21. Coronary artery disease

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Summary

Coronary artery disease, that is, angina pectoris or myocardial infarction, is one of our most widespread public diseases. Coronary artery disease involves the presence of pathological changes, arteriosclerosis, in the walls of one or more of the coronary vessels. Physical inactivity is a potent risk factor for coronary artery disease, but old age, male gender and heredity, as well as smoking, high blood pressure, blood lipid disorders, diabetes and overweight also increase the risk of developing the disease. Prescribing a minimum of 30 minutes per day of regular physical activity constitutes excellent primary prevention against coronary artery disease, and regular exercise, aerobic exercise 3–5 times per week and resistance exercise 2–3 times per week, is a powerful treatment for already established coronary artery disease.

A recommendation to increase physical activity can be given generally in a primary preventive aim, but in order to plan optimal exercise as secondary prevention requires that the patient be tested with respect to aerobic fitness and muscle function.

The assessment begins with a stress test/fitness test with ECG monitoring, a muscle function test, and assessment of the current level of physical activity. Based on these tests and the patient's general condition, a risk assessment is made, and thereafter an appropriate exercise programme and physical activity level is drawn up for the patient.

It is essential that the initial rehabilitation is carried out under supervision, preferably that of a specialised physiotherapist and access to emergency care equipment. Most patients exercise for 3–6 months under the direction of cardiac rehabilitation, and most often the exercise can then continue outside the hospital's management when the condition has been properly stabilised.

Table 1. Description of training methods investigated in different scientific studies in patients with coronary artery disease.

Training method	Intensity	RPE***	Frequency (times/week)	Duration
Central circulation aerobic training, distance or interval	50–80% of VO_2 max*	12–15 central	3–5	40–60 min./ session
Resistance training	1–3 sets of 10–15 RM** (65–75% of 1 RM)	13–16 local	2–3	8–10 exercises

* VO_2 max = Maximal Oxygen Uptake.

** RM = Repetition Maximum. 1 RM corresponds to the maximum weight that can be lifted through the entire exercise movement only one time.

*** RPE = Rate of Perceived Exertion (Borg scale 6–20).

Definition

Prevalence/Incidence

Coronary artery disease is one of the most widespread public diseases with a prevalence in the population in Sweden of just under 200,000 cases. Two thirds of the patients are men. Women develop the disease somewhat later than men. Every year, there are an estimated 10,000 new cases of angina pectoris (1). Both mortality and development of ischaemic heart disease have decreased since 2004, and preliminary data also suggests that the lower numbers remain for 2005. According to the Swedish National Board of Health and Welfare registry for cause of death, 17,971 people died of ischaemic heart disease in 2004, whereof approximately 9800 of myocardial infarction (2). In recent decades, medical treatment and intervention (bypass surgery and percutaneous coronary intervention [PCI]) have yielded better results, which has led to more patients surviving acute development of the disease, meaning in turn a successive increase in the number of patients in need of cardiac rehabilitation with exercise.

Cause

Coronary artery disease involves the formation of pathological changes in the wall of one of more of the coronary arteries, so-called hardening of the arteries or arteriosclerosis, and is the most common cause of acute coronary events, that is, acute myocardial infarction or unstable angina pectoris (3).

Risk factors

Old age, male gender and hereditary factors for cardiovascular disease, as well as risk factors such as physical inactivity, smoking, high blood pressure, blood fat disorders, overweight/obesity and diabetes, increase the risk of developing coronary artery disease (3).

Pathophysiological mechanisms, symptoms and diagnostics

Hardening of the arteries (atherosclerosis) is the predominant cause of acute coronary artery disease. Athersclerosis primarily attacks the innermost layer of the artery wall, the intima, which is made up of endothelial cells. Initially, a storing of blood fats (lipids) occurs between the endothelial cells, where inflammatory cells, macrophages, ingest the fat. The macrophages ingest the lipids until they burst and become so-called "foam cells". A fibrous mass then develops around the foam cell, forming a plaque. These atherosclerotic plaques do not attack the entire vessel but appear in patches. The area around the arterial branch points are particularly susceptible (4, 5).

Symptoms

The dominating symptom in acute coronary artery disease is usually *central chest pain* and includes both unstable angina and acute myocardial infarction. However, at onset women often present with more unspecific symptoms like breathing difficulties, nausea or other forms of pain. *Angina pectoris* (constriction of the arteries) is described as stable when symptoms have been present for at least a few weeks without obvious signs of worsening. Effort angina is angina induced by physical or mental stress that ceases quickly once the exertion has stopped (1), whereas variant (spasm) angina is considered to be induced by contraction of (constriction in) an artery that lasts so long that the heart muscles are subjected to a symptom-producing shortage of oxygen. Variant angina can occur during rest and mixed types are not uncommon (6). The course in people with stable angina has improved with the introduction of effective treatment options, such as anti-ischaemic, antithrombotic, antihypertensive and blood lipid-lowering drugs, as well as surgical and catheter-based coronary artery interventions, percutaneous coronary interventions (PCI). The prognosis for individuals with stable angina is now relatively good. It is important, however, to be alert of any destablisation of the angina, characterised by a rapid worsening, which in most cases requires emergency hospital care (5). In most individuals, fissuring or rupture of an atherosclerotic plaque in a coronary artery is the precipitating cause of the acute element of coronary artery disease (4). The subsequent course, with activation of thrombocytes and plasma coagulation, leads to the formation of a blood clot (thrombosis) that completely or partially blocks the artery. Ischaemia occurs when the artery that supplies blood is partially or completely blocked and leads to reduced availability of oxygen and nutrients as well as removal of debris. When an artery is blocked, a gradual change toward cardiac cell death occurs, that is dependent on the degree of ischaemia and how long it lasts (7). The structural changes that the heart undergoes after a *myocardial infarction* are not restricted to the infarct zone, but also spread to the "healthy myocardium", which must compensate for the loss of function in the damaged area by, among other things, hypertrophy of the heart muscle, capillary growth, and storing of collagen in the healthy areas, resulting in a more rigid heart with poorer energy balance (8). These adverse effects can be reduced by medicating with beta blockers and ACE inhibitors (5).

Diagnostics and assessment of prognosis should be commenced as early as possible parallel to introducing treatment. With a patient history, ECG and biochemical markers of myocardial damage, the diagnosis can be made and prognosis determined within the first few hours in most patients. Sometimes additional examinations are needed, such as echocardiography, coronary radiology and/or a stress test with ECG monitoring. If acute coronary artery disease is suspected, the patient should always be admitted to hospital and treated, with PCI for example, as soon as possible (9).

Treatment principles

The treatment of acute coronary artery disease, which should be initiated as soon as possible after symptom onset, comprises reperfusion therapy and/or antithrombotic therapy. Reperfusion is usually achieved using PCI and/or in combination with insertion of a stent, the purpose of which is to prevent the vessel from closing up again (reocclusion) or pharmacological treatment (thrombolysis) or a combination of these (facilitated PCI). PCI is also used for unstable angina, and in this case after a coronary x-ray to verify actual coronary artery changes. In some cases, coronary artery bypass graft surgery (CABG) is necessary.

In other cases, pharmacological anti-ischaemic treatment to stablise the condition is offered, and then primarily with the aid of pharmaceuticals such as acetylsalicylic acid (ASA), beta blocker, nitrates and calcium channel blockers. In some cases, primarily in the case of reduced pumping capacity such as heart failure, ACE inhibitors are used (5).

Effects of physical activity

The positive effects of being physically active when suffering from coronary artery disease was shown as early as the end of the 1700s (10, 11) These findings were unfortunately lost to memory and it was not until the mid-1960s that exercise was used as therapy for coronary artery disease (12, 13). The first cardiac rehabilitation programmes based on physical training were then started, and the first Swedish recommendations issued in 1980 (14).

Acute effects

Acute physiological effect of exercise in ischaemic heart disease

Heart rate, stroke volume and cardiac output

The cardiovascular system's immediate response to exercise is an increase in heart rate due to reduced activity in the parasympathetic nervous system (vagal slowing). This is followed by increased activity in the sympathetic nervous supply to the heart and the body's blood vessels. Relatively rapid heart rate during submaximal exertion or post-exercise recovery is often seen soon after a myocardial infarction or heart surgery. An unusually low heart rate during submaximal exertion can be due to beta blocker medications or an increase in stroke volume from the exercise. The use of beta blockers, which lower the heart rate, limit the interpretation of heart rate response in exercise.

At an early stage during exercise, cardiac output increases through an increase in stroke volume due to an improved length-tension relationship in the heart muscle. This is called the Frank Starling mechanism, and involves an enhancement of force when the muscle fibre lengthens. The lengthening of the heart muscle fibre is due to increased venous return flow. The increase in cardiac output occurs mainly through an increase in heart rate, meaning that when beta blocker therapy is given the maximal cardiac output becomes lower.

Arrhythmias

The presence of different rhythm disturbances (arrhythmias) is not uncommon in ischaemic heart disease. If the arrhythmias present at rest and disappear during exertion, they are usually benign. If, however, the arrhythmias increase during exertion, there is cause to stop the exercise and discuss further medical investigation (15).

Blood pressure

Systolic blood pressure rises with increased dynamic exercise as a result of the increased cardiac output. Diastolic blood pressure usually remains unchanged or is somewhat higher. It is important to note in the clinical work that, during auscultation, diastolic pressure can be heard right down to zero during exertion, and can thereby be a false reading.

An insufficient fall in blood pressure or elevation of blood pressure can occur during exercise. During ongoing exertion, a poor rise in blood pressure or a drop in blood pressure is due to impeded outflow in the aorta, severe left ventricle dysfunction, angina in the heart or beta blocker medication. In certain individuals with heart disease, however, the blood pressure can increase (over and above the measured maximal exertion value) in the recovery phase.

If the exercise is stopped abruptly, some individuals may experience a substantial fall in systolic blood pressure. This drop in blood pressure is due to accumulation of venous blood and a delayed increase in peripheral resistance adjusted to the decrease in cardiac output.

Oxygen uptake in the heart

The oxygen uptake of the heart during exercise can be calculated using the so-called double product (rate pressure product = RPP), defined as the systolic blood pressure times the heart rate divided by 100. There is a linear relation between the heart's oxygen uptake and the heart's blood supply that occurs primarily in the diastolic phase. During exercise, the blood flow to the heart muscle can increase up to five times the resting value. A person with heart disease is usually not able to maintain adequate blood flow to the ischaemia-affected part of the heart and the heart's metabolic requirements during exercise can thereby not be met, resulting in acute oxygen deficiency in the heart muscle, angina pectoris.

Skeletal muscle blood flow and peripheral resistance

The skeletal muscle blood flow can increase three-fold during exercise and the total peripheral resistance decreases due to increased vasodilatation in working skeletal muscle during exercise. In the case of beta blocker therapy, a somewhat smaller increase in blood flow in the working muscle occurs, which is why the feeling of fatigue in peripheral musculature is greater in patients receiving beta blockers (15).

Long-term effects of exercise in ischaemic heart disease

Regular exercise training in people with coronary artery disease results in similar specific changes, for example, in skeletal muscle- and cardiovascular capacity, as in healthy individuals. Generally speaking, the effect is dependent on the type of exercise. In the case of more aerobic-oriented training, there is improvement in above all oxygen uptake capacity (VO_2), while strength training results in increased muscle function of specifically trained muscles. The training effects obtained allow an individual to exercise at a higher exertion level and/or at a lower heart rate for each submaximal level. Studies have shown that medium intensity aerobic training of both cardiac patients and healthy individuals for 8–12 weeks, in 45 minute sessions 3–5 times per week, leads to marked improvements in both maximal and submaximal exertion levels (16).

Lower resting heart rate (resting bradycardia)

A lower resting heart rate is perhaps the most obvious effect of regular exercise. The underlying mechanisms include an altered autonomic balance and increased stroked volume. This effect is seen in both healthy individuals and those with heart disease, with or without beta blocker (15).

Lower blood pressure

Resting blood pressure and blood pressure at a given level of exertion are lower in well-trained individuals. Blood pressure is cardiac output times peripheral resistance. Because peripheral resistance decreases during exercise, this results in reduced expulsion resistance for the left ventricle and an increased ejection fraction (i.e. the percentage of the blood that is pumped out of the heart with each heart beat, or the heart's ability to pump out blood) and stroke volume are obtained. For every given level of submaximal exertion, a lower systolic pressure results in a corresponding lowering of the double product, and this in turn leads to a reduced risk for ischaemia in the heart. During vigourous exercise, high pressure builds within the working muscle group, which can lead to a reduction or even blocking (occlusion) of muscle blood flow, which is why afterload (i.e. the muscle contraction or tension that develops in the ventricular wall during systole) in turn increases. The consequence of this is a limitation of stroke volume and ejection fraction (15). Occlusion of intramuscular vessels begins when the muscles contract at 15 per cent of their maximal voluntary contraction (MVC) and becomes complete at approximately 70 per cent of MVC. In patients with heart disease and impaired muscle strength, appropriate regular resistance training can lead to better heart function because a stronger skel-

etal muscle results in the vascular contraction (constriction) not occurring until a higher per cent of MVC (17).

Increased peripheral venous tone

Exercise results in an increase in vein tone (tension), which increases central blood volume and thereby the filling pressure of the heart (ventricular preload). Cardiac output thus increases and the risk for a pronounced drop in blood pressure (hypotension) after exercise training decreases (15).

Increased stroke volume and contractility of the heart muscle

Exercise results in a certain increase in the heart muscle's (myocardial) contractility. This helps to increase stroke volume and benefits oxygen uptake. The increased stroke volume leads to about the same corresponding increase in functional activity of the heart, and a given physical exertion can then be performed at a lower level of the individual's VO_2 max. The lower heart rate reduces the double product and therefore the oxygen required by the heart muscle is reduced and the risk for oxygen deficiency (angina) decreases. Aerobic exercise can also increase the blood flow in the coronary vessels by improving the vessel's elasticity and increasing endothelium-dependent vasodilatation of the arteries. Aerobic exercise also leads to regeneration of vessels, which increases the surface of the coronary vessel bed and the density of the heart capillaries. The above-mentioned effects help to increase the ischaemic threshold, such that the exertion level at which angina is precipitated is higher (15).

Endothelial function and the blood coagulation system

Studies of patients with myocardial infarction have shown that exercise has a positive effect on fibrinolytic enzymes. Exercise is also important to reduce the blood platelets' ability to stick together. Together with an increase in plasma volume and decrease in blood viscosity, these changes reduce the risk for blood clots in the coronary vessels. The vascular endothelium plays an important role in the regulation of arterial vessel tone, blood pressure and local thrombocyte aggregation, that is, the ability of the blood platelets to stick together, through the release of endothelium-dependent relaxing factors. One such factor is nitric oxide (NO) that is released via the increased pressure (shear stress) placed on the endothelial cell wall with increased blood flow. Endothelium-dependent vasodilatation is impaired in patients with ischaemic heart disease. There is convincing evidence that exercise improves endothelial function in both healthy individuals and those with heart disease through increasing the endothelium-dependent vasodilatory capacity, mainly by increased release of NO (18–22). Convincing evidence also exists for the positive impact of exercise on the blood coagulation (fibrinolytic) system (23, 24).

Chronic inflammation

Inflammation has been shown to be closely linked to the development of arteriosclerosis. Studies have shown that aerobic exercise lowers the level of C-reactive protein (CRP), which could indicate that regular exercise has an anti-inflammatory effect. However, there are at present no studies on patients with ischaemic heart disease (25–27).

Autonomic function

Aerobic exercise can increase the threshold for ventricular tachycardia (rapid, extra heart beats initiated by the ventricle). This effect reduces the risk for sudden death by reducing the activity in the sympathetic nervous system and raising parasympathetic activity. It has also been shown that exercise raises VO_2 max in both atrial fibrillation and ventricular arrhythmias (28–30).

Exercise also has a positive effect on a number of factors important in the development of cardiovascular disease. Examples of these include blood lipids, cholesterol and insulin sensitivity. Even other lifestyle changes are significant and through adding regular physical activity into one's new lifestyle other lifestyle factors, such as diet and smoking, are also positively impacted. This can further reduce the risk for cardiovascular morbidity and mortality.

Exercise and effect on mortality

Exercise in cardiac rehabilitation, as compared to regular care, lowers both total mortality (20%) and mortality specifically related to heart disease (cardiac mortality) (26%) (31). The specific mechanisms that can contribute to reduced mortality in connection with exercise training are not yet fully established and probably relate to several factors (17). Table 2 describes possible biological mechanisms for the reduced mortality.

Table 2. Long-term regular exercise training affects many of the factors that contribute to a reduction of mortality related to heart disease (cardiac mortality).

Cardiovascular effect
Lower heart rate at rest and during exercise.
Lower blood pressure at rest and during exercise.
Lower oxygen demand in the heart at submaximal levels of exercise training.
Increase in plasma volume.
Increased myocardial contractility.
Increased peripheral venous tone.
Positive changes in fibrinolytic (blood coagulation) system.
Increased endothelium-dependent vasodilatation.
Increased gene expression for production of an enzyme (NO synthase) that helps to produce nitric oxide (NO).
Increased parasympathetic activity.
Increase in coronary blood flow, coronary collateral vessels and myocardial capillary density.
Metabolic effect
Reduced obesity.
Increased glucose tolerance.
Improved blood lipid profile.
Lifestyle effect
Reduced likelihood of smoking.
Possible reduction of stress physiological responses.
Possible short-term reduction of appetite.

Indication

All physically inactive healthy people and patients with established coronary artery disease.

Primary prevention

A number of scientific studies in the last decade have shown regular physical activity to be health-promoting in all age groups (32). Increasing one's capacity for physical activity also reduces the risk of dying of coronary artery disease (33). Physical inactivity is now considered a primary risk factor for developing coronary artery disease (34) and is just as potent a risk factor as smoking, elevated blood lipids and high blood pressure (35). There is a dose-response relation between the level of physical activity and cardiovascular illness and death, which means that every increase in activity level is an improvement! "A little is better than none, more is better than a little" (36).

Epidemiological studies that have looked at the impact of physical activity level on developing and dying from cardiovascular disease have found that if the total amount of energy used for physical activity exceeds 4200 kJ per week (≈ 1000 kcal/week), for example, regular brisk walking for more than three hours per week, complemented by more vigourous activities/exercise, the risk for developing coronary artery disease decreases by 20 per cent for men (37) and 30–40 per cent for women (38). It is perfectly fine to divide the physical activity into shorter sessions (39); the main thing is that one burns energy through physical activity.

Secondary prevention

Secondary prevention of coronary artery disease means that after a manifest cardiac event, such as myocardial infarction, coronary intervention (coronary artery surgery or PCI) or in the case of persistent angina that cannot be further corrected medically (so-called refractory angina), measures should be taken that in both the short- and long-term can prevent death, relapse and progression of the underlying disease (16). In already established heart disease, regular, adapted exercise is required in order to achieve a reduction in mortality. This means that the exercise must be drawn up according to the current physical capacity. As an individual's clinical picture and performance capacity may vary from occasion to occasion, especially in the acute phase, special care is needed for these patients. A stress test/fitness test with ECG monitoring, and a muscle function test should be carried out before exercise commences. Based on the outcomes of these tests and a patient history (anamnesis) aimed at identifying individual risk factors (physical inactivity, smoking, high blood lipids, high blood pressure, overweight, diabetes), a risk profile assessment is made, in which consideration is given to the current physical capacity and possible symptoms during exertion.

Regular exercise in cardiac rehabilitation is a potent measure that reduces mortality by 26 per cent. Training entails aerobic exercise 3–5 times per week and resistance training 2 times per week (see Table 3).

Functional tests

All exercise at the physiotherapist should be preceded by some form of loading test, where general aerobic fitness and functional capacity is evaluated before a level of exercise is selected. *A stress test/fitness test* with ECG monitoring *is a requirement* and should be conducted with current medication. Assessment of muscle function entails testing of 10 RM (repetition maximum) before drawing up an individually tailored programme with resistance exercise.

Physical activity level is assessed with the aid of a questionnaire survey and pedometer. These tests can be performed again after the exercise period is complete to evaluate the results achieved from the exercise programme and continued prescription of exercise (40).

Prescription

Type of activity

The general goal of exercise in cardiovascular disease is to improve aerobic capacity through loading the central circulatory system. When it comes to the central circulation, large muscle groups should be used. Exercise can be conducted as intervals or as distance training. One Norwegian study shows that interval training led to higher VO_2 max compared to distance training (41). There is nevertheless a need for more and bigger studies on interval versus distance training before we are able to state that the one type of exercise is superior to the other in patients with coronary artery disease (42).

Each exercise session should always begin with a warm-up phase and end with a cool-down phase of similar length, regardless of the activity being done. Interval training means alternating between harder and easier intervals while distance training maintains the same level of intensity throughout the entire session (43). If there is a tendency to exertion-induced chest pain, the warm-up should be a bit longer than normal.

All exercise should begin with a successive warm-up of 6–10 minutes at an intensity of up to 40–60 per cent of VO_2 max and an exertion level of 10–12 according to the Borg RPE scale (15, 44). A proposed interval training is three loading exercise sessions of 4–5 minutes at an intensity of up to 60–80 per cent of VO_2 max and with an exertion level of "somewhat hard" to "hard", corresponding to 13–15 on the RPE scale. Between the loading intervals follow 4–5-minute sessions lighter exercise at an intensity of up to 40–60 per cent of maximal capacity and an exertion level of 10–12 on the RPE scale.

Distance training means exercising at the same level for approximately 20–40 minutes. The load can then lie at 13–14 on the Borg exertion scale. All exercise should finish off with successive cool-down and stretching of at least 6–10 minutes.

Table 3. Description of exercise training methods investigated in different scientific studies in patients with coronary artery disease.

Training method	Intensity	RPE***	Frequency (times/week)	Duration
Aerobic central circulatory training, distance or interval	50–80% of VO_2 max*	12–15 central	3–5	40–60 min./ session
Resistance training	1–3 sets of 10–15 RM** (65–75% of 1 RM)	13–16 local	2–3	8–10 exercises

* VO_2 max = Maximal oxygen uptake.

** RM = Repetition Maximum. 1 RM corresponds to the maximum weight that can be lifted through the entire exercise movement only one time.

*** RPE = Rate of Perceived Exertion (Borg scale 6–20).

The choice of activity should always be preceded by a history of the patient's physical activity where consideration is given to current aerobic fitness level, interests and requirements. Aerobic exercise can be carried out in the form of brisk walks, jogging, cycling, swimming, exercise or aquafit classes, skiing, skating, dance or ball sports, depending on the individual's interests, and should include 30–45 minutes of exercise, 3–5 times per week. This should be complemented with at least 30 minutes of daily physical activity, which need not be strenuous nor performed all at once and can include everything from regular moving about to walks and climbing stairs (36, 39). The goal is to achieve a daily energy expenditure of at least 660 KJ (≈ 150 kcal). When the extra weekly energy expenditure from exercise is added to the daily physical activity, the energy expenditure will exceed what is considered sufficient to achieve health effects (39).

Resistance training, which used to be considered contraindicated for cardiovascular disease, has in recent studies shown to be both a safe and effective way to exercise (45, 46). The patient should perform 1–3 sets of 8–10 resistance exercises, 10–15 RM, 2–3 times per week (15). If the patient has a very low physical capacity, peripheral muscle training may in certain cases be the type of exercise needed before other exercise, in order to enable other forms of activity. For a more detailed description of this type of exercise, see the chapter on Heart failure.

Women, the elderly and certain immigrant groups and cardiac rehabilitation

Studies have shown that rehabilitation for cardiovascular disease is underused by women, the elderly and certain immigrant groups (47) despite these patients having great benefit from cardiac rehabilitation (48, 49). It is therefore especially important to offer and encourage these patient groups to take part in exercise for cardiac rehabilitation.

Interactions with drug therapy

Beta receptor blockers

Beta blockers have a well-documented effect for coronary artery disease. They reduce the the myocardial oxygen demand primarily through a reduction of heart rate, but also by lowering blood pressure as well as some reduction in myocardial contractility. These effects are seen both at rest and during exertion. The effect is similar for all drugs in this group and is dose-dependent (50). A certain local fatigue, above all in the leg muscles, can present during exertion, however, and can be attributed to a reduced blood flow with subsequent shortage of oxygen in the working muscles (51). In spite of the metabolic and circulatory changes reported for beta blockers, the oxygen uptake capacity increases after fitness training similarly in people with coronary artery disease and concurrent beta blocker therapy and in people without beta blockers (52). The effects of exercise are independent of age and resemble the effects attained in healthy individuals (53).

Calcium channel blockers

Certain calcium channel blockers (verapamil, diltiazem) are negative chronotropes, that is, they lead to a lowering of resting heart rate and reduced maximal heart rate. As a rule, this limits VO_2 max, though the drugs themselves do not present a particular risk in connection with exertion.

Diuretics

Diuretics do not affect heart rate and cardiac contractility to any great extent, but lead to a decrease in plasma volume, peripheral resistance and blood pressure. Diuretics can also produce hypokalaemia, which leads to muscle weakness and extra ventricular beats.

In warm weather, diuretics can have potentially negative effects through an increased risk of dehydration and electrolyte disturbances (15).

ACE inhibitors

ACE inhibitors have a secondary preventive effect after myocardial infarction and here especially in people with concurrent heart failure (50). From a haemodynamic standpoint, these drugs have similar effects both at rest and during exertion, and lower the blood pressure by reducing peripheral resistance. None of the drugs have a negative effect on the haemodynamic response in exercise.

Nitrates

The oldest drug still being used for coronary artery disease is nitroglycerin. Nitrates come in short-acting forms, which counteract individual attacks, and in long-acting, preventive form. None of these affect physical performance capacity negatively, and can sometimes be taken before exercise with a preventive aim (50).

Contraindications

Absolute contraindications for physical activity and exercise are unstable angina and/or recent symptom onset that are severely debilitating. These people should be treated in hospital, with medical and/or invasive therapies. Serious heart rhythm disturbances (e.g. ventricular tachycardias, total atrioventricular block) constitute an obstacle, as do insufficiently regulated hypertension and ongoing infection that affects the patient's general condition.

Relative contraindications. Tolerance for arrhythmias is generally reduced if the patient is hypoglycemic (low blood sugar level) and/or dehydrated. It is therefore important to monitor these factors in all types of training and especially in people with heart disease.

Risks

The relative safety of supervised exercise in cardiac rehabilitation is well documented. The incidence of cardiovascular events during supervised exercise is low and ranges from 1/50,000 to 1/120,000 person hours of exercise for non-fatal cardiac events and 1 death/750,000 person hours of exercise. Cardiac rehabilitation always contains risk stratification in order to identify patients with an increased risk of cardiovascular events in connection with exercise (15).

It is important to note, however, that approximately half of all cardiac complications occur during the first month after suffering an acute coronary event. At 1-year follow-up, a high-risk patient runs three times the risk of myocardial infarction compared to a low-risk patient. It is therefore essential that the initial rehabilitation is carried out under supervision, and under the direction of a physical therapy specialist with access to emergency care equipment. An stress test with ECG monitoring before commencement of exercise is an important tool for determining the level of exercise, as well as for ruling out possible exertion-related symptoms that can have a negative effect on one's ability to train (54).

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