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Physical activity of elderly people

Aktywność fizyczna osób starszych

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Abstract

The aging is attended with changes in different physiological systems and body organ. This is the cause of worsening of movement activity for old adults. The review of age-related changes, their impact on human body functioning and development of activities strategies for seniors' health preservation was the aim of the paper. The scientific literature review showed that the decreasing of functional possibilities is the cause of working capacity and social activity limitations. Physical activity is one of the methods for improving of fitness. It was proposed to choose physical exercises according to biological age of elderly person, their aging profile, the presence of disease and physical activity level. Optimal intensity and character of exercise were established for the old adults with and without chronic pathological disease. The feeling of well-being or heart rate indexes can be used for control by physical training.

Key words: elderly person, aerobic physical activity, muscle-strengthening activity

Streszczenie

Procesom starzenia towarzyszą zmiany w wielu układach i narządach, które istotnie wpływają na aktywność ruchową osób starszych. Celem pracy jest przegląd specyfiki zmian związanych z wiekiem i ich wpływ na funkcjonowanie różnych układów organizmu człowieka, oraz opracowanie szeregu środków mających na celu poprawę stanu zdrowia osób starszych. Wyniki analizy danych zawartych w literaturze przedmiotu wykazały zmniejszenie funkcjonowania głównych układów organizmu starszych osób, co znacznie ogranicza ich operatywności oraz aktywność społeczną. Podstawową metodą zwiększenia kondycji fizycznej jest wzrost aktywności fizycznej. Programy ćwiczeń powinny być zgodne z wiekiem biologicznym ludzi starszych, profilem starzenia, obecnością choroby i aktywnością fizyczną. Należy ustalić optymalny czas trwania, intensywność i charakter ćwiczeń dla starszych osób w kontekście ewentualnych chorób przewlekłych. Poczucie komfortu i wskazniki hemodynamiczne mogą być używane w celu kontroli treningu fizycznego.

Słowa kluczowe: osoby starsze, tlenowa praca fizyczna, ćwiczenia rozwijające siłę mięśniową

Introduction

The number of elderly people continuously increases as the result of different population processes in region. According to prognoses the ratio of residents aged 20-64 years to elderly residents aged 65 years will be 2 to 1 [1]. Therefore, an important part of policy of each European country is the care about health and welfare of the elderly. Life quality of elderly people dependent on social security, material welfare, rational nutrition, organization of medical and social services and so on.

Age-related changes in the body are the causes of the deterioration of the physical and mental health problem thus the number of disabled people or persons which need social care increase. The aging of population is accompanied by health deteriorating, morbidity growing at the negative socio-economic and environmental conditions. The investigation of medical, social and psychological aspects of old age is important today.

The number of seniors which take active part in economic and social life increases rapidly. Thus it is necessary to develop such methods that would support the maximal long and full life. The review of age-related changes, their impact on human body functioning and development of activities strategies for seniors' health preservation and improvement was the task of the paper.

The aging process has an individual character. The dominance of degradation changes in a particular physiological system determines the type of aging – cardiovascular, endocrine, nervous or metabolic. Typically aging profile is determined by the parameters of the cardiovascular, respiratory, muscular system, nervous and mental performance, the state of analyzers system. If the causes, mecha-

Table 1. Duration of physical activity of different age groups (during the week) [7]
Tabela 1. Czas trwania aktywności fizycznej wśród osób w różnych grupach wiekowych (w ciągu tygodnia) [7]

Age group, gender	Walking, minutes	Moderate –intensity physical activity, minutes	Vigorous –intensity physical activity, minutes	Daily working and gardening, minutes	Total physical activity, minutes
18-44 years (n = 6 328)					
Male	118.2 ± 3.2	61.4 ± 2.5	122.3 ± 3.6	93.4 ± 3.4	394.9 ± 6.9
Female	135.5 ± 2.7	33.2 ± 1.6	73.5 ± 2.3	59.3 ± 2.2	301.7 ± 5.1
45-54 years (n = 2 317)					
Male	113.8 ± 5.2	53.8 ± 4.2	65.1 ± 4.3	106.4 ± 5.8	343.2 ± 4.2
Female	135.9 ±4.5	33.8 ± 2.9	45.4 ± 3.2	76.3 ± 4.4	291.9 ± 8.4
55-64 years (n = 1 719)					
Male	139.2 ± 6.8	86.7 ± 5.1	33.1 ± 3.4	124.5 ± 7.9	383.5 ± 13.8
Female	132.7 ± 5.2	75.3 ± 4.2	33.1 ± 3.3	85.4 ± 5.3	317.2 ± 10.5
65-75 years (n = 1 759)					
Male	144.5 ± 2.4	68.8 ± 2.1	31.4 ± 3.8	117.4 ± 7.9	394.2 ± 14.2
Female	124.8 ± 5.0	43.3 ± 1.4	17.9 ± 2.0	67.9 ± 4.7	298.7 ± 3.7

nisms and key areas of functional changes are known than such methods for correction of age-related changes can be proposed:

1. Reduction of harmful effects (stress, negative environmental conditions).
2. Stimulation of organism for improving of reparative mechanisms.
3. Slowing of metabolic process (diet, starvation).

The completely reducing of negative factors and significant slowing of metabolism is impossible. Thus for stimulation of reparative system next action can be used:

1. The enhancing of immune resistance.
2. The use of dietary supplements (adaptogens, antioxidants, etc.).
3. The participation in physical training.

Physical activity is one of the best ways to improve the seniors' health. The regular physical exercises are necessary for prevention of cardiovascular diseases, osteoarthritis, osteoporosis and hypertension [2-5]. However, elderly people with chronic diseases spend on physical activity less than 1 000 calories per week. Thus the risk of depression and musculoskeletal disorders increased [6]. According to the surveys, elderly were not engaged to the regular physical exercise. More than 60% of Europeans older than 65 years did not perform any exercise within seven days [7]. In the United States, only 31% of people aged 65 to 74 years performed moderate-intensity physical activity for 20 minutes three times a week. 16% of elderly people have physical trainings for 30 minutes five or more times per week [8]. Seniors older than 75 years were the least active population group. Only 12% were engaged to regular physical trainings (five or more times per week). Also similar results were also obtained by other researchers [9]. Other conclusions were made by Australian researchers [7]. The least active population group was residents aged 45-54 years. The persons aged 55-75 years were more likely to spent more time for walking and moderate physical activity than other age groups (tab. 1).

The level of physical activity of Ukrainian seniors' was analyzed by the IPAQ survey [10]. The amount of METs spent by leisure time physical activity, transport-related physical activity, work-related physical activity and domestic and gardening activities was calculated. The main part of the total physical activity for adult falls on work. It should be

Table 2. Adult physical activity level
Tabela 2. Poziom aktywności fizycznej osób dorosłych

MET-hours / week1	Adults (n = 350, age – 26-50 years)		Seniors (n = 100, age 58-69 years)
	Female	Male	Female
Physical activity at work (including volunteering, courses, studying etc.)	108.4 ± 9.9	150.0 ± 12.2	55.5 ± 11.7
Physical activity associated with moving from one place to another	27.3 ± 2.4	37.6 ± 5.3	35.8 ± 3.4
Domestic and gardening (yard) activities	85.8 ± 5.4	98.3 ± 15.8	66.0 ± 8,1
Leisure time physical activity	15.4 ± 2.2	43.4 ± 7.0	22.3 ± 3.6
The general level of physical activity	236.9 ± 14.7	329.3 ± 25.8	179.6 ± 15.8

* MET (metabolic equivalent of task) – it is physiological parameter that reflects energy consumption during any physical work; index is similar to 3.5 ml O_2 consumption per kg body weight for 1 min or equivalent to using of 1 kcal per 1 kg for 1 hour (or 4.184 joules per 1 kg for 1 hour). MET level depends on physical activity and ranges from 0.9 (sleeping) to 18 (running at a speed of 17.5 km per hour).

Table 3. The correlation between the life quality of seniors and the level of physical activity
Tabela 3. Związek między jakością życia seniorów i poziomem aktywności fizycznej

Physical activity	Correlation coefficient / MOS SF-36 scales							
	PF	RP	BP	GH	VT	SF	RE	MH
Moderate intensity activity	0.71*	0.65*	0.20	0.45*	0.31*	0.65*	0.48	0.63*
Vigorous intensity activity	0.45*	0.31	0.15	0.23*	0,33	–	–	–
Walking	0.43	0.45	0.34	0.82*	0.43*	0.50	0.56*	0.73*

* Significant correlation, $p < 0.05$.

noted that for seniors special physical training lessons were organized. Thus their physical activity level was only 2-fold lower compared for respondents who have paid work (tab. 2). Female were 2.8 times less likely to be physical activity at leisure time.

The relationships between life quality and physical activity level of older people were analyzed. Strong correlation coefficients were found for moderate intensity physical activity and scales SF-36 scales Physical Functioning and Role Physical ($r = 0.71$ and $r = 071$, respectively) and also between the scale Mental Health and walking ($r = 0.73$) (tab. 3).

Thus intense physical activity was not a prerequisite for optimal health and well-being of older people. Instead, daily activities – walking, lifting up the stairs, farm work, housework can improve the life quality of older people. Thus, the statistically significant correlation coefficients were found between the number of metabolic equivalents spent on average power walking and components of life quality.

In recent years the number of older person who are engaged in various type of physical activity increased slightly. The elderly can be divided into several groups according to the level of daily physical activity [11]:

a) disabled people;
b) physically dependent person – cannot perform all or one of the daily needs (to walk, to bathe, to dress, to eat) and require daily care;
c) people with weak physical preparedness – perform domestic work, can cooking and buy necessary things; achieve all necessary basic activity and some specially organized exercises activity;
d) people which have good physical preparedness – perform low physical work, engaged in sports or have hobbies that do not require vigorous physical activity (golf, crafts, gardening, walking, driving);
e) athletes – perform vigorous physical work, are engaged to endurance sport or sport game; physical activity is among the hobbies;
f) veteran sportsmen – take part in sports competitions, involved in extreme sports.

Although the level of strength and endurance of physical active elderly is significantly higher than their untrained peers, nevertheless the level of muscle activity after 40-50 years decreases [12]. What are the changes in the body elderly that determine the ability to perform the physical load? How effective are physical trainings in this period?

The aging processes are accompanied by changes in many systems and organs of the elderly that appears in their motor activity. These changes occur in the locomotor apparatus, also reflex processes deteriorate at the level of the central nervous system and peripheral structures.

The loss of elasticity in cartilage and ligaments, hardening of the synovial capsule, decreasing of synovial fluid excretion leads to deterioration of articular apparatus, stiffness of movement and reducing of the movement amplitude and speed in the joints [13]. Osteoarthritis (pain in the knee and hip joints) and spondyloarthrosis (pain in the spine) are developed, painful “bones” in the phalanges appears. The deformity of the vertebrae and intervertebral discs leads to the development of osteochondrosis and radiculitis. Also these diseases are caused by decreasing of elasticity of muscles and their ability to relax. Such changes are the reason of reducing of physical activity level and avoiding of public transport.

The structure and composition of bone change with the age. Mostly person 45+ has the thinning of bone tissue and loss of calcium salt.

With age the frequency and severity of muscle hypotrophy increased. From 20 to 70 years the average diameter of muscle fibers reduced almost twice. After 50 years, the total number of muscle fibers is reduced by 10% every 10 years [14]. Also it was found the trophic muscle deterioration in the elderly. The decreasing of IIB type of muscle fibers is the cause of strength and speed reducing of muscle contraction. Strength indexes are stable to the age of 40-45 years and decreasing by 25% at the age 60 years. Record indexes in powerlifting are decreases after the age 30 years by approximately 1.8% per year [12]. Regular physical training can delay these changes.

Changes in motor activity are caused by the processes in the different structures of the motor unit. In particular, the relaxation ability of muscles is deteriorated. The relaxation time decreases after voluntary reduction from 0.5 s to 1 s in the elderly.

In older age groups, the deterioration of all forms of speed is observed. Thus, from 20 to 60 years latency period of motor response increases in 1.5-2 times. Tempo of movement reduced also. It is especially noticeable during the sophisticated movements that required perfect muscles cooperation and appropriate synergistic changes of their tone. The symptoms of movement slowdown were detected during walking in 45.5% of elderly patients and 87.8% of centenarians. According to Vilmor’s and Kostill’s data [12], the maximal running speed is reduced from 25 to 60 years by 1% per year and by 2% per year after 60 years. The disintegration in combined movements and changes in motor skills (walking, positions changing) are observed.

The heart activity slowdown is characteristic for the aging organism, but these processes have significant individual differences. The slowing of heart rate can be caused by decreasing of sinus automatism or the weakening of sympathetic influences. Myocardial sclerosis, atrophy of muscle fibers also is proper for the heart of elderly person. The hypoxia and negative changes in violation of myocardium energy supply are the main causes of such changes. All this leads to a decreasing of systolic volume and blood minute volume, which after 50 years is reduced on 1% per year. This reduction occurs due to decreasing of systolic volume and heart rate. Also these changes are typical for athletes.

According Saltin's data [15], in the age of 50 years the maximal cardiac output of athletes engaged to sport orienteering was on 20% lower than in younger athletes.

The sclerotic thickening of the inner membrane the atrophy of the muscular layer developed in large arteries during aging. The elasticity of the large arteries walls of the person aged 70 years is two times less than in 20 years aged person. This loss of elasticity leads to overspending of heart energy on overcoming of vascular resistance, thus the increasing of blood pressure in the aorta occurs. The reducing of small arteries' diameter is the cause of increased peripheral resistance of the vascular bed and worsening of tissues blood supply. Capillary membrane thickening, increasing of collagen amount in it, reducing of capillary diameter is among age changes. The number of active capillaries per unit of area is significantly reduced. For example, in 90 years old elderly in some areas of the skin the capillary grid density decreased by 30% compared with 18-40 years elderly persons.

The changes in respiratory system of older persons are mainly structural. Low elasticity of the costal cartilages, reduced mobility of vertebrae joints, costae and sternum us typically for elderly people. The fibers of the intercostal muscles and diaphragm that are directly involved in breathing become atrophied. Thus the decreasing of chest excursion and aperture is accompanied by deterioration of respiratory function parameters and the decreasing of vital capacity (respiratory volume, inspiratory reserve volume and expiratory flow) can be determined. The increasing of residual air volume from 25 to 45% of total lung capacity can be detected during a period of 20-70 years. The functional reserves of breath system dramatically reduce. In particular, the maximum value of ventilation is reduced from 100 l/min (for the person aged 30-40 years) to 76 l/min (for the 60-70 years aged). Arterial hypoxemia in elderly people can be result of low physical work. The recovery period of pulmonary ventilation also is longer in elderly.

For the correction of age-related changes different kinds of exercises can be proposed. For example stretching or Amosov and Bendet system [16] provides thousand movements for each joint. The determination of optimal duration, power and character of physical exercises is necessary for improving of seniors' physical activity. Also it is important to use an integrated approach that combines special exercise, proper diet and optimization emotional condition of the elderly.

The basic principles of the exercise selection, that can activate and improve the life quality of elderly people include:

a) constancy (realization throughout the life);
b) positive emotional orientation (sense of satisfaction from the trainings);
c) determination of optimal power of work;
d) versatility (rowing exercise, exercise bicycles, etc.);
e) combination with massage and correction of the spine;
f) combination with showers, baths and hydromassage);
g) combination with starvation, body cleansing.

Aerobic exercises, resistance exercises (isometric and isotonic) and flexibility trainings have the positive effect on elderly people life quality. However, before resistance trainings it is the strong necessary in medical consulting.

Long walks in the mountains or plains, Nordic Walking, jogging, yoga, tai chi, cycling, dancing, swimming, kayaking etc. are recommended in warmer month for persons aged 50-70 years. Skiing is useful in winter. Walking, Nordic Walking, elements of yoga, running, skiing, tai chi, cycling, dancing, swimming, gymnastics are helpful for seniors older than 70 years. Exercise can be combined with Jacobson's and Schultz's relaxation method [13].

How effective can exercise be in reducing of age-related changes? According to scientific data, the level of physical health is closely correlated with maximum oxygen uptake. This rate depends on the cardiovascular and respiratory systems, so it can be used to assess the effectiveness of exercise. It was found [17] maximum oxygen uptake in physically healthy men reduced gradually from 25 to 75 years with a rate 1% per year. Maximum oxygen uptake varies with age, although this index of trained individuals significantly exceeds the index of untrained persons.

According to Pollock's et al. data, significant reduction of maximum oxygen uptake is observed in older athletes (50-80 years) after termination of training [18] that was observed for other person of some age group. Maximum oxygen uptake of Norwegian skiers of age 55-66 years was on 30% higher than in officers of the same age group [19]. The increasing of male and female (age 60-70 years) aerobic capacity can be stimulated by endurance developing (walking, jogging) on 20% during 9-12 months [20]. Thus, exercise helps elderly to maintain and improve maximum oxygen uptake.

The risk of cardiovascular diseases and stroke can be reduces by 30-50% by regular physical activity (five or more times a week for 30 minutes) [7, 21-25]. The risk of type II diabetes decreased by 40-50% for female who was engaged to daily 30 minutes physical training. The risk of breast cancer can be reduced by 20% with regular exercise of medium intensity [7, 26].

Physical training helps to preserve muscle component of body mass index [27] (fig. 1).

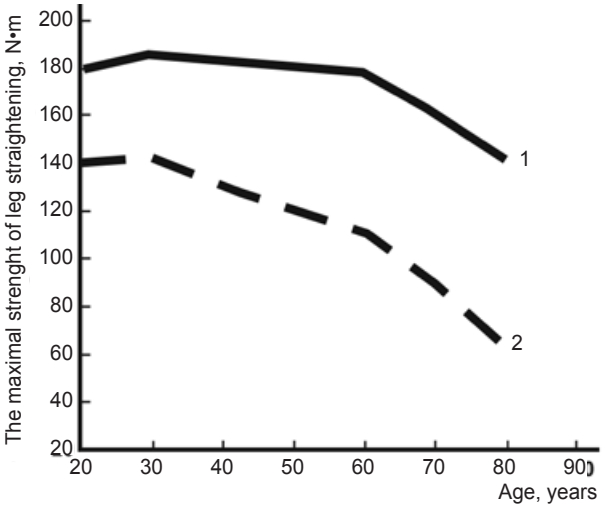

Fig. 1. Age-related changes in strength of leg straightening in knee joint. 1 – trained men, 2 – untrained men [12]
Ryc. 1. Związane z wiekiem zmiany w sile rozprostowania kolana. 1 – mężczyźni wyszkoleni, 2 – mężczyźni niewyszkoleni [12]

12 weeks resistance training for older male increased strength indexes in 2-3 times [28]. Thus the age-related functional changes of muscles can be slowing by physical activity of appropriate direction.

Sports training preserve higher values of systolic volume and end-diastolic volume for older persons [15]. Also the normalization of blood pressure [2, 4], the correction of lipid metabolism (lowering of cholesterol and triglyceride levels in the blood) [4, 29], improving blood flow to the brain and heart muscle [4, 30] are among the positive results of sport training. Regular physical activity improves mood, promotes better resistance to stress and helps to avoid or overcome pho-

Table 4. Physical activity recommendations
Tabela 4. Rekomendacje do aktywności fizycznej

Population group	Recommendations for different types of physical activity
Healthy adult [34]	*Aerobic work* Frequency: the physical work of average capacity must be performed at least five days a week, vigorous physical activity – at least three days a week. Intensity: for moderate physical activity – between 3.0 and 6.0 METS, for vigorous physical activity – 6.0 METS. Duration: for moderate physical activity – not less than 30 minutes a day, for continuous vigorous work – at least 20 minutes a day. *Resistance training:* Frequency: At least twice a week. Number of exercises – 8-10 (this exercises must involve the major muscle groups). Number of repetitions: 8-12.
Elderly person [33]	*Aerobic work* Frequency: 5 days per week for moderate physical work or 3 days per week for vigorous physical work. Intensity: 5-6 points (for the 10 point scale) for moderate physical work or 7-8 points for vigorous. Duration: 30 minutes per day for moderate physical work or at least 20 minutes for continuous physical work. *Resistance training* Frequency: at least twice a week. Number of exercises: 8-10 Number of repetitions: 10-15 *Exercises for flexibility and balance* at least twice a week
People with diseases of the musculoskeletal system, osteoporosis [5]	*Aerobic work* Frequency: at least three times a week Intensity: the work must be performed in the rhythm of 60 to 85% of maximal heart rate. Duration: 30 minutes a day and 7 days a week for moderate physical work; persons who do not engage in physical activity, should start with 5-10 minutes per day. *Resistance training* Frequency: 2-3 times per week. Special constructed complex of exercises for all muscle groups. Number of repetitions: the number of repetition must be increased gradually.
Person who suffer from osteoarthritis [35]	*Aerobic work* Frequency: 3-5 times per week. Intensity: 50-60% of maximal heart rate. Duration: start from 20-30 minutes a day, the level of physical work increase gradually. *Resistance training:* Frequency: 2-3 times per week (preferably isotonic exercises are recommended, but isometric exercises can be done). Number of exercises: 8-10. Number of repetitions: 6-15 according to intensity; the number of repetition must be increased gradually. *Exercises for flexibility and balance:* 3-5 times per week.
People who suffer from cardiovascular disease [2, 36]	*Resistance training* Frequency: 2-3 times per week. Number of exercises: 8-10 (this exercises must involve the major muscle groups). *Exercises for flexibility and balance* Number of repetitions: 1 set – 8-15 repetitions (can be performed more than one set). *Exercises for flexibility* 2-3 times per week
People after stroke [37]	*Aerobic work* Frequency: 3-7 times a week. Intensity: 50-80% of maximum heart rate. Duration of one training – 20-60 minutes. *Resistance training* Frequency: 2-3 times a week. Number of exercises: 8-10 (this exercises must involve the major muscle groups). Number of repetitions: 1-3 sets of 10-15 repetitions. *Exercises for flexibility* 2-3 times per week
People with type 2 diabetes [38]	*Aerobic work* Frequency: at least three days a week, during the week cannot be three consecutive days without any physical activity. Intensity: 50-70% of maximum heart rate for moderate physical activity, 70% of maximum heart rate for vigorous physical activity. *Resistance training* Duration: at least 150 minutes per week for moderate physical work or at least 90 minutes per week for vigorous physical work. Frequency: three times a week. Number of repetitions: 3 sets of 8-10 repetitions.
Person with high cholesterol level [38]	*Aerobic work* Frequency: preferably daily. Intensity: moderate. Duration: at least 30 minutes a day. *Resistance training* The specially selected complex of exercises for the major muscle groups

bias and depression [31], corrects hormonal imbalances [13], enhances immunity, improves bone mineralization [3, 5], enhances sleep, allows to reduce the cancer incidence [32] etc.

The effectiveness of physical activity greatly depends from their duration, intensity and character. The intermittent stretching, breathing exercises, Hermes gymnastics, resistance training, swimming, running, walking, special gymnastic complex with running or walking is proposed by authors of different health system [16]. The minimal work duration depends on its character and intensity. It ranges from 2 to 4 sessions per week and with total duration not less than 2 hours. It is noted the 15 kilometers minimal distance that must be run in a week for a positive effect.

According to the guidelines of the American College of Sports Medicine, elderly people must perform endurance exercise, exercises for strength development and special exercises for flexibility and balance. Endurance exercises affect positively on cardio-respiratory system and resistance training prevent the decreasing in muscle mass [13, 33]. But the effectiveness of physical trainings is hard to check with special markers (for example by increasing of maximal oxygen consumption or by mitochondrial oxidative capacity). The aerobic work of moderate intensity duration by 150 minutes per week or high-intensity work is recommended for people under 65+. Also the different types of physical activity should be combined. For example, brisk walking during 30 minutes can be combined with jogging during 20 minutes.

Aerobic exercise of modern intensity accelerate heartbeat and breathing and are essential for the daily physical activity (self-care, cooking, daily walks) or motor activity that lasts less than 10 minutes (walking around the house, to work, from the parking place). Also, the strength exercises for the major muscle group is necessary to perform at least twice a week (8-10 different exercises, 10-15 repetitions). Physical exercises intensity is determined by the 10 point scale. By null is taking a resting state, by ten – maximal physical effort. When physical activity capacity is higher than average (7-8 points) than heart rate and breathing frequency significantly increased. The age, the presence of chronic diseases must be taken into account during composing of training program (tab. 4).

The physical exercises for elderly person must be chosen according to their functional state (biological age), aging profile, the presence of disease, lifestyle, previous experience of exercise and other factors. Monitoring of physical training can be performed by well-being, based on heart rate zones or calculated by power zones. The development the criteria for physical activity for elderly person should be the subject of further theoretical and experimental studies.

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