PRE-PARTICIPATION SPORTS SCREENING

Abstract
This paper describes the most important goals of a pre-participation sports screening, factors for individual adjustment of examination and important factors that enable each person to safely engage in physical activities. In relation to age, special attention, in terms of additional diagnostic procedures, is paid to prepubertal, pubertal age and to older people. Disturbances in menstrual cycle often occur in active women athletes and require early assessment of nutritional and hormonal status. In assessing the state of the cardiovascular system, it is especially important to assess the risk of sudden cardiac death. According to Maron study (Maron et al, 1996), causes of sudden cardiac death are hypertrophic cardiomyopathy, anomalous origin of the left coronary artery, atherosclerosis and aortic rupture. Physical examination of the cardiovascular system involves a good knowledge of the subtle changes of electrocardiographic and echocardiographic parameters, with particular attention that should be focused on electrocardiographic changes that change with age and the changes that are under the influence of training load, especially in terms of disruption of redox balance and nutritional status.

Key words: MEDICAL EXAMINATION / AGE / GENDER / SUDDEN CARDIAC DEATH / ECG

INTRODUCTION

Prior to active participation in organized sports activities, young athletes have to undergo a medical examination. Especially the elderly persons, before taking up initial sports activity, should be thoroughly examined in accordance with the known warning: „It is necessary to consult a physician before the beginning of any physical exercise.” This paper describes the most important goals of medical screening before initial sports activity, factors for individual adjustment of examination and important factors that enable each person to safely engage in physical activities.

Because of unsatisfactory health status, only 1.0 to 2.0% of athletes is disqualified or limited in participation in sports activities. Because of such low prevalence among thousands of people who participate in sports, there is a question of financial justification for conducting pre-exercise screening. However, timely detection of at least one such case gives a moral justification for the invested funds.

Within the examination, a particular attention should be paid to condition of cardiovascular, nervous, muscular and skeletal system.

There are two ways of performing examination: individual examinations in the surgery or examinations in specialized medical institutions. The second mentioned method assumes that a person is examined by more specialists in different medical institutions. It is often applied to groups of school-age athletes before participation in organized sports activities at school level.

There are seven basic objectives of a pre-participation sports screening:

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• to reveal the possible existence of a condition that could endanger a person’s health or cause an injury if a person took up sports,
• to assess the general health of a person,
• to ensure the maintenance of good health,
• to comply with regulations and requirements to obtain insurance for participation in organized sports activities, and
• to assess the degree of physical development and maturity of young athletes.

In addition, for many people this examination represents the first encounter with the health service and the opportunity to be educated in health preservation. This is probably the most important goal because in such a way a good relationship between a physician and a patient is established, which provides better health care. Although the fulfillment of some of these goals is more important for younger people, most of them are relevant to people of all ages.

IMPORTANT FACTORS

Pre-participation sports screening must be adjusted to each athlete individually in accordance with the age and gender, current health status, sport intended to be played, as well as his / her personal goals related to that sport. Although it is not possible to give a comprehensive pattern of examination that would meet all of these conditions, some of the possible protocols are described. Particular attention should be paid to the physiological changes related to growing up and aging at each person individually so that examination would be more complete and direct.

Age

In accordance with body changes related to growing up and aging the following division can be applied:

• prepubertal age (6 – 10 years of age)
• pubertal age (11 – 15 years of age)
• postpubertal age / young persons (16 – 30 years of age)
• adults (31 – 65 years of age) and
• the elderly (over 65 years of age).

(The given years are taken approximately and should be regarded only as guidelines in work. Some people do not „become older” but become „more mature” and better and better.)

In recent years, children of prepubertal age take up sport more and more in the form of organized sports activities rather than spontaneous physical activity through play. They often play football, basketball, hockey, and swimming and play sports in an organized way. It was found that 95% of children consider entertainment to be the most important aspect of sport, and not winning at all costs. At medical examination of this group, one of the most important factors to be considered is excluding the presence of undiagnosed congenital anomalies.

Pubertal age athletes grow and mature rapidly both in physical and in sexual way. Puberty is a period of intensive social development of personality when young people become aware of their sexuality and appearance, and there is a danger of drug abuse. Young athletes in this group typically have many school duties and it is important that regular physical activity be introduced because of stimulating a healthy lifestyle that will be adopted as a lifestyle. For children of prepubertal and pubertal age of a competitive level or younger children who are competing in older categories, along with determining general health ability, determination of special health ability is anticipated, as defined by law and regulations on pre-exercise medical examination of athletes (Regulations were published in Official Gazette of the Republic of Serbia, no. 15/2012 on March 2, 2012).

Reasons for playing sports by young people of postpubertal age are different, as well as their preferences and abilities. Pre-participation sports screening in this group should be adapted to each person individually to determine the appropriate intensity and other characteristics of physical activity that this person wants to take up. Special attention should be paid to the earlier injuries, poor rehabilitation, and other conditions that may be relevant to a certain sport. In this group attention should paid to the potential abuse of narcotics. Instructions and advice should be given separately for each sport.
Adults are mainly engaged in recreational sports, but the intensity and frequency of recreation varies considerably.

Elderly people know that physical activity can improve quality of life but also to provide an opportunity for socializing. Exercises are an important part of many rehabilitation programmes for the elderly, especially in the treatment of chronic diseases, such as diabetes mellitus, depression, cerebrovascular disease, and myocardial infarction (Mujović and Ćubrilo, 2012). In this age category, in addition to determining general health condition and testing functional reserves for specific physical loads, it is necessary to determine the specific biochemical parameters, hormonal status, as well as the level of redox equilibrium with the aim of adequate support in terms of making an individual nutrition programme, supplementation and hormone replacement. All this is necessary in order to maintain the vitality within the anti-aging strategy the objective of which is to preserve cognitive functions, eyesight and mobility. Inadequately dosed and incompetently managed physical activity without the above mentioned health screening could be harmful to general health of older people and consequently speed up the aging process (Gaman, Stoian, & Atanasiu, 2011; Burks, & Cohn, 2011).

Gender

Another important factor that should be taken into account at examination is the person’s gender. Recently, the concept of so-called female triad, which consists of eating disorders, amenorrhea and osteoporosis in women who participate in sports (Sehtscherbyna, Soares, de Oliviera, & Ribeiro, 2009; Thompson, 2007).

Although eating disorders can occur in all athletes, they are especially common in women (Barone Gibbs, Kinzel, Pettee Gabriel, Chang, & Kuller, 2012).

Menstrual cycle disorders often appear in active female athletes and require early estimation. In recent studies, the relationship among menstrual cycle, body weight, intensity of physical activity and nutrition is considered. In assessing the health status of women in sport all these factors should be taken into account. To find the cause of amenorrhea or oligomenorrhea it is necessary to evaluate each case individually and it should not always be assumed a priori that physical activity is the main cause of these disorders.

The link among amenorrhea, the amount of mineral salts in bones and the risk of osteoporosis and subsequent stress fractures was examined in several recent studies (Veskovi, Jamal, & de Souza, 2008). Medical examination before initial sports activities is an opportunity for a male / female athlete to be educated about proper eating habits for better preservation of the skeletal system, and achieving better results.

Sport that a person intends to play

The third factor that determines the way of approaching a person at a medical examination is a type of sport that he or she intends to play. Requirements that a person must meet in order to take up weightlifting or running a marathon are considerably different. There are three basic types of exercises: (1) aerobic, (2) anaerobic and (3) combined aerobic-anaerobic. During aerobic exercises that last long with small power consumption, the energy obtained by the process of oxidative phosphorylation is used. These exercises include activities such as swimming, running and cycling. Anaerobic exercises are characterized by short duration and high consumption of energy generated by glycolysis. These exercises include jogging, sprinting and weightlifting. Both described mechanisms are combined in aerobic-anaerobic activities. Examples of these activities are football, basketball, field hockey and ice hockey.

Sports can also be classified according to the extent of contact with other participants. This division should be considered if there is a concern that an athlete’s health condition might be threatened by a contact. Then each case should be estimated individually and an individual advice should be given.

Motivation

The last component that should be considered for individual adjustment of screening is to define motivation and objectives that a person has and wants to achieve by playing the chosen sport. The question that should be asked is: „Why do you want to prac-
Young people can have the goal of becoming members of the school or college team. Older people, however, usually want to improve the general health condition and physical appearance, or to socialize by exercising.

Introduction of health examination before taking up initial sports activities as standard practice requires an organized approach, good knowledge of the basic elements of examination and knowledge of the most common possible health disorders of athletes. Both examination methods mentioned earlier – individual and examinations in specialized medical institutions have their advantages and disadvantages, but both can give valid results. The locker-room technique, which includes examination of a larger number of athletes in a limited, shared space, is no longer considered an appropriate method.

Each method has its advantages and its application ensures that there will be no mistakes and gives a certain consistency to the process.

**Frequency**

Pre-exercise sports screening should be repeated before each transition to a new level of physical activity.

Children of prepubertal age should be examined individually in the surgery. The first examination is very important for a child because it can represent the first encounter with the health service. Many children do not even see a doctor after compulsory vaccinations in the fifth year of life.

Athletes of pubertal and postpubertal age should be examined before each transition to the next level of loading. A specialized medical examination technique is often applied. In the meantime, vital signs should be routinely checked, body height, body weight, blood pressure should be measured, heart rate should be determined and eyesight should be checked.

For adult persons, health examination before taking up a sport should be a part of a detailed assessment of health status, if the person has not been extensively examined recently. Particular attention should be given to the elderly, especially those with risk factors for a coronary artery disease such as hypertension, diabetes mellitus, hypercholesterolemia, smoking, history of heart disease, a positive family history, obesity, and sedentary way of life.

**The best time for having medical examination**

The following factors should be taken into account when determining the best time to perform medical examination: pre-exercise screening should be done early enough to leave time for adequate rehabilitation if it is found that there are health problems, but the examination should not be carried too early in order to avoid developing new health problems in the period from examination to the initial sports activity. It is believed that it is the best to perform examination 4 to 6 weeks before the beginning of the sports season (NMAA Sports Medicine Advisory Committee 2009).

**MEDICAL HISTORY**

Well taken, detailed medical history is a cornerstone of all medical evaluations, including medical examination before taking up sports. When taking the medical history, a special attention should be paid to the information on the state of cardiovascular, nervous, muscular and skeletal system. Moreover, additional questions related to the specific problems that are typical for athletes should be asked: eating disorders, bronchospasm related to physical activity, menstrual cycle disorders, drug abuse and substances to increase physical strength and endurance, thermo-regulatory disorders.

**Cardiovascular system**

In assessing the state of the cardiovascular system, it is especially important to assess the risk of sudden cardiac death caused by a heart attack. Thompson estimated that in people older than 40 one death occurs in every 360,000 hours of jogging (Thompson, 2009). Sudden cardiac death caused by a heart attack is rare among young athletes, but is always tragic and shocking for everyone involved. All possible measures to detect disorders that could represent a risk of a heart attack should be taken (Kaltman et al, 2011). In athletes younger than 30, the cause of sudden cardiac death is most often a structural abnormality of the cardiovascular system (Ilić, and Mazić, 2008). According to Maron study, the causes of sudden cardiac death are hypertrophic
cardiomyopathy, anomalous origin of the left coronary artery, atherosclerosis and aortic rupture (Maron et al, 1996).

Hypertrophic cardiomyopathy or idiopathic hypertrophic subaortic stenosis produces symptoms and may lead to sudden cardiac death caused by myocardial hypertrophy, reduced volume of heart cavities and the associated reduction in diastolic volume (Mujović, Jakovljevic, and Velkovski, 2004). Hypertrophy of subaortic septum as well as a forward movement of the anterior mitral leaflet during systole leads to ductus tract obstruction. It is believed that the ultimate cause of sudden cardiac death is malignant arrhythmia (Mujović, 1998a).

It is very important to discover this condition during medical examination because such persons are at high risk of sudden cardiac death. When present, symptoms include fatigue, syncope, palpitations, or severe dyspnea related to strain. Since hypertrophic cardiomyopathy is an autosomal dominant disorder, it is very important to take a family history well.

Numerous abnormalities of coronary arteries can cause sudden cardiac death in young athletes. The most common is abnormal origin of the left coronary artery from the right sinus of Valsalva or from the right coronary artery itself.

Another important cause of sudden cardiac death in young people is cystic necrosis of the tunica media of the aorta that can lead to rupture of the vessel. This condition often occurs, especially in people with Marfan syndrome – an autosomal dominant disorder characterized by generalized degeneration of connective tissue (Glorioso, & Reeves, 2002). There should be at least two of the four symptoms for diagnosing Marfan syndrome (Koester, 2001):
1. positive family history of Marfan syndrome,
2. cardiovascular disorders,
3. disorders of musculoskeletal system,
4. disorders of the optic apparatus (Table 1).

In 90% of deaths in patients with Marfan syndrome, the cause of death were rupture of aortic aneurysm, aortic dissection and severe aortic insufficiency. Patients with Marfan syndrome may have arrhythmia, chest pain, and syncope, either at rest or during physical effort.

Table 1. Basic features of Marfan syndrome

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<th>Positive family history</th>
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<td>Abnormalities of cardiovascular system</td>
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<td>Cystic necrosis of the tunica media</td>
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<td>Dilatation of the aorta</td>
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<td>Aortic aneurysm</td>
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<td>Aortic dissection</td>
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<td>Aortic insufficiency</td>
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<td>Mitral valve prolapse</td>
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<td>Mitral regurgitation</td>
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<tr>
<td>Abnormalities of the musculoskeletal system</td>
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<tr>
<td>Kyphoscoliosis</td>
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<td>Deformities of the anterior chest</td>
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<td>Pectus excavatum, pectus carinatum</td>
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<td>Great body height, length of limbs longer than the length of trunk</td>
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<td>Arachnodactyly</td>
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<td>Spina bifida</td>
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<td>Spondylolisthesis</td>
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<td>Disorders of the optic apparatus</td>
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<td>Ectopia of intraocular lenses</td>
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<td>Myopia</td>
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<td>Iridodonesis</td>
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Atherosclerosis of the coronary arteries rarely causes death in young athletes, but in athletes older than 30 years of age, it is the cause of death in 90% of cases. Therefore it is very important to examine the risk factors for coronary artery disease, as well as possible symptoms (Mujović, 2000a; Mujović, 2000b) (Table 2). Symptoms of myocardial ischemia can be classic (pain and tightness in the chest on exertion) but are more often vague (nausea, pain in the shoulders, syncope on exertion, or expressed fatigue in disproportion with physical exertion). In patients with diabetes, these symptoms may be masked and there may be „silent” ischemia. If medical history points to the possible existence of this disorder, more detailed laboratory tests and diagnostic procedures should be undertaken.

Table 2. Risk factors for coronary artery disease

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<th>Risk Factors</th>
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<td>Hypertension</td>
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<td>Diabetes mellitus</td>
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<td>Earlier coronary artery diseases</td>
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<td>Early coronary artery disease (before the age of 50) in a family history</td>
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<tr>
<td>Smoking</td>
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<td>Age</td>
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<td>Male gender</td>
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<td>Obesity</td>
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<td>Sedentary way of life</td>
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Nervous system

Another important part of medical history is examining the nervous system. It is important to identify and quantitatively examine the nervous system deficits of an athlete. Questions about possible earlier injuries of the nervous system should be asked, including concussion, injuries of the neck, plexus brachialis injury and loss of consciousness and seizures, as well as the presence of any neurological injuries or sequelae of concussion (Mujović, 2004; Mujović, 2010).

Musculoskeletal system

The last part of examination before taking up initial sports activities should be devoted to musculoskeletal system assessment. It is important to determine any previous injuries, surgeries, fractures or stress injuries. If an elderly person reports to have morning stiffness, joint pain or other rheumatic symptoms, further diagnostic procedures should be taken.

MEDICAL EXAMINATION

Medical examination should be short and focused on cardiovascular and musculoskeletal system. Because of the low prevalence of conditions that may be a cause for disqualification of younger athletes, as well as the absence of objective signs of such diseases, sensitivity is very low.

During medical examination body height, body weight, blood pressure and heart rate are measured and heart rate frequency is determined. In addition, a thorough ophthalmological examination should be performed and any irregularity or asymmetry of the iris should be noted. It should be borne in mind that the examination ought to be adjusted to specificities of a sport which a person intends to take up. Thus, an otoscopic examination is more important for swimmers than for tennis players, while skin diseases (e.g. herpes gladiatorum) are more important to observe in wrestlers than in golf players.

When examining heart, insignificant heart murmur can often be found. Special attention should be paid to systolic murmur that is amplified at maneuvers that reduce the volume of the left ventricle, because they occur in hypertrophic cardiomyopathy (or idiopathic hypertrophic subaortic stenosis) and mitral regurgitation (Mujović, 1999a; Mujović, 1999b). In differential diagnosis, in athletes over the age of 30, it could be helpful to perform auscultation while the person moves from upright to crouching position. This maneuver reduces obstruction caused by overloading and leads to a decrease of murmur.
while insignificant murmurs become louder. All dia-
stolic murmurs, and the existence of the second heart
tone that does not double are also an abnormal find-
ing. Holosystolic noise should arouse suspicion of
the septal defect.

Examination the musculoskeletal system
should be focused on determining the range of mo-
tion, strength of individual muscle groups and joint
stability. This examination should also be adapted
to the sport a person intends to take up. If there is
muscle instability, inflexibility or low strength, a spe-
cial preparatory programme should be recommended
before initial taking up sport. Finally, the assessment
of the nervous system condition and documentation
analysis of possible earlier disturbances should be a
compulsory part of examination.

Athletic heart

Back in 1899, Henchen „performing only
percussion of the thorax showed that the heart of an
athlete who took up cross-country skiing was larger
than the heart of people with sedentary way of life,
while the biggest heart have athletes who win races”
(Henchen, 1899). Clinical and structural changes in
the heart that exist in well-trained athletes depend
on the type of physical activity to some extent. An
activity may be dynamic, mainly isotonic (marathon
runners), or static, mainly isometric (weight lifters).

In athletes involved in dynamic activities, bra-
dycardia, increased stroke volume and left ventricu-
lar hypertrophy are found by examination. The sec-
ond heart sound is often elevated and duplicated. Due
to higher diastolic filling there is often the third tone.
In 20 to 50% of these athletes, the fourth heart sound
can also be heard, although it is more common in
athletes involved in static activities. The existence of
the fourth heart sound is a cause of concern because it
can indicate hypertrophic cardiomyopathy or hyper-
tension that occurs in rigid, noncompliant ventricle.
Radiograph of the athletic hearth shows an enlarged,
often globular cardiac shadow and cardiothoracic in-
dex greater than 0.5.

The electrocardiogram (ECG) can show
changes caused by long, intensive training. However,
as on radiography, changes are not always specific.
There may be a sinus bradycardia, blocks of the first
and the second degree type 1 more often than in peo-
ple with sedentary lifestyle. ST segment and T wave
abnormalities can also be found. Voltage changes are
also common in athletes. Hypertrophy of both left
and right ventricles are present. The increased am-
plitude and double P wave may also be present. ECG
changes in athletes are often lost during physical ac-
tivity. A research by Ćubrilč et al. (Ćubrilč, Macura,
Pešić, Jakovljević, 2009) shows that ECG changes
in young athletes of competitive level depend on the
age of an athlete and training experience. ST elevation
height, values of PQ, QT and QRS intervals, si-
inus arrhythmia and prevalence of incomplete right
bundle branch block occurrence depends on the age
of young athletes, while on the other hand voltage at
D2, axis deviation level of QRS and the value of the
sum RD1 + SD3 depend on the number of years
spent in active training process. A special attention
is drawn by the results of the latest research obtained
in our laboratory that show significant correlations
of redox balance and ECG parameters, with particularly
intriguing fact that correlations change with the age
of athletes examined (Ćubrilč et al, 2009; Jakovljević,
Ćubrilč, Živković, Đordović, Đurić, 2012).

Echocardiography permits noninvasive de-
tection of conditions such as hypertrophic cardiomyp-
athy (or idiopathic hypertrophic subaortic stenosis),
mitral valve prolapse, aortic root dilation and valvul-
lar lesions.

It can be concluded that it is sometimes diffi-
cult to distinguish physiological changes in the heart
of an athlete because of normal adaptation of a heart
to physical effort from pathological conditions. Since
some of these conditions may cause sudden cardiac
death, it is very important to pay special attention to
those medical history data and objective findings that
may require additional tests. Certain ECG abnormali-
ties often found in athletes that represent physiological
rather than pathological changes should be known. A
significant contribution to ECG changes in terms of
subtle changes at the level of the conducting system
of the heart and the myocardial cells is an eicosanoid
status (Mujović, 1998b). Nutritional manipulation and
specific regimens of supplementation with the aim of
controlling levels and de novo synthesis of polyun-
saturated fatty acids represent a challenge of molecu-
lar medicine, which should shed light on the possible
ystemic effects of eicosanoids and their products to
changes in myocardial morphology and status of elec-
trochemical gradients of excitable tissues.
Additional examination and health assessment

Without specific indications for laboratory tests, routine blood tests and urine tests are not very useful. Proteinuria in children, for example, is benign in 99.92% of cases. Since at increased physical activity hematuria and proteinuria in trace can occur, the qualitative urine analyses do not help much. In conducting additional analysis individual characteristics of an athlete – age, gender, chosen sport and personal goals should be taken into account. It is especially important to take a good medical history to determine whether it is necessary to take additional diagnostic procedures. If there is a positive family history of hypertrophic cardiomyopathy or Marfan syndrome, electrocardiographic and echocardiographic tests should be performed. In women with menstrual cycle disorders further examination, particularly of a detailed hormonal status should be undertaken. In young adults with a positive family history of coronary artery disease and hypercholesterolemia blood pressure should be closely monitored. In these cases lipid profile of a person should also be made. In elderly persons, the determination of the lipid profile and ergometric tests should be a routine part of examination. If at standard examination any abnormalities are found, additional diagnostic procedures should be performed. Further testing should be adapted to individual qualities of a person and directed in accordance with medical history and physical findings.

REFERENCES


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