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Review

Physical Activity, Exercise Prescription for Health and Home-Based Rehabilitation

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Abstract: The aim of this overview was to recommend individual training plans using exercise prescriptions for adults and older adults during home-based rehabilitation. Over the last decade, many regular physical activity studies with large prospective cohorts have been conducted. Taken together, more than a million subjects have been included in these exercise studies. The risk of morbidity and mortality has been reduced by 30% to 40% as a result of exercise. These risk reductions hold true for many diseases, as well as for prevention and rehabilitation. Physical activity has also been in the treatment of many diseases, such as cardiopulmonary, metabolic or neurologic/psychiatric diseases, all with positive results. Based on these results, the prescription of exercise was developed and is now known as the exercise prescription for health in many European countries. Details have been published by the European Federation of Sports Medicine Associations (EFSMA). The exercise prescription is strongly recommended for inpatients, discharged patients and outpatients who have recovered from severe diseases. Rehabilitation improves general health, physical fitness, quality of life and may increase longevity of life.

Keywords: training; cardiopulmonary diseases; exercise prescription; lifestyle; fitness

1. Introduction

The aim of this overview was to present information for individual training recommendations through exercise prescriptions, also known as the exercise prescription for health, for adults and older adults during home-based rehabilitation. Within the framework of conservative medicine specialties, such as general medicine, internal medicine, cardiology, neurology or orthopedics, therapy is preferably carried out with medication, provided that interventions via endoscopy, catheter or surgery are not indicated. After discharge, it is common for patient hospital letters from these departments to show four to six or more drugs recommended for further therapy. Detailed recommendations for physical activity are rarely mentioned. Occasionally, non-drug measures, such as physiotherapy, are suggested. Reports from rehabilitation clinics recommend "even" lifestyle changes without providing further details. The results of a large number of prospective cohort studies on the effects of regular physical activity have remained largely unnoticed yet have been published for more than 30 years now. However, these studies have demonstrated evidence-based health benefits of exercise and physical activity for prevention, therapy and rehabilitation (Figure 1), and are comprised of more than a million subjects [1–8]. Furthermore, it has been shown that a sedentary lifestyle that includes a lack of exercise, too much sitting and too much screen time, along with smoking, is the most important risk factor for various diseases [7–9]. Patients who have been discharged from hospitals or who have recovered from severe diseases need rehabilitation as inpatients at rehabilitation clinics or as outpatients in

ambulant training groups or at training facilities. Ambulant rehabilitation must be continued with home-based rehabilitation over a long period of time. The primary task of a general physician is to motivate patients to engage in an intensive home-based rehabilitation accompanied by a qualified training instructor. Such rehabilitation and exercise training leads to a general health improvement and an increased quality of life, physical performance and life expectancy [6,8–11].

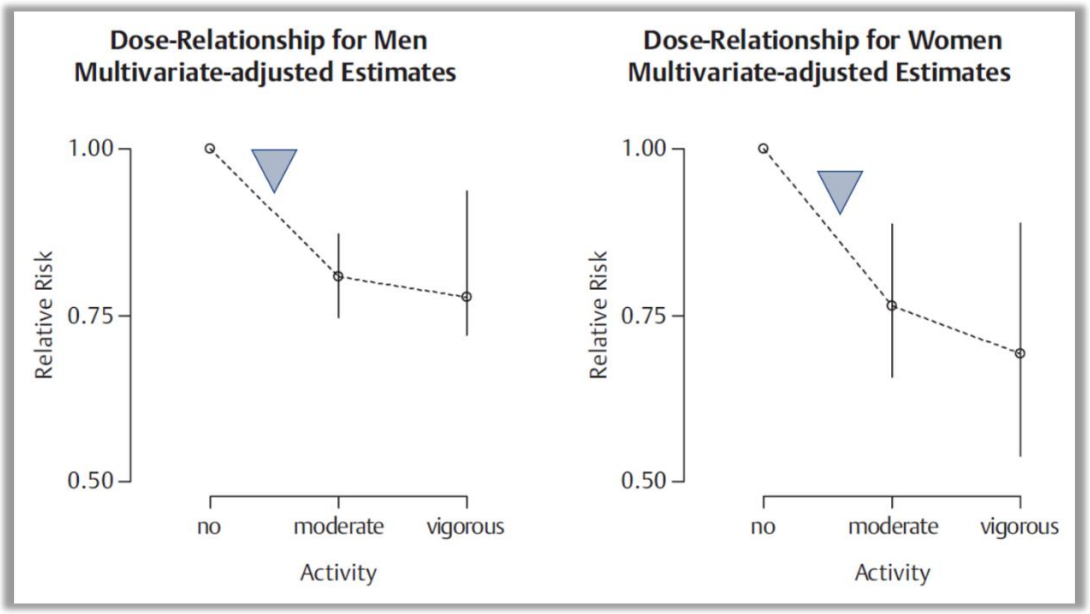

Figure 1. The non-linear relationship between exercise intensity and risk reduction for all-cause and cardiac mortality. Note that the strongest risk reduction occurs between inactivity (1.00) and moderate activity, indicated by the triangle pointing down (modified from [3]).

2. Health as Self-Reliant Behavior

Recommendations on physical activity in the context of rehabilitation also requires students, physicians and even patient education on the importance of personal responsibility for maintaining good health. This can be explained using the operational definition of health as an example. The definition of health in this context is composed of the following aspects: genetics (approximately 15%), general environmental influences, the medical environment and the residential and living environment, including parks, sports facilities, forests, etc. (approximately 30–35%) [2,12–16]. These percentages of components clearly show that, with regular physical activity, persons with a healthy lifestyle can actively influence up to 50% of their own health [17–19]. This is significant motivation for subjects to optimize their lives through a healthy lifestyle. Furthermore, a healthy lifestyle is based on four well-known pillars: no smoking, regular physical activity, a healthy (Mediterranean) diet and a normal body weight [10].

3. Effects of Regular Physical Activity: Physiological Aspects

Regular physical activity is an integral part of prevention and rehabilitation. Physical activity has a variety of effects on many organs and organ functions (Figure 2). The primary changes that are induced by physical exercise take place in the working muscles. As the amount and intensity of training increases, the cardiovascular system is adjusted, blood pressure is lowered and endothelial function is improved [5,11,13,20,21]. As regular training proceeds, general metabolic functions are optimized, neurological adjustments occur and the autonomic system stabilizes through the balancing of the sympathetic and parasympathetic nervous systems. Remarkably, regular physical activity is the only procedure, including the prescription of medication, that improves cognitive function so far (Figure 2; Table 1). Most of the mentioned changes occur at the molecular level [2,5,11]. The musculoskeletal

system can also be strengthened by physical activity including resistance exercise. As such, sarcopenia can be attenuated and even eliminated [4,10,11,14].

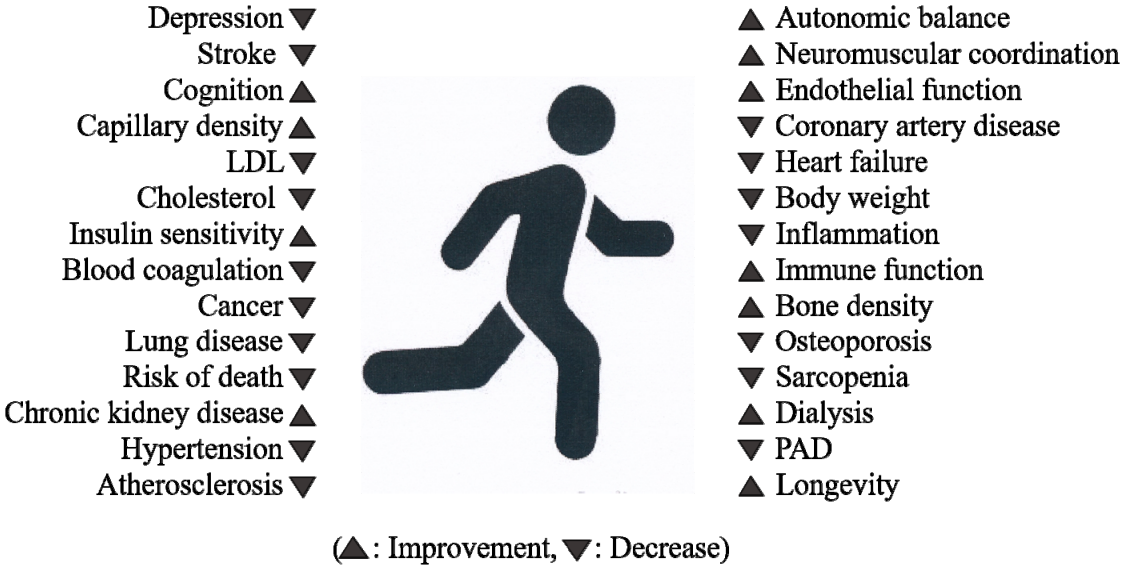

Figure 2. Some positive effects of regular physical activity [1,3,5].

Table 1. Evidence-based indications for prescribing regular physical activity in diseases (class: class of recommendations, from I–III with I as the highest class; level: level of evidence from A to C or even to D with A as the highest level) (modified from [1,9]).

Diseases	Class/Level of Evidence
Coronary artery disease	IA
Arterial hypertension (−4–−8 mmHg)	IA
Chronic obstructive lung disease	IA
Heart failure	IA
Cancer (colon, breast, lung)	IA
Osteoporosis	IA
Metabolic syndrome and Diabetes mellitus	IA
Chronic kidney disease	IA
Peripheral arterial disease	IA
Cognitive mental disorder	
Dementia	IIB
M. Alzheimer	IB
Depression	IB
Stroke	IA
Fibromyalgia	IA
Parkinson's disease	IB
Chronic bowel disease	IA
Bipolar disease	IIB

4. Evidence of Manifold Positive Effects through Physical Activity for Prevention and Therapy

Today, regular physical activity is recommended and used with high-grade, evidence-based approaches to prevention, therapy and rehabilitation [1,2,4–6]. A large number of studies on physical fitness, measured as the maximum possible load achieved on a bicycle ergometer or a treadmill, has shown that high fitness reliably promotes prevention of many diseases within the following years and decades [1,4,7] (Table 1). For people who suffer from a long-term lack of movement and activity, starting with regular activity even at moderate intensity has shown to produce positive effects and risk reduction. From a sports medicine perspective, the most important step is the change from a sedentary

lifestyle or inactivity to regular activity (Figure 1). Fast walking or "Nordic walking" activity in daily life is effective in improving fitness. Nonetheless, physical activity in sufficient amounts (see below) reduces not only morbidity but also mortality, thus increasing longevity of life [14].

5. Diseases and Evidence for Physical Activity in Prevention, Therapy and Rehabilitation

In coronary heart disease, physical activity leads to a 30–40% reduction in mortality. Several meta-analyses confirm these results. For example, physical activity after a heart attack is absolutely necessary for a healthy lifestyle in the future (Table 1). Rehabilitation, either home-based or participation in heart groups, increases recovery and is mandatory for patients [1,4,5,14,21]. For those with arterial hypertension, physical activity lowers systolic values, on average, between 5 and 10 mm Hg. According to recent studies, additional strength training also lowers blood pressure, and the combination of strength training with physical activity has the strongest lowering effect on blood pressure. Even hard endpoints, such as mortality due to high blood pressure, are reduced by regular physical activity [22].

Heart failure is a clear-cut indication that active rehabilitation is necessary, as has been shown in many studies. Again, individual training leads to an improvement in cardiac function and reduces morbidity and mortality [1,20,23]. One long-term study has shown that the effects of physical activity persist even after 10 years of observation [24,25]. In peripheral arterial occlusive disease, consistent gait training works better than or equal to vascular dilatation with a stent insert [26].

Those with diabetes mellitus can benefit greatly from physical activity. As a form of causal therapy, physical activity lowers medication or insulin consumption, thereby decreasing insulin resistance. Over time, hard endpoints such as morbidity and mortality are significantly reduced by up to 40% [27]. Treatment of diabetes mellitus without the prescription of physical activity, in addition to diet and possibly medication, is regarded as a kind of malpractice.

The positive effects of exercise have now been described in the treatment of many lung diseases [1]. Patients with chronic kidney disease show an improvement in kidney performance and, in some cases, in kidney function. Dialysis patients with regular bed ergometer training show better kidney performance and a better quality of life than those without the training. Today, ergometer training during dialysis should be part of the standard accompanying therapy [28].

In oncology, physical training is now considered an essential adjuvant to therapy, especially chemotherapy. Women with breast cancer or men with colon and prostate cancer benefit from such exercise training. This also applies to other types of cancer, especially when cardio depressive drugs are administered [29,30].

Examples of many other diseases that have been improved or eliminated by physical activity are osteoporosis, degenerative spinal disorders and fatigue syndrome. Parkinson's disease and strokes are considered absolute indicator for exercise therapy combined with inpatient rehabilitation, group therapy and home-based rehabilitation [29].

In psychiatry, regular exercise, such as walking, hiking or cycling, is regarded as an important and effective accompanying therapy for depression and bipolar diseases. Remarkably, in animal experiments, neurogenesis in the hippocampus can be significantly increased by physical training, indicating improved cognitive function [30,31]. So far, physical activity is the only treatment or "drug" that may delay or prevent dementia [32].

6. Physical Activity as a Drug and Therapy

Physical activity has numerous and proven indications that it can be considered a drug. It can be dosed individually as personalized therapy and results in a non-linear dose-response relationship [2–4,8]. In addition, physical activity results in numerous somatic and psychosomatic effects. Further, its possible side effects are minor, and it has only a few contraindications (Table 2). Thus, physical activity is comparable to a very effective drug, one that is potentially better than cardiovascular polypills [33,34].

Accordingly, physical activity must be implemented for prevention, therapy and rehabilitation in special clinics, sports facilities and at home.

Table 2. Arguments for evaluating physical activity as a drug.

	Many: All Organs and All Body Functions
Dose-Response relationship:	Strong relation, non-linear
Dosage: FITT rule	Frequency, intensity, time of session, type of sport
Somatic effects:	Manifold, from brain and heart to toes, in health and disease
Psychoactive effects:	Present, many diseases
Side effects: or contraindications	Rare, acute illness, injuries

Compared to some drugs, regular physical activity has a stronger effect and, above all, a pleiotropic effect, meaning that regular activity has a variety of positive effects. This pleiotropic effect has been observed in only a few drugs [33,34] (Table 1). These positive effects in treating diseases led to the concept that physical activity or exercise as a drug should be prescribed, known as the exercise prescription for health (EPH) [8–10,35–42]. Therefore, physical activity can and should be recommended and prescribed to all patients whenever possible [9].

7. Rehabilitation for Inpatients and Outpatients

Physical activity is an essential, if not the most essential, part of home-based rehabilitation [9–12]. The enumeration and description of the positive effects of physical activity strongly contrast with the lack of its implementation and recommendation in clinics and practices. Discharge letters from most hospitals are usually handed out to patients with a list of medications (Figure 3). Conversely, specific advice for regular physical activity upon discharge is missing. This is because physicians lack knowledge in the field of sports medicine. A requirement of every physician and specialist should be a basic level of knowledge in the field of physical activity. Every physician should discuss the level of physical activity of their patients as part of anamnesis (5th vital sign).

Recipe on discharge from hospital, Patient after STEMI with Stent	Exercise prescription by Sports Physician Practice:
• Lisinopril 2 × 5 mg; ASS 100 mg • Bisoprolol 5mg; Prasugrel 2 × 5 mg • Rosuvastatin 20 mg Recipe after discharge from Rehab. Clinic: • L-Tyroxin, Bisoprolol, Ramipril, ASS • Molsidomin, Fluvastatin, Moxonidin • Spironolactone, Aliskiren, Omega-3 FA	Regular physical activity: • Frequency: 3-4 × /week • Intensitiy: Borg 11-13, Heart rate: 105-120 • Type of sports: Endurance (walking, cycling, running, swimming, ergometry, • Resistance training: 2 × /week Drugs: 5 of 9 (see left site) Diet: Mediterranian diet

Figure 3. Examples of prescriptions of many drugs upon discharge by the hospital after myocardial infarction with ST-Elevation (**left**) and examples of exercise prescriptions by a sports physician (**right**) (STEMI: ST-Elevation myocardial infarction; Stent: Vascular prosthesis; Rehab.: Rehabilitation; ASS: Aspirin; Omega-3-FA: Omega -3 fatty acid.).

8. Exercise Prescription for Home-Based Rehabilitation

First, rehabilitation typically takes place in special rehabilitation clinics after discharge from acute care hospitals in some countries (Figure 3). After discharge, the next stage of outpatient rehabilitation takes place in sports groups (e.g., "heart groups"), more rarely in sports clubs or fitness

studios, conducted by trainers with special experience as exercise physiologists. Above all, additional home-based exercise training should be a lifelong physical activity.

As such, it is of the utmost importance to include physical activity as a vital component in the follow-up application of home-based rehabilitation [11,14,43]. For these patients, motivation is absolutely mandatory. This can be done by providing brief advice and detailed information about the benefits of a lifestyle change (Table 3). Motivational interviewing is probably the most effective intervention but is considerably time-consuming. Accordingly, the exercise prescription for health (EPH) is a cheap but effective approach to motivate patients in regular activity and in longer adherence to that activity [44–46] (Tables 3 and 4, Figure 4).

Table 3. Interventional steps for motivation in physical activity: From brief advice to the exercise prescription for health (EPH).

1. Brief advice provided by the physician to be active according to guidelines, such as interrupting sitting time every 30 min
2. Physician questioning of patients about their activity level (5th vital sign)
3. Motivational interviewing (if possible, time consuming)
4. The exercise prescription for health

Table 4. The exercise prescription for health EPH (modified from [2,10,29]).

European Sports Physicians' Recommendations for Physical Activity in Children and Adults	
Children	Daily moderate or vigorous physical activity for at least 60 min per session, composed of endurance, flexibility, balance and muscular endurance training at least once per day.
Adults aged 18 to 65 years	150 min/week of moderate-intensity aerobic physical activity or at least 75 min/week of vigorous-intensity or an equivalent combination of moderate and vigorous-intensity activity.
Adults aged 65 years and above	At least: A total of 150 min/week of moderate-intensity aerobic physical activity for at least 30 min 5 days a week or 50 min 3 days a week. 75 min/week of vigorous-intensity aerobic physical activity throughout the week or an equivalent combination of moderate- and vigorous-intensity activity and moderate to vigorous strength training at least 2 days per week, complemented by flexibility, balance and muscular endurance training. Aerobic activity can be performed in bouts of at least 10 min.
Elderly adults with poor mobility	Physical activity to enhance balance preventing falls on 3 or more days per week. Muscle-strengthening activities should be done involving major muscle groups on 2 or more days a week. Comment: When elderly adults cannot do the recommended amount of physical activity due to health conditions, they should be as physically active as their abilities and conditions allow. Resistance exercise, which means exercise that is performed by the patient against resistance, as from a weight.

Following the introduction of the exercise prescription for health, the positive results from improved adherence to training have been published by several authors [22–24,39,40,44]. Studies from Sweden, in particular, have promoted the use of the EPH, as well as the activities by EFSMA in several member countries [9,10,38,42,47,48]. These studies presented results such as stronger adherence to physical activity and improvements in fitness and in quality of life. Hard endpoints were not investigated in these trials because of the short duration of the trials (6–12 months) and the small sample sizes. Therefore, in the future, trials with larger numbers of patients and longer study durations are necessary to prove the validity and efficiency of the EPH. Brief advice provided to patients at the beginning of their rehabilitation may be effective, but the EPH, as an individualized procedure, enables a

significantly stronger and longer adherence for up to 6 to 12 months [45,47,48]. After issuing the EPH, regular monitoring through functional or fitness testing, as well as monitoring for quality of life improvements, is strongly recommended as a means of further increasing adherence. After long-lasting training, the patient usually feels a subjective improvement in performance during activities in daily life (ADL). Improved quality of life also increases a patient's motivation to continue with regular exercise.

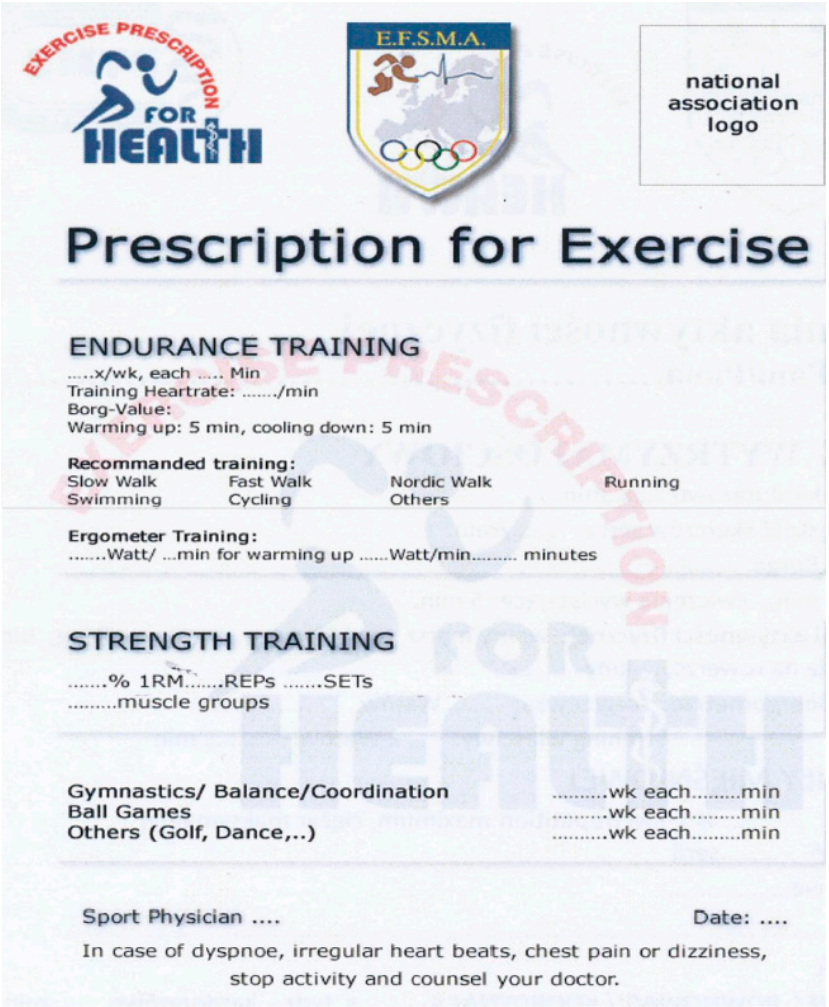

Figure 4. The recipe for the exercise prescription for health (see www.efsma.eu).

9. Pre-Participation Evaluation and Risk Evaluation

A clinical examination, a medical history and a risk assessment using an electrocardiogram (ECG) of the patient should always be required before training recommendations are given, In addition, a maximal ergometry stress test is strongly recommended. These recommendations must be based on measured values, such as maximum power (watts, MET's and/or V02max), and on the perceived exertion during exercise testing [49]. Using the FITT rules, frequency, intensity, time and type of training can be determined, as well as the time required for each training session [48]. Reliable formulas (algorithms) for non-invasive estimation of V02max (maximal oxygen uptake) are available if a stress testing unit is not available. Depending on the severity and the potential risk of the disease [50], a cardiac ultrasound examination is recommended before the commencement of training.

Any increases in exercise difficulty or session duration should take place after consulting a physician and an intermediate physical examination. Furthermore, wearables, such as accelerometers,

may be very useful in monitoring a patient's regular activity and in the analysis of their basic physical activity [5]).

10. General Training Recommendations

For a physician's use, many exercise tables for the treatment of various diseases have been developed that take into account the varying fitness levels of patients (Figure 4, Tables 4 and 5). These 18 tables have been developed and presented by the EFSMA (available on www.efsma.eu). With these lists of parameters, individualized and personalized training recommendations can be provided. A formula to simplify the different parameters should be created and should take into account anthropometric data, as well as age, risk of disease and the results of pre-participation examination data.

Table 5. Recommendations for prevention and treatment: The exercise prescription for health. Tables for a physician's desk: For example, 1 of 28 tables for a physician's desk [3,38].

	Frequency/ Week	Intensity	Time (Duration)	Type of Training	Type of Sports	Strength Training
Prevention in general	**Low intensity:** 5/week **Vigorous intensity:** 3/week	**Low intensity:** 40–65% HR max. RPE 10–13 **Vigorous intensity:** 65–85% HR max. RPE 13–16	**Low intensity:** >30 min/session or 150 min/week **Vigorous intensity:** >25 min/sessionor 75 min/week	Endurance, strength	Running, walking, cycling, swimming, skating, cross-country skiing	70% of 1RM >2–3/week, 10–15 reps 1–3 sets
Coronary heart disease	3–5/week **Vigorous intensity:** 3/week	50–80% VO_2 max or 40–70% HR max RPE 12–15 maybe HITT *	40–60 min/session **Low intensity:** >30 min/session **Vigorous intensity:** >20 min/session HITT	Endurance, strength	Running, walking, cycling, swimming.	60–75% of 1RM >2/week, 8–12 reps 2–3 sets

General recommendations: warming up should last about 3 to 5 min and cooling down should last 3 to 5 min, with flexibility training performed daily *(HITT: High intensity intermittend training).

In addition to endurance training, interval training can also be done, usually intermittently, i.e., one or two days a week. High-intensity interval training should be performed in a fitness facility with the necessary expertise and emergency equipment.

11. Long-Term Effects of Training Recommendations Using Prescription for Exercise

The current general training recommendations for recreational athletes have been published by many professional societies. These include aerobic exercise activities in daily life and resistance exercise (Tables 4 and 5) [12]. Over time, physicians should take care of the patient through follow-up examinations on a regular basis, for instance every 3–6 months. The success of the training should be evaluated and problems with training progression should be discussed with the patient. The continuation of regular physical activity over a longer period of time must be advised, if possible as a lifelong activity [2,24,45,46,51–53]. Some of the most important recommendations for patients are to start low and slow and with low intensity activity, increasing slowly under medical observation.

A further recommendation should be to incorporate regular activity into daily life, such as climbing stairs, intensive gardening, shopping on foot, walking to the post office, engaging in regular gymnastics and flexibility exercises and possibly engaging in sensomotoric training (Figure 4). Training is possible

at any age, even at a very advanced age. More importantly, however, training should begin early in life. If this is maintained for the following decades, self-determination and autonomy will be longer and health will be improved in old and very old age.

12. Conclusions

Regular physical activity is an important part of maintaining or restoring health. Physical activity has a variety of positive effects on somatic and psychosomatic functions; its effect can be considered and used like a drug or polypill. Physical activity should be prescribed both in clinics upon discharge and in private practices (Figure 3). When counselling, it should be pointed out that everyone, whether healthy or ill, can make a significant contribution to their own health if they incorporate the four important pillars of a healthy lifestyle, which include physical activity, a healthy diet, not smoking and maintaining a normal body weight (Box 1). The exercise prescription for health stimulates and enhances adherence to regular physical activity in the context of home-based rehabilitation and during daily life. Thus, a patient may be more willing to adhere to and sustain the four pillars of health throughout their life.

Box 1. Summary Box.

Default, Road and Goals:
Physical activity,
non-smoking,
normal or near-normal body weight
Mediterranean diet
and stress coping
Regular physical activity means:
feeling better,
looking younger,
more physical resilience
and increased physical fitness

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