifications and in accordance with established clinical guidelines to ensure accuracy and reproducibility of results. Participants were instructed to abstain from consuming caffeine, alcohol, and nicotine, and to avoid strenuous physical activity for at least 30 minutes prior to measurement. The arm used for measurement was supported at heart level, with the cuff placed on the bare upper arm. A properly sized cuff was selected to ensure that the bladder encircled at least 80% of the arm's circumference. The procedure involved palpating the brachial artery to position the cuff correctly, followed by inflating the cuff to 20–30 mmHg above the level at which the radial pulse disappeared. Deflation of the cuff occurred at a rate of 2–3 mmHg per second. Blood pressure was recorded on the right arm three times at 5-minute intervals, with the lowest reading used for analysis [1].

All statistical analyses were performed using Statistica 6 software (StatSoft Inc., license number AXXR712D833214FAN5). All variables are presented as mean ± standard error of the mean (SEM). The normality of data distribution was evaluated using the Shapiro-Wilk test. For comparisons of means between two groups, Student's t-test was applied. Categorical data were analyzed using the Chi-square test. A two-tailed p-value of <0.05 was considered statistically significant for all analyses.

Research results. Of the total cohort of athletes examined (n = 285), 166 (58.2%) exhibited a dystonic type of reaction, characterized by the "infinite tone" phenomenon, following the second physical load on the bicycle ergometer. To facilitate the interpretation of the data, the athletes were categorized based on their sport and the presence or absence of this phenomenon. An age comparison revealed the following results (Figure 2). Soccer players: 69 athletes with the "infinite tone" phenomenon (15.8 ± 0.21 years) compared to 105 athletes without it (15.8 ± 0.21 years, p = 0.895); male swimmers: 32 athletes with the phenomenon (15.0 ± 0.26 years) compared to 33 without it (14.1 ± 0.26 years, p = 0.024); female swimmers: 12 athletes with the phenomenon (14.2 ± 0.32 years) compared to 17 without it (13.3 ± 0.35 years, p = 0.091); handball players: 6 athletes with the phenomenon (14.5 ± 0.68 years) compared to 11 without it (14.0 ± 0.30 years, p = 0.566).

Fig. 2. Distribution of the athletes with and without "infinite tone" (IT): SP – soccer players, SM – swimmers (males), SF – swimmers (females), HP – handball players

The age distribution was generally consistent across groups, with the exception of male swimmers, where those with the "infinite tone" phenomenon were significantly older than those without it.

The prevalence of the "infinite tone" phenomenon was highest among swimmers (49.2%), slightly exceeding that observed in male swimmers (41.4%; p = 0.642), football players (39.7%; p = 0.365), and handball players (35.3%; p = 0.530). However, these differences were not statistically significant, suggesting that the occurrence of the "infinite tone" phenomenon is not influenced by the type of sport.

Comparative analyses of relative physical performance (PWC170/kg) across athletes from different sports, stratified by the presence or

absence of the "infinite tone" phenomenon, are presented in Figure 3.

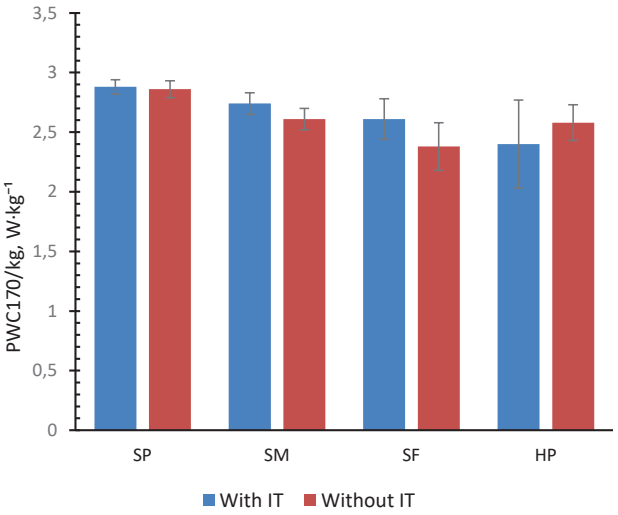

Fig. 3. Relative physical performance (PWC170/kg) between athletes of different sports with and without the "infinite tone" (IT): SP – soccer players, SM – swimmers (males), SF – swimmers (females), HP – handball players

Among soccer players, the mean PWC170/kg value was 0.7% higher in those with the "infinite tone" phenomenon compared to those without ($p = 0.842$). Similarly, in male swimmers, the mean PWC170/kg value was 4.7% higher in athletes with the "infinite tone" phenomenon than in those without ($p = 0.316$). In female swimmers, the mean PWC170/kg value was 8.8% higher in individuals with the phenomenon than in those without ($p = 0.284$). Conversely, in handball players, the mean PWC170/kg value was 7.5% lower in athletes with the "infinite tone" phenomenon compared to their counterparts without it ($p = 0.564$).

These findings suggest that the relative physical performance (PWC170/kg) of young athletes remains consistently high across all groups and does not differ significantly based on the presence or absence of the "infinite tone" phenomenon.

Discussion. Athletes experiencing physical overstraining or overtraining are known to exhibit significant reductions in physical performance. However, in the present study, no significant decrease in physical performance was observed in young athletes presenting with the "infinite tone" phenomenon. This finding suggests the absence of a state of physical overstraining or overtraining in these athletes, and thus, a decrease in physical performance cannot be considered the underlying cause of this phenomenon.

In a previous study conducted by our group, similar results were obtained in a larger cohort of athletes ($n = 741$). That cohort included not only soccer players with a sports qualification of 2nd–3rd class but also highly qualified adult players (Master of Sport and Master of Sport International Class). Among these athletes, a tendency toward higher PWC170/kg values was noted in those with the "infinite tone" phenomenon. Furthermore, in soccer players with a sports qualification Candidate Master of Sport and 1st class athlete, the PWC170/kg value was significantly higher in those with the "infinite tone" phenomenon compared to those without it (3.2 ± 0.03 vs. 3.1 ± 0.04 $W \cdot kg^{-1}$, $p = 0.016$) [22].

Freedman et al. have reported uncertainties regarding the relative importance of the K_{IV} and K_V phases as indicators of diastolic pressure in children. In their study of 11525 adolescents aged 5–17 years, they analyzed inter-expert variability and the relationship of these phases with blood pressure and hypertension in adulthood [11]. A follow-up study several years later included 2156 children who were re-evaluated at the age of 25 years. The findings demonstrated that the K_{IV} phase had lower inter-expert variability compared to the K_V phase, with 7% of children having at least one (of six) K_V values equal to 0 mmHg. Upon reanalysis, the K_{IV} phase showed a stronger association with blood pressure levels and the risk of hypertension in adulthood.

Correlation analysis conducted in subjects not receiving antihypertensive therapy in adulthood ($n = 1848$) revealed that the K_{IV} phase was more strongly associated with diastolic blood pressure in adulthood than the K_V phase ($r = 0.22$ vs. $r = 0.17$, $p < 0.01$). The authors concluded that, compared with the K_V phase, the K_{IV} phase demonstrates lower inter-expert variability

and is more strongly associated with adult hypertension.

De Mey et al. argue that auscultatory data for diastolic blood pressure assessment based on the K_V phase often demonstrate its abrupt decreases [9]. Therefore, they propose using the K_{IV} phase as an alternative. Nevertheless, they recognize the utility of measurements from the K_V phase as a highly sensitive, albeit nonspecific, indicator of pronounced shifts in cardiovascular function. Accordingly, the authors recommend employing both phases in tandem for a more comprehensive evaluation.

A similar perspective is presented by Alpert et al., who suggest utilizing the K_{IV} phase in children aged 3 to 18 years, particularly when the K_V phase is absent [3].

Glenning et al., in a study involving 90 children (mean age: 12.3 ± 3.5 years) undergoing a bicycle ergometer stress test based on the Bruce protocol, identified the K_{IV} phase in 29% and the K_V phase in 37% of participants. Their findings indicate that higher physical performance in children correlates with a greater likelihood of the K_V phase being absent post-exercise. Furthermore, plausible K_V phase values were not obtained in 59% of subjects ($p < 0.001$). The authors reported that a novel hybrid approach combining both phases enabled reliable diastolic blood pressure measurement in 97% of cases [15].

Duff et al. conducted a treadmill test on 70 children (33 boys and 37 girls) aged 10–18 years, employing the K_{IV} phase for diastolic pressure assessment. Two protocols were used: the Bruce protocol and the Columbia Children's Clinical Hospital protocol. Their analysis confirmed the interchangeability of these protocols as alternatives for clinical evaluation of physical activity in children [10].

O'Sullivan et al. highlight the scarcity of studies examining the distribution of Korotkoff phases in pediatric populations. In their investigation, Korotkoff sounds were recorded using a stethoscope bell connected to a MiniDisc system in 70 children aged 11 years. Each sound was classified twice according to phases I, II, III, and IV, with phase V marking the disappearance of sound. Notably, all five Korotkoff phases were detected in 40% of participants [26].

It is well established that the absence of the K_V phase, also referred to as the "infinite tone" phenomenon, is relatively rare in clinical medicine. However, in sports medicine, this phenomenon is observed more frequently following controlled physical activity. According to Viru, in adolescents aged 11–16 years (79 boys and 76 girls), the "infinite tone" phenomenon occurs in 16–30% of boys and 21–27% of girls after performing 20–35 squats, depending on age [32].

In our study of 3914 athletes of both sexes, including sports veterans, this phenomenon was identified in 57.5% of cases [2]. Specifically, among 741 soccer players ranging from 3rd class athlete to Master of Sports of International Class, the "infinite tone" phenomenon was observed in 52.4% of participants. The lowest prevalence was noted among 2nd–3rd class athletes (37.7%), followed by Master of Sports of International Class athletes (49.6%), with the highest prevalence among 1st class athletes and Candidates for Master of Sports (58.2%) [22].

Some international authors [10, 16] recommend registering diastolic pressure based on the onset of the K_{IV} phase. Following this approach, the significance of the "infinite tone" phenomenon diminishes, which may explain the limited number of scientific publications addressing this phenomenon, particularly among Ukrainian and international studies on athletes. To date, we have not identified any scientific papers by Ukrainian authors reporting complaints, pre-pathological conditions, or pathological conditions associated with the "infinite tone" phenomenon in athletes. Furthermore, no prospective studies have suggested restrictions on athletic activities due to this phenomenon.

Nonetheless, the national textbook for higher medical education in Ukraine – "Physical Rehabilitation, Sports Medicine", describes the dystonic type of reaction to physical activity, accompanied by the "infinite tone" phenomenon, as unfavorable. The functional state of such individuals is characterized as unsatisfactory or low. The textbook recommends that athletes

or physical education professionals exhibiting this reaction be assigned to a preparatory or special medical group (in the absence of contraindications) and begin with a gentle training or motor regimen [1].

Studies by Freedman et al. demonstrated a connection between the "infinite tone" phenomenon in childhood and adolescence and the development of hypertension by the age of 25 [11]. This finding holds scientific interest in the context of preventive measures for hypertension in children exhibiting this phenomenon. According to Pickering, the phenomenon has limited physiological significance and is observed in children, as well as during physical exertion [15; 28]. Additionally, there is evidence suggesting that sound attenuation may serve as a more accurate endpoint for diastolic pressure measurement.

In our study, the "infinite tone" phenomenon was detected in young athletes following a dosed physical load using the submaximal PWC170 test. However, some cited studies lack clarity regarding the subjects' involvement in sports or whether a prior testing load was applied. Burton and Park & Menard, proposed that the point at which sounds become muffled during blood pressure measurement should be considered the diastolic pressure [8; 27]. They recommended reporting three values – such as 120/80/65 or 150/70/0 – to reflect systolic pressure, K_{IV} (muffling) phase, and K_V (disappearance) phase. Despite this, the muffling phenomenon remains speculative, as its biomechanical basis is not well understood and is challenging to determine objectively [8].

Historically, there has been ongoing debate about the precise level of diastolic pressure. In current clinical practice, the K_V phase (disappearance) is favored for adults, whereas the K_{IV} phase (muffling) is preferred for children under 12 years of age. For children aged 13 years and older, the pediatric literature predominantly recommends using the K_V phase. These discrepancies suggest that the auscultatory method may not always yield an accurate measurement of diastolic pressure, particularly under certain conditions [20].

Conclusions.

1. Among young athletes participating in soccer, swimming (both boys and girls), and handball, the occurrence of the "infinite tone" phenomenon following the submaximal PWC170 test was largely independent of the type of sport, ranging from 35.3% to 49.2%.

2. The relative physical performance of athletes exhibiting the "infinite tone" phenomenon showed no significant differences compared to those without this phenomenon. This finding suggests the absence of physical overstrain in these athletes.

3. The focus of international researchers on the "infinite tone" phenomenon primarily revolves around determining whether diastolic pressure should be assessed at the beginning of the K_{IV} or K_V phase, or whether three readings (e.g., 130/70/15 or 150/70/0) should be reported. Additionally, studies have investigated blood pressure changes after physical exertion in children and adolescents with this phenomenon in relation to the potential development of arterial hypertension by the age of 25. In contrast, Ukrainian researchers advocate evaluating the functional state of these athletes as unsatisfactory or low, recommending that they participate in special medical group training programs.

Conflicts of interest. The authors declare no conflict of interest.

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