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Review article

ASSESSMENT OF PHYSICAL FITNESS IN CHILDREN AND ADOLESCENTS

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Abstract. *Existing evidence suggests that physical fitness is an excellent indicator of the health of children and adolescents and is a predictor of health in later life. Furthermore, measuring, assessing and monitoring of physical fitness should be considered a public health priority. Currently in the world there are more than fifteen battery (group) tests for the assessment of physical fitness in children and adolescents. Unlike most European countries which are already applying the EUROFIT battery of tests in schools, or the United States where the FITNESSGRAM battery test is being applied, Serbia lacks a clearly specified and well defined strategy for testing physical fitness in children and adolescents. The obvious problem of testing physical fitness in children and adolescents is the focus of this review. The basic idea is to, by showing the most common battery of tests and the circumstances in which they are incurred and being replaced, clarify the concept and importance of testing, select the components that are necessary to test and propose a valid, reliable and objective group of tests for fitness in children and adolescents. The analysis of the most common groups of tests and new scientific evidence has highlighted the importance of evaluation of the components of health-related fitness. ALPHA-FIT battery tests are proposed in physical education, which were incurred as part of the ALPHA project of the European Union (Assessing Levels of Physical Activity and Fitness).*

Key words: *health, testing, EUROFIT, FITNESSGRAM, ALPHA-FIT.*

INTRODUCTION

There are more than 15 battery tests for the assessment of the physical fitness of children and adolescents and several key components of physical fitness currently in use worldwide (Castro-Piñero et al., 2010). Unlike most European countries, which are ap-

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plying the EUROFIT test battery in schools, and the U.S. where the FITNESSGRAM test battery is being used, Serbia lacks a clearly specified and well defined strategy for testing the physical fitness of children and adolescents.

Teachers are directed to existing tests published in the *Official Gazette* and the EUROFIT battery of tests (Radojević, 2011). Although testing is provided, there is no evidence that it is implemented and there are no centralized databases of the results that can be later processed and compared. On the other hand, the obligation of the Institute of Sports Medicine and Sports of the Republic of Serbia is the periodic testing or monitoring anthropometric characteristics of children, youth and adults (Sport Act, 2011). Bearing in mind that anthropological human space consists of biological (morphological and physiological), psychological (cognitive and conative), sociological and a complex of motor activities (Rodić, 2011), the question is what complex, or components (dimensions) of the complex the Institute should test. It is highly probable that this institution does not have sufficient staff which can perform the testing of all the school children, especially not all the anthropological components. The obvious problem of testing physical fitness in children and adolescents is the focus of this review. The basic idea is that, by showing the most common battery of tests and the circumstances that have arisen, we can explain the concept and importance of testing, select the components that are necessary to test and propose a valid, reliable and objective battery of tests to assess the physical form of children and adolescents.

Physical fitness

Physical fitness is defined as the ability of an individual to competently and capably perform everyday tasks without excessive fatigue, and with enough energy remaining to enjoy spending free time, as well as to resolve unusual situations of sudden and unforeseen emergency (Council of Europe, 1983). It can be seen as an integrated measure of, if not all, then most of the body functions (muscle-skeletal, cardio-respiratory, hemato-circulatory, psycho-neurological, metabolic and endocrine), involved in the performance of daily physical activities and/or physical exercise (Ortega, Ruiz, Castillo & Sjöström, 2008b). In the Serbian language we use the term physical condition. Although the words are basically synonyms, it is widely believed that the term condition applies only to athletes. Therefore, the term fitness extends the discussion to the entire population, i.e. athletes and non-athletes.

There is no universal consensus on the definition of key components (dimensions) of physical fitness. Most are defined according to two objectives: a) sporting achievements or b) health. a) Fitness associated with sporting achievements refers to the components that are needed in individual sports competitions, skills tests or professional work. b) Fitness associated with health (medical form) refers to components relevant to a favorable health status. By health fitness we mean the ability to perform daily activities with energy characteristics and capacities that are associated with a lower risk for developing chronic disease and premature death. It directly depends on the level of physical activity of the individual (Ruiz et al., 2009).

The cardio respiratory component is one of the most important components of health-related fitness. It is a direct indicator of the physiological status of the person. It reflects the total capacity of the cardiovascular and respiratory systems to supply oxygen during

long-term physical activity and reflects the ability to perform prolonged strenuous exercise (Ruiz et al., 2006a).

The musculoskeletal component includes a balanced, healthy functioning of the musculoskeletal system. This requires that a particular muscle or group of muscles can produce force or torque force (i.e. muscle strength) to withstand repeated contractions over time or to maintain maximal voluntary contraction for a prolonged period (i.e. muscular endurance), and perform maximal, dynamic contraction of a muscle or group of muscles in a short period of time (the explosive power or muscular force). Flexibility as a factor of the musculoskeletal components is the ability of a muscle or group of muscles to move freely through a full range of motion (Ruiz et al., 2009).

The morphological component refers to the relative position of muscle, fat, bone, and other vital components of the human organism (Ruiz et al., 2009). Body composition is essential for optimal health and athletic performance. Excess fatty tissue above the optimal value exposes a person to an increased health risk of obesity, cardiovascular disease, diabetes and malignant diseases (Ostojić et al., 2009), and prevents athletes from optimal performance in sports dominated by running or jumping activities (Ostojić, 2003).

The motor component (physical fitness associated with skills) consists of factors of physical fitness that are associated with improved sporting achievements and motor skills. Individuals with a good level of motor fitness are more likely to engage in regular physical activity, and therefore may have a better health-related fitness. Motor fitness factors are estimated by measures of success. These factors, such as speed, vary over inherited predisposition rather than healthy lifestyles, especially among children (Ruiz et al., 2009).

Reduced physical activity and/or physical fitness is associated with the etiology and prevalence of several non-communicable diseases, such as cardiovascular disease, diabetes, cancer, and their risk factors (high blood pressure, elevated blood sugar, and obesity), affecting the public health of people worldwide (World Health Organization, 2010). Physical activity of moderate to high intensity stimulates functional adaptation of all the tissues and organs of the body (i.e., improved form), thus reducing the negative impact of lifestyle on degenerative and chronic diseases (Ruiz et al., 2006a). In a systematic review of the literature Ruiz et al. (2009) concluded that:

A) there is strong evidence to suggest that: I) higher levels of cardio respiratory fitness in childhood and adolescence is associated with a healthier cardiovascular profile later in life; II) improvement of muscle strength from childhood to adolescence is inversely associated with changes in total fat cells (adipocytes); and III) a healthier body composition in childhood and adolescence is associated with a healthier cardiovascular profile and a lower risk of death later in life;

B) There is moderate evidence that: I) higher levels of cardio respiratory fitness in childhood and adolescence reduce the risk of developing metabolic syndrome and arterial wall stiffness later in life, II) increased cardio respiratory fitness is inversely associated with changes in lipids and lipoproteins in the blood; III) improving muscle strength from childhood to adolescence are inversely associated with overall obesity, and IV) there is no correlation between body composition (i.e., body mass index - BMI) and pain in the lumbar region of the back;

C) from a limited number of studies, inconclusive evidence suggests that: I) changes in cardio respiratory fitness are associated with changes in the thickness of the middle part of the artery wall, stretching the carotid artery compliance, weight gain, diabetes and metabolic syndrome, II) changes in muscle strength are associated with changes in sys-

tolic blood pressure and concentrations of blood lipids and lipoproteins, III) motor fitness in childhood and adolescence lowers cardiovascular risk factors in later life, and IV) motor fitness in childhood and adolescence lowers the risk of lower back pain later in life.

Research results should be interpreted with caution because of the different tests used to assess physical fitness, follow-up time, age, test results, as well as parasitic factor measurements (Ruiz et al., 2009).

Increasing levels of physical activity in children and adolescents improve physical fitness. A high level of fitness in childhood has a positive effect on health (Mesa et al., 2006, b) and has a prolonged effect later in life (Ruiz et al., 2006b, c).

Assessment of physical fitness

The results and experience gained from several European studies suggest that physical form is a key indicator of the health of children and adolescents (Ruiz et al., 2006) and is a predictor of health in later life (Ruiz et al., 2009). Regular monitoring of the level of physical activity and physical fitness of the entire population should be considered a public health priority (World Health Organization, 2010). Monitoring involves constant measuring and/or estimating (collective test) levels of physical activity and physical fitness of the individual as well as the evaluation of the data.

The level of physical activity, in practice, is mostly estimated by means of questionnaires or diaries, collectively called "self-reports of activities", although technical devices are being used more and more in recent years - accelerometers and pedometers (Vanhees et al., 2005). Physical fitness can objectively be measured in the laboratory. However, the use of such tests is limited in practice due to the necessity of sophisticated instruments, qualified technicians and time constraints. Field tests provide a reasonable alternative because they are more time-efficient, requiring a lower cost of equipment, and they are capable of testing more people at the same time (Castro-Piñero et al., 2010). By testing physical fitness we actually check the functional status of all the systems of a man (Ortega et al., 2008b).

Schools can play an important role in identifying children with low physical form by applying the standardized field test. They can also promote positive behavior related to an increase in fitness (España-Romero et al., 2010), and to promote good health habits by encouraging children's activities with a particular focus on the intensity of the activities (Ortega et al., 2008b). As the organizational forms and content of physical education have always depended on the degree of development of a particular society and environment being studied (Dedaj, 2011), it should not surprise us that many countries have recognized the importance of measuring and assessing physical fitness and have included the required battery of tests in their education strategy (Table 1).

Battery tests applied in Serbian schools were developed by the Yugoslav Institute for Sports Medicine and Sports in the late eighties. The system was functional until 1999 when it stopped working. Finally, in 2009, after a few sporadic attempts, the Institute of Sport and Sports Medicine tested 878 pupils with a modified Eurofit battery test which did not include measurement of cardio-respiratory endurance, and skin fold thickness (Gajević, 2009). After examining the new scientific evidence, some of the mentioned battery tests do not meet the necessary psychometric properties (Castro-Piñero et al., 2010; Ruiz et al., 2011).

Table 1. Existing field-based physical fitness test batteries for children and adolescents (Ruiz et al., 2011; according to: Castro-Piñero et al., 2010).

Age	Acronym	Society/Organization	State/ Region
6–18	EUROFIT	Council of Europe Committee for the Development of Sport	Europe
5–17	FITNESSGRAM	The Cooper Institute	USA
6–17	PCHF	The President's Council on Physical Fitness and Sports/American Association for Health, Physical Education, and Recreation (AAHPER)	USA
6–17	PCPF	The President's Council on Physical Fitness and Sports/American Association for Health, Physical Education, and Recreation	USA
6–17	AAUTB	Amateur Athletic Union Test Battery. Chrysler Foundation/Amateur Athletic Union	USA
6–17	YMCAYFT	YMCA Youth Fitness Test	USA
5–17	NYPFP	National Youth Physical Program. The United States Marines Youth Foundation	USA
5–18	HRFT	Health-Related Fitness Test, American Association for Health, Physical Education, and Recreation (AAHPER)	USA
5–18	Physical Best	American Association for Health, Physical Education, and Recreation (AAHPER)	USA
9–19	IPFT	International Physical Fitness Test (United States Sports Academic/General Organization of Youth and Sport of Bahrain)	USA
7–69	CAHPER-FPT II	Fitness Performance Test II. Canadian Association for Health, Physical Education and Recreation (CAHPER)	Canada
15–69	CPAFLA	The Canadian Physical Activity, Fitness & Lifestyle Approach (Canadian Society for Exercise Physiology)	Canada
9–19+	NFTP-PRC	National Fitness Test Program in the Popular Republic China (China's National Sport and Physical Education Committee)	China
6–12	NZFT	New Zealand Fitness Test. Rusell/Department of Education	New Zealand
9–19	AFEA	Australian Fitness Education Award. The Australian Council for Health, Education and Recreation, ACHER	Australia

EUROFIT battery of tests

The Committee of Experts on Sports Research launched the testing of physical fitness and the establishment of normative data for European students in 1977 for the first time. The main objectives included:

a) agreement on joint battery of tests in Europe
b) help in assessing the effectiveness of physical education in schools
c) help in measuring the fitness of school children.

The set goals stemmed from the conclusion that due to the changed lifestyle in the future, conditioned by industrialization and automation (reduced physical activity and an increased sedentary lifestyle), children and adults will have difficulty solving everyday challenges. Consequently, physical fitness will be reduced, which will have a negative

impact, particularly on health status. Therefore, physical exercise will not be a matter of personal choice, just for fun and pleasure, but a necessity for everyday, smooth functioning (Council of Europe, 1983). We see that the conclusion holds true.

After several meetings of experts in 1983, the temporary manual "Physical fitness testing EUROFIT - experimental battery" was developed. Four years later, the Committee of Ministers of the Council of Europe adopted a recommendation for the use of the EUROFIT battery of tests to assess the physical fitness of children and the young. It was suggested to all European countries to adopt this battery of tests, since: a) physical fitness is an important component to not only sport and physical education but also health and health education, and that it is necessary for the state of general well-being; b) that accurate and reliable measures of physical fitness are of great importance for individuals, educators and policy makers in order to improve the level of general or individual fitness; c) that teaching and learning about physical fitness can make an important contribution to the self-knowledge and motivation of the individual to remain active, and on the educational process in general; d) that the testing, under controlled conditions, will provide important data which will be used in the creation of a national policy for children's health, nutrition, physical education and sport; e) that EUROFIT provides a simple and practical set of tests suitable for widespread use among school children, and that it is designed, among other things, to achieve set goals, providing information on the physical fitness of school children in each state (Council of Europe, 1987).

In accordance with the adopted recommendations, a Handbook for the EUROFIT tests of physical fitness manual was made which was intended for examiners (teachers, educators). The EUROFIT battery of tests was accepted by the majority of European countries, and it is also used in countries outside Europe. The tests are simple, designed for mass use in the field, and in the application of regular physical education classes. Based on the data obtained by this battery of tests (Table 2) the physical condition of children and young people is estimated in relation to their health (Council of Europe, 1988). Testing on this model does not extract all the latent dimensions of motor space, but is based on an estimate of components closely related to health.

Table 2. Eurofit tests of physical fitness (Council of Europe, 1987).

Dimension	Factor	Factor Eurofit Test
Cardio-respiratory endurance	Cardio-respiratory endurance	Endurance shuttle run (ESR) Bicycle ergometer test (PWC 170)
Strength	Static strength	Hand grip (HGR)
	Explosive power	Standing broad jump (SBJ)
Muscular endurance	Functional strength	Bent arm hang (BAH)
	Trunk strength	Sit-ups (SUP)
Speed	Running speed - agility	Shuttle run: 10 x 5 meters (SHR)
	Speed of limb movement	Plate tapping (PLT)
Flexibility	Flexibility	Sit and reach (SAR)
Balance	Total body balance	Flamingo balance (FLB)
Anthropometric measures	Height (cm):	
	Weight (kg):	
	Body fat (5 skinfolds: biceps; triceps; subscapular, suprailiac, calf):	
Identification data	Age (years, months):	
	Sex:	

FITNESSGRAM battery of tests

The FITNESSGRAM battery of tests comprises a program for the assessment of physical fitness of children concerning health. It includes a variety of tests designed to evaluate: a) cardiovascular endurance, b) body composition, c) muscle strength, d) muscle durability and e) flexibility (Table 3). The FITNESSGRAM battery test uses the criterion that indicates health standards and the standards associated with good health. Specifically, the standards are based on what kind of fitness is necessary to keep a child in good health.

The results of previous scientific research were used to define the fitness required to meet the basic health requirements and to define "physical fitness in a healthy zone". With it, it indicates the range of results related to good health. Results below this zone are classified as "need improvement", and notify that it is necessary to work out in order to set the results in the healthy zone (Pangrazi & Corbin, 2008).

Table 3. Additions and Deletions to the FITNESSGRAM Health-Related Fitness Test Battery 1987–2005 (Plowman et al., 2008).

Fitness component	Test item	Year included	Year deleted
Aerobic Capacity	One Mile Run/Walk	1987	
	PACER	1992	
	One Mile Walk Test	1999	
Body Composition	Skinfold Measure of % Body Fat	1987	
	Body Mass Index (height & weight)	1987	
	Portable Bioelectric Impedance Analyzers	2004	
Muscular Strength &	Modified Sit-up Test	1987	1992
Endurance	Curl-up Test	1992	
	Pull-up	1987	2005
	Flexed Arm Hang	1987	
	90° Push-up	1992	
	Modified Pull-up	1992	
	Trunk Lift	1992	
Flexibility	Sit-and-Reach Test	1987	1992
	Back-Saver Sit-and-Reach Test	1992	
	Shoulder Stretch	1992	
Other Items	Shuttle Run (K–3)	1987	1992

The FITNESSGRAM concept began in 1977 in America. Its creation is related to the director of the Health and Physical Education from Texas, Charles M. Sterling, who, interested in the physical form of his students, began to make a "report card". In collaboration with his teachers he performed tests for the assessment of motor abilities of students and kept a record in the main school using computer software which was developed for the integration of the personal report cards.

From the moment of its creation, the FITNESSGRAM program evolved from a report card about the motor abilities of students into personalized reports about physical fitness and physical activity of students related to their health. Today the FITNESSGRAM, along with self-reports on activities – the ACTIVITYGRAM is a software system for educational assessment and reporting used by thousands of teachers for millions of young

people in schools around the world. By monitoring forms related to health and physical activity over time we gain the information necessary to create personalized reports for children, parents, and school administrators (Plowman et al., 2008).

The main purpose of these batteries of tests is to promote lifelong physical fitness, exercise and behavior that reinforces health. Results obtained from the tests are a starting point from which: a) children acquire knowledge about their health, as well as methods and ways in which to strengthen and preserve it, b) parents of children get to know the fitness of their children and indicate the steps to be taken in planning activities with children, c) the teachers and others get familiar with the fitness of students and consequently design the physical education curriculum (Pangrazi & Corbin, 2008).

The ALPHA-FIT battery of tests

Most battery field tests for the assessment of fitness that are available (see Table 1) were developed for children and adolescents in the United States. In Europe, the EUROFIT has solely been applied for many years. The European Union, in the last few years, funded a number of pan-European projects in order to strengthen and preserve the health of children and adolescents (Ruiz et al., 2006). One of the last ones, ALPHA (see http://sites.google.com/site/alphaprojectphysicalactivity/Home), was launched with an aim to provide a set of instruments for assessing levels of physical activity and physical fitness in a comparable way within the European Union countries. After years of studious and systematic studies that included more than 10,000 patients - children and adolescents in Europe, an ALPHA-FIT battery of tests for the evaluation of physical fitness related to health was defined.

The battery of tests consists of valid, reliable, manageable and secure field tests that can be used to monitor public health. Based solely on new scientific evidence from currently available transversal and longitudinal researches in the world, the ALPHA-FIT battery test includes the following tests: (1) the 20 m extended run between cones to assess cardio respiratory fitness, (2) the hand grip, and (3) the standing jump to evaluate muscular-skeletal fitness, and (4) the body mass index BMI, (5) waist size and (6) skin fold thickness (triceps and subscapular skin fold) for body composition assessment. Feasibility studies in the school environment indicate that the time required for the implementation of these tests in a group of 20 students with one teacher is about 2 hours and 30 minutes, or three classes of physical education of approximately 55 min. When there are time constraints, as the case may be in schools, tests included in high priority ALPHA-FIT are recommended. It includes all forms of tests based on evidence other than skin fold thickness measurements. The time needed for the performance of the battery of tests for 20 students with one teacher is less than 2 hours (i.e., two classes of approximately 55 min). When there are no deadlines, as might be the case in sports clubs or during research, it is recommended to use the extended ALPHA-FIT, which includes an additional test: pin running 4 × 10 m, to assess motor form (Ruiz et al., 2011). This test is an indicator of speed and agility, and is associated with bone mass in young people (Ortega et al., 2008a). However, there is no evidence of its intuitive and criterion validity (Ruiz et al., 2011).

Requirement for an ideal battery of tests

Traditional practice of testing which assessed the so-called latent dimensions of motor space (e.g., speed, strength, coordination, etc.), has been replaced by tests that assess the health-related physical fitness of children (Hastad & Lacy, 1998). We can see this in this study by analyzing the circumstances in which the most common battery of tests were used, and the reasons why they have changed over time. The large and undoubted significance of the data obtained through testing of the components of health-related fitness contributed to the abandonment of the traditional practice of testing.

Therefore, the ideal battery of tests should assess the dimensions (components) of fitness that are associated with the health of children and adolescents. This conclusion leads to a single "ideal" group of ALFA-FIT tests, based solely on sound scientific evidence, many longitudinal and transversal studies.

CONCLUSION

Physical fitness is a significant indicator of the health of children and adolescents and also a good predictor of health in later life. In recent years interest in the evaluation of form has increased in the public domain. In contrast to the traditional practice tests which assessed the latent dimensions of motor space (physical fitness in order to be successful), new scientific evidence suggest and point to the validation of the component-size fitness that are directly related to health (physical fitness for the purpose of health). Many developed countries have included this group of tests in their educational strategies. This certainly does not diminish the need to assess motor skills in children and adolescents. Bearing in mind that the level of motor skills depends on success in sports performances or competitions, they should be and have to be assessed, but within sports clubs, school sports sections, the Department of Sport and Sports Medicine or scientific research. However, given the importance of the multiple components on the basis of which one can determine the health status of children and adolescents, the assessment of physical fitness should be implemented in schools as part of physical education classes. The data obtained by testing would be used by: 1) the participants - students would have knowledge of their physical fitness; consequently, their teachers would have to teach the methods and ways to strengthen and preserve their fitness, and also health, 2) teachers by founding out their students' fitness levels could design individual programs, and 3) parents, who would care more about the activities of their children (influenced by the time spent at the computer or TV, and encourage involvement in sports clubs and other forms of physical activity), 4) "society", in the planning or design of more effective strategies for the prevention of health.

The fact that a child has "low" results shown in the testing of fitness (results that do not meet the minimum health criteria), will probably not leave any parents, teachers, and "society" as a whole indifferent, especially if it is known that there are ways to improve fitness and strengthen and preserve health. Therefore, it is necessary to set the required battery of tests to assess the physical fitness of children and adolescents in Serbia at all levels of education. The results should be centralized, and after reviewing the situation, concrete measures should be adopted in order to increase the fitness of children and adolescents. Bearing in mind that the ALPHA-FIT battery of tests showed the best metric properties in European children, it is necessary to examine this battery of tests on a sample of children from Serbia.

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PROCENA FIZIČKE FORME DECE I ADOLESCENATA

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Postojeći dokazi ukazuju da je fizička forma odličan indikator zdravlja dece i adolescenata i prediktor zdravlja u kasnijim godinama života, kao i da merenje, procenjivanje i praćenje forme treba smatrati prioritetom javnog zdravlja. Trenutno u svetu postoji više od petnaest baterija (grupa) testova za procenu fizičke forme dece i adolescenata. Za razliku od većine evropskih zemalja koje u školama već primenjuju EUROFIT bateriju testova, SAD koje primenjuju bateriju FITNESGRAM, Srbija nema jasno preciziranu i potpuno određenu strategiju testiranja fizičke forme dece i adolescenata. Evidentan problem testiranja fizičke forme dece i adolescenata je u fokusu ovog preglednog rada. Osnovna ideja je da se prikazom najzastupljenijih baterija testova i okolnosti zbog kojih su nastale i menjale se, pojasni pojam i značaj testiranja, izdvoje komponente koje je neophodno testirati i predloži validna, pouzdana i objektivna grupa testova za procenu forme dece i adolescenata. Analizom najzastupljenijih grupa testova i novih naučnih dokaza istaknut je značaj procene komponenti forme povezanih sa zdravljem. Na časovima fizičkog vaspitanja je predložena upotreba baterije testova ALFA-FIT nastale kao deo projekta Evropske Unije ALPHA (prema engl. Assessing Levels of Physical Activity and fitness – procena nivoa fizičke aktivosti i forme).

Ključne reči: *zdravlje, testiranje, EUROFIT, FITNESGRAM, ALFA-FIT.*