Chapter 6
Physical Activity and Prevention of Chronic Non-communicable Diseases

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Stillness is disease, movement is recovery.
— Gabriella Roth (1941–2012)

Abstract Movement is naturally related to human life. Especially the first years of life are characterized by high mobility of children and this activity should not be restricted. It has a great influence on many physiological and anthropometric parameters and on the organism's efficiency, both in developmental age and in adulthood. Physical activity (PA) is one of the recognized methods of non-pharmacological treatment of non-communicable diseases (NCD), including arterial hypertension, excess body weight and the increasingly common type II diabetes in developmental age. It is also an important element in cardiological rehabilitation of people in various ages. There are methods to assess both the efficiency of the body and physical activity. There are various tests used for this purpose and the Internet tools, including calculators, are also increasingly used. An important element of the prevention of chronic non-inflammatory diseases is encouraging appropriate PA among young people and presenting them with methods of activation. The paper presents the current state and the observed trends in the last decades of the PA and physical fitness (PF) for Polish children and youth. Selected own experiences related to the assessment of PF in developmental age are also presented.

Keywords Physical fitness · Prophylaxis · Body weight · Children and youth

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Abbreviations

BMI	Body mass index
H-RF	Health–related fitness
H-RF	Health related fitness
LTPA	Leisure–time physical activity
MVPA	Moderate-to-vigorous intensity PA
NCD	Non-communicable diseases
PA	Physical activity
PF	Physical fitness
VPA	Vigorous intensity PA
WC	Waist circumference

Introduction

Regular physical activity (PA) as well as its influence on health, shaping and keeping skills [1, 2]. A healthy lifestyle is also an important non- the human body in the best shape for many years are considered increasingly important. They are part of a healthy lifestyle that stimulates the proper development of a child and results from inborn needs and acquired pharmacological element in the prevention of many diseases.

WHO defines PA as any bodily movement produced by skeletal muscles that requires energy expenditure—including activities undertaken while working, playing, carrying out household chores, travelling, and engaging in recreational pursuits [3].

The terms PA and physical fitness (PF) should not be considered synonymous. PF is a conscious and planned type of activity, often repetitive, defined, intended to maintain or improve one or more elements of physical fitness.

Everyday PA is divided into: home, professional, sports and other activities. All these activities bring beneficial health effects. PA, both professional and non-professional, is related to such determinants of health as: gender, age, level of education, level of urbanization and others. It has been shown that non-professional activity undertaken consciously in leisure time has clearly beneficial health effects. It should be remembered that the influence and example of parents and teachers who shape the health behaviour of the young generation are important here. The view that the influence of parents (the awareness, knowledge and financial situation) on the PA of children and adolescents is significant [4–6]. It is especially important to practise various forms of exercise in the family. It was noticed that children of active parents are more often (than children of inactive parents) physically active. Regular, moderate-intensity PA has a beneficial effect on the body. It develops muscles, affects the proper growth and shape of bones, develops the circulatory and respiratory system and increases dexterity and physical efficiency [7, 8]. A beneficial hypotensive effect is observed not only in people with elevated blood pressure. Movement is also a factor

that hardens the body preventing many childhood diseases. An important function of PA is its influence on one's psychological health, well-being, and coping with stress, can also support treatment of depression [9, 10]. Moreover, it helps to improve some mental skills such as planning or speed of decision-making [11]. It facilitates both short-term and long-term memory, the ability to divide attention and to focus. It has also been observed that movement reduces anxiety and improves the quality of sleep. It influences the development of responsibility, self-confidence and self-esteem, stimulates empathy, creativity and social skills [12]. Therefore, children's physical activity is important for their psychomotor development.

As a result of reduced PA the developing organism does not fully develop: it has weaker muscles, smaller lung capacity and lower physical performance, slower reflexes and poorer coordination of movements. Limiting movement and spending a long time in front of a computer, mobile phone or TV results in: reduced learning ability, physical exhaustion, reluctance to learn and concentration problems, irritability, and even aggression [13, 14].

Reduced activity is indicated as one of the causes of overweight and obesity. It is estimated that in 2016, the global number of overweight children under the age of five was 41 million, and over 340 million children aged 5–19 were overweight or obese. According to the data of the World Health Organization (WHO), overweight and obesity are the biggest public health problems of the twenty-first century [15].

PA also has a prophylactic effect in many diseases, e.g., hypertension, type II diabetes, depression or colon cancer. It affects the process of the final bone mass building, which also contributes to the fractures, e.g., of the hip bone in menopause and post menopause. In addition, regular physical activity is conducive to maintaining a regular body weight, prevents overweight and obesity, and affects one's well-being. Improving the well-being or mood is associated with endorphins produced during exercise, which are called the happiness hormone [16, 17]. It has been observed that the athletes' levels of endorphins increase during competitions. Stopping exercising involves the risk of complications in adulthood, e.g., ischemic heart disease, hypertension, diabetes and tumors.

Moderate activities include cycling, dynamic walking, dancing and water aerobics, whereas activities such as fast walking, running, fast cycling and swimming fall into the category of intensive exercise.

WHO provides recommendations for PA for children and adolescents up to 17 years of age. They involve 60 min of moderate to vigorous activity per day consisting of endurance exercise, exercising flexibility, balance and muscle endurance (Exercise prescription for Health), strengthening muscles and bones at least 3 times a week [18].

The types of activities recommended for children are presented in the activity pyramid. Various forms of PA that affect health and good physical condition are shown there. The activities presented in the lower part of the pyramid should be performed daily, much more often than the activities presented in the upper part of the pyramid. These are activities that do not require physical activity restrictions. In order to encourage children and adolescents to become interested in physical activity, exercise should be enjoyable and varied and comprise physical education

Fig. 6.1 Physical activity pyramid for children according to WHO

lessons, additional school activities as well as out-of-school sports and recreational activities. Children's PA is influenced by the knowledge, motivation and activity of parents who, by setting an example, organizing family recreational sports activities, participating in such activities with children and encouraging children to take part in physical activities at home, school and with friends can shape pro-health behaviour and promote increased physical activity. It is parents who, to a large extent, shape pro-health attitudes and active relaxation habits of their children by setting an example (Fig. 6.1).

Increased physical activity has an impact not only on the body mass reduction and the change of its components, but it can be considered a routine non-pharmacological method of lowering blood pressure. The mechanisms responsible for the reduction of blood pressure accompanying regular physical exercise are multidirectional. They may be related to: reduction of catecholamines, normalization of the activity of the autonomic nervous system (increased activity of the sympathetic part and decreased activity of the parasympathetic part), decreased activity of the renin–angiotensin–aldosterone system or increased vasodilation capability of skeletal muscles. In the search for relationships between regular exercise and its cardioprotective effects, changes in the functions of the vascular endothelium are of great importance.

Reduced PA of children and adolescents, and the accompanying reduced physical fitness, are a growing problem of the twenty-first century. The increasingly reduced physical activity along with a sedentary lifestyle also affects the adult population. And now, in the specific global health situation that has lasted for many

months, this problem is becoming more and more serious. The announced lockdown related to the increased number of COVID-19 infections and the declared pandemic significantly limited physical activity of all people. Therefore, one should take into account the increased morbidity and even mortality due to many non-communicable diseases NCD. This problem may particularly concern the youngest generation, in which habits favoring a healthy lifestyle should be formed. Staying in isolation for several months has a significant impact on the pro-health behaviour of children and adolescents. Lack of school activities, including physical education lessons, and no extracurricular physical education classes, remote learning and the related several hours of sitting at the computer have an impact on both the physical and mental health of children and adolescents. Lack of exercise, limitation of direct contacts between them is the limitation of their natural needs necessary for proper development. Announcing further bans on leaving the house is associated with very big restrictions, and their effects can be difficult to predict.

Physical Activity of Children and Adolescents in Poland—Observed Trends

Research on PA and PF in paediatric population has a long tradition in Poland.

The interest in this problem in Poland is presented in the pioneering work of Jan Mydlarski entitled "Physical fitness of young people in Poland" published in 1932, in which the author described the close relationship between the degree of development of somatic features and the level of general fitness [19]. Since then, research on the proper motor and somatic development of children and adolescents has been the subject of interest of many scientific institutes and public health units [20–22]. It should be emphasized, however, that despite many pro-health initiatives undertaken both at the governmental level and by many research centers, the physical activity of both children and adolescents as well as adult Poles is highly unsatisfactory [23]. The observed decline in the physical activity of the Polish population corresponds at the same time to the data indicating a rapid increase in the prevalence of overweight and obesity in the entire population.

Particularly disturbing data come from long-term international studies of children and adolescents. International research on health behavior in school-aged children HBSC (Health Behavior in School-aged Children) has been carried out cyclically every 4 years since 1982. Currently, the research covers 49 countries from Europe and North America [24]. Poland has been a member of the HBSC network since 1989.

According to the HBSC protocol, students in three age groups 11, 13 and 15 are cyclically tested. The proposed multidimensional research model allows for a better understanding of health behaviors of adolescents as well as analyzing trends in changes in individual health areas and international comparisons. The frequency

of undertaking both moderate—(MVPA) and intensive physical activity (VPA) by the surveyed students as recommended by WHO was also analysed [25].

The latest research results conducted in 2017/2018 of Polish youth showed that only 19.6% of boys and 14.8% of girls (on average 17.2%) achieve the recommended MVPA [26].

Compared to the previous research results (HBSC 2014), a statistically significant reduction in the percentage of adolescents meeting the WHO-MVPA recommendations was found from 24.2% in 2014 to 17.2% in 2018. Intensive physical activity in line with WHO- VPA recommendations (at least 4 times a week) is undertaken by 33.1% of Polish teenagers (38.2% of boys and 28.2% of girls). The percentage of adolescents meeting the recommendations in this respect decreases with age: 39.3% of 11-year-olds and over 10% less 15-year-olds (28.1%) meet the recommendations. Compared to the previous HBSC studies, the VPA level decreased statistically from 40.5% in 2014 to 33.1% ($p < 0.001$) in 2018. The decline in daily MVPA since 2014 observed among young people both from Poland and from many other European countries is deeply worrying [26].

The systematically declining PA and PF of the Polish pediatric population and the parallel growing problem of obesity are noticed and signaled by many other scientific and expert units [27, 28].

Interactive Tools Supporting the Assessment of Physical Fitness in Children and Adolescents—Own Experiences

Currently, great importance is attached to the proper assessment of the PF of children and adolescents. PF usually means the ability to perform various forms of movement, associated with a particular level of development of motor characteristics, and morphological, physiological as well as mental functions. PF as an objective measure of PA is an important element of health and quality of life and early NCD prevention.

In the recently promoted concept of Health-Related Fitness (H-RF), the results of individual fitness tests should primarily support changes in health-related behavior patterns, create a healthy lifestyle and not solely concentrate on their numerical values [29].

The physiological and medical components of H-RF (Morphological-, Cardiorespiratory-, Musculoskeletal- and Motor Fitness) and the system energy efficiency are both of great importance. PF reference systems have been developed in many countries, including various performance tests in the form of percentile tables or graphical distributions [30–32]. The percentile values of PF for Polish school age children and youths (7–19 y), according to EUROFIT test battery, the International Physical Fitness Test (IPFT) and Cooper Test of PF, were developed in 2015 at the University of Physical Education in Warsaw [33]. Recently, PF reference systems for Polish preschool children have also been developed [34].

European PF percentiles in children between the ages of 6 and 9 were obtained for the first time in the IDEFICS study (identification and prevention of dietary and lifestyle-induced health effects in children and infants) in 2014 [35].

Recently, PF norms (Alpha—Fit) have also been developed for European children and adolescents aged 5–18 [36, 37]. It should be emphasized that in practice, the H-RF components are evaluated using various tests which sometimes hinder comparative analysis.

Dynamically developing e-Health and m-Health sectors as well as many other newer technology solutions (e.g., Wearable Technology, Internet of Things: IoT, Videogames for health: G4H, Intelligent Technologies, smartwatches and many others) have a great potential for effective prophylaxis of many Non-Communicable Diseases (NCDs), including the prevention of obesity complications [38]. Interactive network tools in the form of dedicated calculators are currently very helpful in quick interpretation and assessment of the child's physical fitness level. They are often an integral part of many portals and websites of leading societies and scientific organizations or medical universities.

The authors developed several tools of this type supporting the PF assessment in children and adolescents, intended mainly for school staff.

PF Calculators Based on Standard Field Tests

As the PF reference systems, the results of population studies of children and adolescents according to the standards EUROFIT (nine tests), IPET (eight tests) and Cooper test, developed by researches of the Polish Academy of Physical Education in Warsaw were used Dobosz Stupnicki [39–41]. The absolute values of all PF tests are also presented in the percentile, the z-score and the T-score scales. Indyvidual test can be independently acivated and interpreted using typical, a five step grading system of test results (Low, Moderately Low, Medium, High and Excellent). The results of each test are present graphically in the form of colored bars, with the use of three „traffic light" colors.

The designed fitness calculators allow for an interpretation of the various tests, in terms of both the actual calendar- as and the morphological age. This approach enables relativization of the motor test results and may be useful in the progressive development (pubertal spurt) which is the largest somatic differentiation between pupils in the same calendar age.

In subsequent modifications of the EUROFIT calculator, we also used a simple fuzzy inference system to assess PF [42]. Fuzzy logic (FL) is a very attractive field of artificial intelligence because it is based on natural language and allows for the interpretation of imprecise data [43–45]. The FL system used in the developed calculator enables the classification of both the individual four H-RF components and the general PF using language variables: very low (VL, low (L), median (M), high (H), very high (VH).

The use of FL in relation to the morphological component of H-RF allows for a more in-depth analysis of the nutritional status of a child, including, for example, central obesity [46–48].

A Calculator of Zuchora Index of Physical Efficiency (IPE)

Parents are crucial for shaping their children's behaviors, but many lack the knowledge and skills to provide optimal support for PA. In Poland, a popular test intended for both children and adults is the test developed by K. Zuchora [49].

It allows one, also at home conditions, to evaluate six basic motor abilities:

- Speed (10 s speeding run in a place with the lifted knees accompanied by clapping under each rised leg; the total number of claps is counted)
- Explosive strength (long jump from place; the jump distance is measured by the number of the own feet)
- Streng of arms (free overhang on a bar or on the tree branch in different configurations)
- Suppleness (standing forward bend without bending the knees)
- Abdominal muscles strength (lying on one's back, doing transverse leg shears as long as possible) and
- Endurance (maximum running time in a place at rate of 120 steps per minute or maximum distance running).

The results of each test is evaluated in a 6-point scale:

Minimum—1 point, sufficient—2 points, good—3 points, very good—4 points, high—5 points and an excellent—6 points.

In the end, the total number of points collected in all the tests performed allowed one to determine the Index of Physical Efficiency (IPE) as an average measure of PF with respect to age category.

The IPE is objectively comparable with the results obtained in different period of life, other people, and adults and children.

The developed calculator includes a detailed description of each test, the rules of score and additional accessories (virtual stopwatch and metronome) which can be used in the implementation of various tests. The results of all six tests are presented in a single window, both in numerical and graphic form, enabling an assessment of the fitness profile.

An example of a screenshot of an internet calculator is shown in Fig. 6.2.

Summary

The widely conducted activities promoting pro-health behavior are, among others, aimed at increasing physical activity. The current epidemiological situation overlaps with the already existing unfavourable trend favouring a further reduction in physical

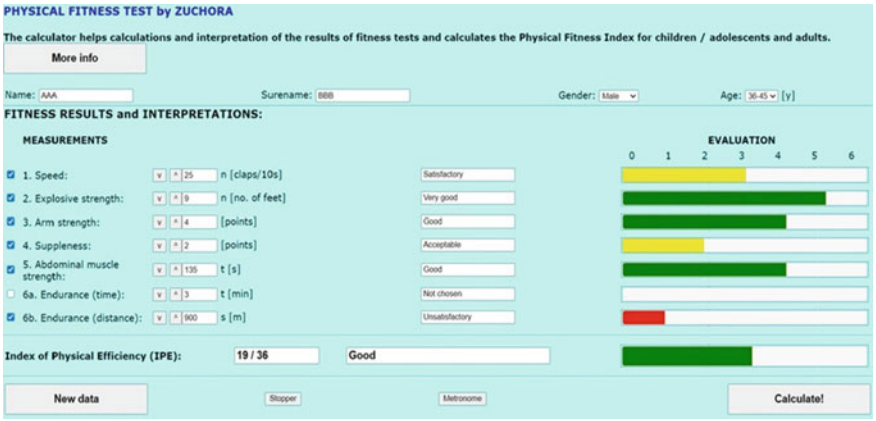

Fig. 6.2 An example of a screenshot of an internet calculator page with Zuchora's test

activity. There is a decrease in activity in the entire population. This unfavourable tendency, which has been perceived for many years in Poland and other countries, is particularly disturbing because it concerns children and adolescents. HBSC research conducted in Poland among adolescents showed a significant reduction in daily physical activity from 24.2% and in 2014 to 17.2% and in 2018. This is related to the unsatisfactory health condition of the developmental age population. This includes declining physical performance. Low physical activity and often concomitant obesity are factors that increase the risk of developing chronic non-communicable diseases.

In order to effectively change the behavior related to low physical activity of children and adolescents, multidirectional projects should be implemented. Parents, teachers (not just physical education teachers), health promoters and medical staff should participate in these activities. Children, adolescents and their parents should be encouraged to increase their daily physical activity and its beneficial influence on health should be emphasized.

An important element supporting pro-health behaviors, including physical activity, are new digital technologies, which are attractive to children and adolescents and may constitute.

The implementation of environmental and political activities means creating places for physical activity with increased access, without incurring financial costs for parents. Other implemented activities in the field of public health include: health education, education in schools and universities, social support for families and social campaigns in the mass media, but the effects of their impact are diverse and difficult to assess.

"*Movement will replace almost any drug, while no drug will replace exercise*

— Wojciech Oczko (1537–1599)

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