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Endurance Training in Cardiovascular Patients – Practical Aspects

Ausdauertraining bei Herz-/Kreislauf-Patienten – praktische Aspekte

REVIEW

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Summary

› **Endurance training** is the mainstay in the exercise and sports therapy of cardiovascular patients. Both morbidity and mortality are improved in the long-term.
› **The importance** of this therapy is still underestimated, and it seems prudent to give individualized training recommendations on mode, duration and intensity of physical activity, analogous to prescription of medication. The level of fitness being low in especially cardiovascular patients, the aim should be to start with a rather low intensity and duration ("begin low, go slow") with clear instructions for increasing the exertion. At least a moderate level of physical activity should be achieved, if possible and wished even a higher intensity. A moderate intensity (150min per week at 3 to 6 metabolic equivalents MET or 50 to 100 Watt with 70kg body weight, desirable at least 1500kcal per week of energy consumption) should be reached.
› **More recent data** indicate that in endurance training, approximately 80% of the maximum heart rate achieved in the exercise test, possibly even 5% more, can be recommended (if there are no symptoms!). Alternative training modes such as, for example, high intensity interval training, have not yet proved better neither in coronary heart disease nor in heart failure.
› **Patients with heart failure** should have a cardiopulmonary exercise test in order to determine the appropriate level of exercise based on the first ventilatory threshold.

KEY WORDS:
Endurance Training, Exercise, Cardiovascular Patients, Exercise Intensity, High Intensity Interval Training

Zusammenfassung

› **Ausdauertraining** ist die wichtigste Säule bei der Bewegungs- und Sporttherapie kardiovaskulärer Patienten. Sowohl Morbidität als auch Mortalität werden langfristig günstig beeinflusst.
› **Die Bedeutung** dieses Therapeutikums wird nach wie vor unterschätzt und es erscheint wichtig, individualisierte Trainingsempfehlungen in Art, Dauer und Intensität der körperlichen Aktivität zu geben, analog einer rezeptierten Medikation. Da das Ausgangsniveau der Fitness besonders bei kardiovaskulären Patienten niedrig ist, sollte mit eher geringer Intensität und Dauer begonnen werden („begin low, go slow") mit klarer Anweisung für die Steigerung. Zumindest ein mittleres Leistungsniveau sollte angestrebt werden, wenn möglich und erwünscht auch eine höhere Intensität. Eine moderate Intensität (150min pro Woche bei 3 bis 6 metabolische Äquivalente MET oder 50 bis 100 Watt bei 70kg Körpergewicht, wünschenswert mindestens 1500kcal pro Woche Energieverbrauch) sollte erreicht werden.
› **Neuere Daten** deuten darauf hin, dass man beim Ausdauertraining ungefähr 80 % der maximal erreichten Herzfrequenz im Belastungstest, möglicherweise sogar 5 Prozent mehr empfehlen kann (ohne Symptome!). Alternative Trainingsformen, wie zum Beispiel das hochintensive Intervalltraining, haben sich in vorliegenden Daten bisher weder bei koronarer Herzerkrankung noch bei Herzinsuffizienz als besser erwiesen.
› **Patienten mit Herzinsuffizienz** sollten als Belastungstest eine Spiroergometrie erhalten, um anhand der ersten ventilatorischen Schwelle das geeignete Leistungsniveau zu ermitteln.

SCHLÜSSELWÖRTER:
Ausdauertraining, körperliche Bewegung, kardiovaskuläre Patienten, Trainingsintensität, Hochintensitäts-Intervall-Training

Introduction

Endurance training is the mainstay of exercise and sports therapy in cardiovascular patients. In an editorial in Circulation in April 2016, Lance Gould summarized the mass of evidence of the beneficial effects of endurance training: "Regular exercise improves everything – hypertension, diabetes mellitus, lipid profile, endothelial function, heart failure, diastolic dysfunction, weight loss, catecholamine regulation, mobility, balance, strength, endurance, and mental function..." (overview: 8, 25, 33).

Unfortunately, average daily exercise levels in the general population seem to be very low. This situation may be even worse in cardiac patients. In practice, it must be our aim to get people "moving" again. The large muscle groups should be included (mainly the legs) and the appropriate dose "prescribed" ›

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Table 1

Relationship among indices of exercise intensity and training zones. HR_{max}=maximum heart rate; HRR=heart rate reserve; METs=metabolic equivalents, I MET=individual metabolic resting demand, when sitting quiet, about 3.5ml oxygen/kg/min or 1kcal (4.2kJ/kg/h) in the general population; RPE, Borg rating of perceived exertion (6–20 scale). Intensity examples: 1. Low: walking slow, light gardening; 2. Moderate: walking brisk, bicycling 16-19km/h; 3. High: jogging, bicycling 20-22km/h. (Copyright 2011 by the European Society of Cardiology. Reprinted by permission of SAGE Publications, Ltd. www.sagepub.co.uk (30, 31)).

INTENSITY	LACTATE (MMOL/L)	METS	VO_2MAX (%)	HRR (%)	HR_{MAX} (%)	RPE SCALE	TRAINING ZONE
Low intensity, light effort	2–3	2–4	28–39	30–39	45–54	10–11	Aerobic
Moderate inten-sity, moderate effort	4–5	4–6	40–59	40–59	55–69	12–13	Aerobic
High intensity, vigorous effort	6–8	6–8	60–79	60–84	70–89	14–16	Lactate, aerobic, anaerobic
Very hard effort	8–10	8–10	>80	>84	>89	17–19	Lactate, aerobic, anaerobic

similar to medication (32). Some precaution should be taken into account before starting. For physically unfit, untrained patients, training should begin low and go slow. High risk has to be assessed and a stable status achieved. Subjective factors (self-assessment) and objective factors (comorbidities, muscular status) must be reviewed.

Plan the Training

Before prescribing a training plan for cardiac patients with normal or near- normal ejection fraction, an exercise test to the maximum attainable workload is necessary in order to determine the maximum heart rate achieved. This can be on a treadmill or bicycle on a graded basis according to the diagnostic guidelines (29). Adequate testing achieves at least 85% (submaximal) or optimal 100% of the maximal heart rate (220 – age in years) (29) or the peak VO_2 (maximum oxygen uptake in cardiopulmonary exercise test CPET) achieving at least a RER (respiratory exchange rate) of 1.10 or higher (10, 26). Alternative models include: heart rate 208-0.7 x age for females and 206-0.88 x age for males. Medication may require some adjustment, especially for betablockers (164-0.7 x age) (5).

The German Guideline for Physical Activity in Secondary Prevention (4) recommends 20-30 minutes 5 times a week, or 100-150 minutes at 60-75% of the maximum heart rate achieved in the stress test, respectively 40-60% of the heart rate reserve (maximum heart rate minus resting heart rate) The heart rate reserve method is considered preferable for patients with chronotropic incompetence, i.e. patients on betablockers. On the Borg scale (of percieved exertion, 6 no exertion, 19/20 very, very hard) that equates to 11 to 13. This is consistent with current international guidelines and reviews (27, 32). These emphasize training in terms of volume (= intensity x duration). 150 minutes/week at 3.5-6 METs (metabolic equivalents, approximately 50-100 watts with 70 kg body weight), in the "moderate" range (500-1000 MET-min, approx. 550-1100kcal/week, optimal up to 1500kcal). Alternatively, higher ("vigorous") activity levels can be set, i.e. 75 minutes/week at 6-8.5 METs (about 100-150 watt), on the Borg scale 14 to 16. Low fitness levels are observed in the vast majority of patients with coronary artery disease (CAD). The SAINTEX-CAD study (6) in stable coronary patients without compromised ejection fraction reported that endurance training intensity of up to 80-85% of the maximum heart rate achieved was feasable and safe, if tolerated. Training zones from low to high intensity are summarized in table 1 (30, 31). For details on different training modes see publication cited (13). In Germany, a unique system exists whereby exercise can be prescribed in so-called "Rehabilitationssportgruppen" or Rehab exercise groups, which unfortunately are underused (15).

In the growing subgroup of the "elderly" (75 years and older), training is absolutely necessary to maintain mobility and independence. With increasing age, the fitness category declines physiologically in the general population (reduced by around 30% from the age of 50 up to 70 and older) (16). This group is at risk for overtraining, frailty and falling. The maxim: "Begin low, go slow" applies here. Training can start at 50% of maximum heart rate achieved and only 3 (-4) times a week for 10 (-15) minutes, with low increments every 2 weeks for example.

The same applies for women, who often have lower fitness levels (than same-aged men). Among patients with CAD, the female subgroup are generally older, have more comorbidities, and the course of disease and prognosis is more adverse than in the male subgroup. At the beginning of cardiac rehabilitation, women achieve a peak VO_2 of 14.5ml/kg/min, which is similar to that of patients with heart failure (1).

Heart Failure

In heart failure, calculating the risk is the first step in initiation of prescribed exercise . In addition to clinical assessment (low systolic blood pressure during exercise test and reduced heart rate recovery) and imaging techniques (low ejection fraction) CPET variables are important. Peak VO_2 lower than 14ml/kg/min (12 with betablockers), first ventilatory threshold lower than 9ml/kg/min combined with VE/VCO_2 slope beyond 36 and exercise oscillatory ventilation is associated with higher risk (10, 11, 18). If the patient presents with the above clinical conditions, optimizing therapy must first be urgently addressed before initiating training. In all others, CPET is the gold standard to determine the ventilatory thresholds (see Figure 1, (3)). This applies to heart failure with reduced ejection fraction (HFrEF) as well as to heart failure with preserved ejection fraction (HFpEF).

However, a paucity of evidence proving benefits of exercice training in HFpEF warrants caution. The optimal training range is at the first ventilatory threshold (usually at 40-60% of VO_2max, (10, 11)). Some data show that a better effect is achieved above this threshold without risk. Because of the "slow component" of the VO_2 kinetics, it should be well under the second ventilatory threshold (usually at 60-70% of VO_2max). As a rule of thumb, it should be 10 watts less for a 10 watt/min incremental exercise test protocol (20). But there is not much scientific evidence for this yet. The maximum heart rate for the training can be estimated in correlation to the ventilatory thresholds. If a maximal stress test is not feasable and/or training levels are initiated at a very low level, either the Borg scale or the 6-minute walking test may provide orientation.

Alternative Modes of Training

In recent years, alternatives to endurance training have been discussed. In contrast to the training principle of endurance training (ET) with a constant load (after warm-up), in high intensity interval training (HIIT) phases of very high load alternate with phases of "active recovery" at a low level. An initial pilot comparison study (34) seemed to favour HIIT. Several subsequent studies compared the two methods.

There are several publications of the Saintex CAD study from Leuven, Belgium in patients with coronary artery disease (CAD) (6, 22). The authors compared ET and HIIT in CAD patients with normal ejection fraction. Two groups, each of 100 patients, were randomized to either "moderate" ET (target 75-80% of the maximum heart rate, approx. 150 minutes/week) or aerobic interval training (HIIT according to Wisloff (34) at target 90-95% and approx. 120 minute week). The actual heart rate achieved was 88% with ET (which was higher than expected) and under 90% with HIIT (which was lower than expected). In consequence, the increase in peak VO_2 was the same in both groups. Even after one year of follow-up, there was no difference between groups. The same was found in patients with angina after 4 weeks of high intensity training compared to moderate ET (21). Remarkable is the finding in the Leuven group that the energy consumption was higher with ET. This effect is considered beneficial in patients with hypertension and diabetes mellitus (Metabolic Syndrome). The small "time-saving" (30 minutes exercise-time/week) with HIIT is offset by increased complexity of monitoring heart rate.

ET and HIIT were compared in heart failure patients in the recently-published SMARTEX-HF study (9). Baseline mean ejection fraction was less than 35%, and NYHA (New York Heart Association) stage II-III with a predominantly ischaemic etiology. The exercise protocol was analogous to the Saintex CAD study. A total of 261 patients were allocated to either "moderate" ET (target 60-70% of maximum heart rate, 38 minutes/session) or aerobic interval training (HIIT according to Wisloff (34) at target 90-95% and 47 minutes/session). The actual training level was higher than per-protocol for 80% of the ET patients whereas 51% of the HIIT patients were below the protocol target levels. The mean increase in peak VO_2 once again was the same between groups. Adverse events were more frequent in the HIIT group. Again, no superiority for HIIT. Recently, a study was published (28), which shows that positive peripheral muscular effects only occur with HIIT. However, the following question was asked: "who is the beneficiary candidate and how many patients may really tolerate HIIT...?".

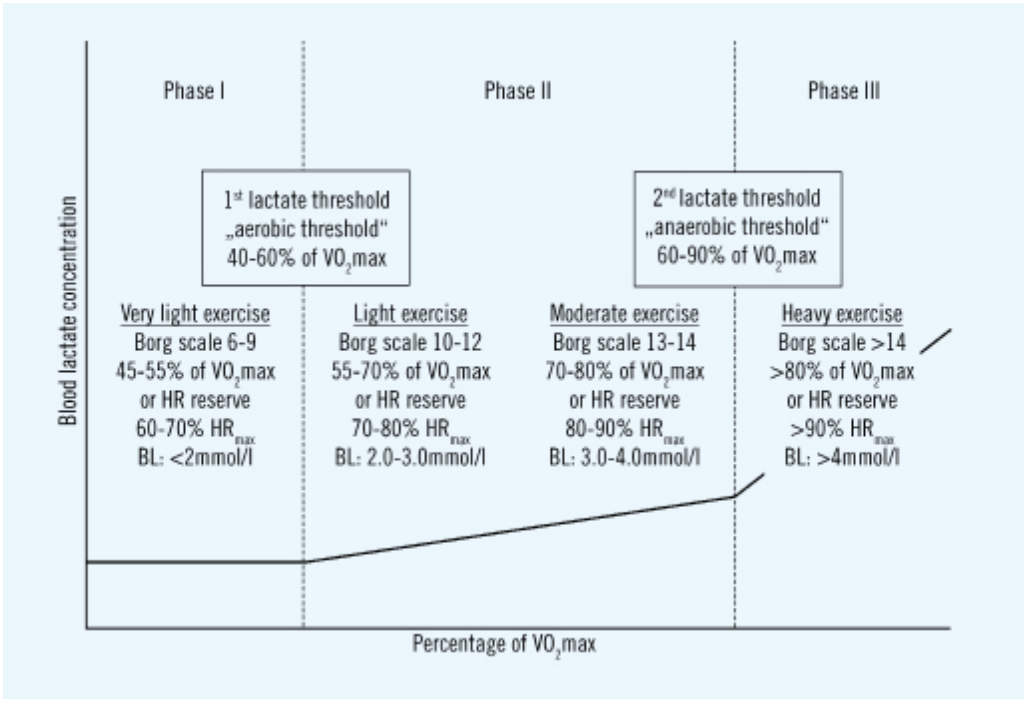

Figure 1

The three-phase model according to Skinner: relation between blood lactate concentration (BL) and exercise intensity. HR=heart rate;VO_2=oxygen consumption; Borg scale: subjective rating of perceived exertion. (Copyright 2008 by the European Society of Cardiology. Reprinted by permission of SAGE Publications, Ltd. www.sagepub.co.uk. (3)).

What else?

There is a longstanding controversy about "overdose" (2, 19, 33) and about athletes and competitors, especially with cardiomyopathies, channelopathies and after ICD/CRT. These persons need an individual approach by experienced specialists (for further information (7, 14, 17, 23, 24)).

Online Decision Making

There is a new tool that offers digital, interactive decision support for exercise prescription. For now, there is a pilot version of the EXPERT tool (based on the Expert Flowchart, (12)). This flowchart assists physicians and healthcare professionals in choosing and adopting the optimal exercise intervention in patients with various cardiovascular diseases and/or combination of risk factors. It is now available as a web-based software (pilot). Clinical experience must be gathered with this tool.

Conclusion

In summary, more experience should be gained using higher training levels in ET patients with no complaints (approximately 80% of the maximum heart rate, possibly +5% more). For the different conditions in cardiac patients see table 2 (20). Well-trained patients may be given the option to change from moderate intensity (150 min/week at 3.5-6 MET) to more challenging ("vigorous") intensity by shortening the duration (75min/week at 6-8.5 MET). Considering the situation in the unfit general population and particularly in cardiac patients (with growing risk of metabolic syndrome), the attainment of a "moderate" training level appears challenging. ET is especially beneficial in this population for energy balance. From today's point of view, the (small) subgroup suitable for HIIT remains to be ›

Table 2

Evidence-based prescribable aerobic exercise intensity in cardiac patient groups (YES=Y). Intensity domains for which no scientific evidence is available in a specific population (NO=N); CAD=coronary artery disease; PCI=percutaneous coronary intervention; ICD=implantable cardioverter defibrillator; AF=atrial fibrillation; CABG=coronary artery by-pass grafting; CHF=chronic heart failure; LVAD=left ventricular assist device; [a]=Heart rate and/or work rate must in any case be lower than those corresponding to the ischaemic threshold; [b]=Heart rate may not be usable due to highly variable chronotropic response; [c]=Heart rate may not be usable due to denervation-related blunted chronotropic response. (Copyright 2012 by the European Society of Cardiology. Reprinted by permission of SAGE Publications, Ltd. www.sagepub.co.uk. (20)).

	EXERCISE INTENSITY DOMAINS			
	LIGHT TO MODERATE	MODERATE TO HIGH	HIGH TO VIGOROUS	VIGOROUS TO EXTREME
Stable angina pectoris	Y[a]	Y[a]	Y[a]	N
Chronic CAD (no residual ischaemia)	Y	Y	Y	Y
PCI	Y	Y	Y	N
Pacemaker	Y	Y	N	N
ICD	Y	Y	N	N
Chronic AF	Y[b]	Y[b]	N	N
CABG	Y	Y	Y	N
Valve repair/replacement	Y	Y	N	N
CHF	Y	Y	Y	N
LVAD	Y	N	N	N
Heart transplantation	Y[c]	Y[c]	Y[c]	N

defined scientifically and ET remains the mainstay. Clinicians should keep in mind "that it is the least active individuals who stand to benefit the most from even the smallest increments in exercise and physical activity – some is better than none" (33). Let´s get moving!

Conflict of Interest

The author has no conflict of interest.

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