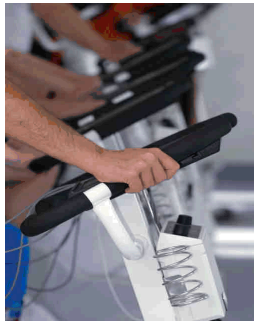
Implementation of exercise training into cardiac rehabilitation program according to the guideline based on the results of the assessments - **endurance training** - theoretical basic knowledge

基于评估结果指导方针，运动训练在康复中的应用—**耐力**—基础理论知识




Prof. Dr. Birna Bjarnason-Wehrens

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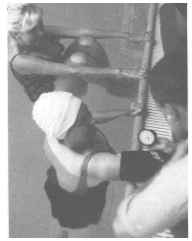
Exercise therapy is an essential part of the cardiac rehabilitation program and consumes 30-50% of the time spent on therapeutic measures.

运动疗法是心脏康复计划的重要组成部分，占总的治疗措施中时间的30 - 50%。










Phase II
第二阶段

Intensive after care
加强的出院后护理

Phase III
第三阶段

Prof. Dr. Birna Bjarnason-Wehrens, Institute for Cardiology and Sports Medicine, German Sport University Cologne

Exercise therapie in cardiac rehabilitation guidelines
心脏康复指南中的运动疗法

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…

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…

Objectives of exercise based training interventions in cardiac rehabilitation
心脏康复中基于运动训练的治疗目标

Primary objective
主要目标

- to positively influence disease progression and prognosis
- 积极影响疾病进展和预后

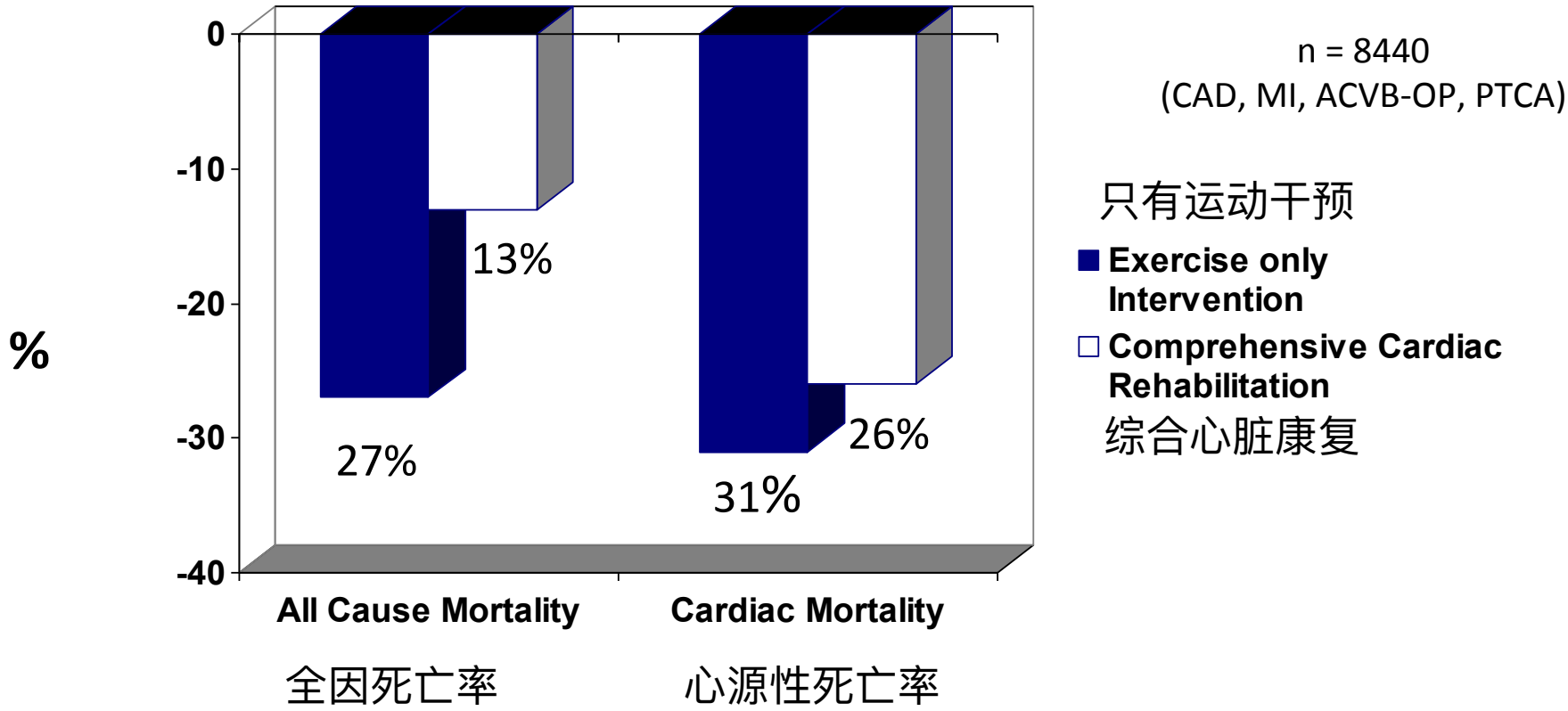
Main secondary objectives
主要次级目标

- improvement in the symptom-free exercise tolerance
- 改善无症状状态下的运动耐力
- improvement in overall quality of life
- 改善生活总体质量

Effectiveness of exercise only or exercise as part of a comprehensive cardiac rehabilitation programme on all cause mortality and cardiac mortality

只做运动或心脏康复综合计划中的运动训练对全因死亡率和心源性死亡率的效用

(Joliffe et al. Cochrane database Syst Rev Update 2001; CD001800)



Meta-Analysis: Secondary Prevention Programs for Patients with Coronary Artery Disease
荟萃分析:冠心病患者的二级预防方案
Clark et al. Ann Intern Med. 2005;143:659-672.

aim: evaluation of the efficacy of cardiac rehabilitation programs with and without exercise training
目的:对有无运动训练的心脏康复项目的疗效进行评价

Meta analysis including the results of 63 RCS (n=21.295 CHD-patient).
包含63组回顾性群组研究结果的荟萃分析（n=21.295 冠心病患者）

Programmes 项目	all cause mortality 全因死亡率	Re-infract 再梗塞
Educative elements without exercise training 教育成份，没有运动训练	- 13%	- 14%
Educative elements combined with exercise training 教育成份与运动训练结合	- 12%	**- 38%**
Exercise training without educative elements 运动训练，没有教育成份	**- 28%**	**- 43%**

Exercise-Based Cardiac Rehabilitation for Coronary Heart Disease
Cochrane Systematic Review and Meta-Analysis
冠心病运动心脏康复循证医学系统回顾和荟萃分析
Anderson et al. J Am Coll Cardiol 2016;67:1–12

Aim: The goal of this study is to update the Cochrane systematic review and meta-analysis of exercise-based CR for CHD.

目的：本研究的目标，是更新冠心病运动心脏康复的循证医学系统回顾和荟萃分析

A total of 63 studies with 14,486 participants with median follow-up of 12 months were included.

共对14486名参与者进行了63项研究，平均随访时间为12个月。

12 months (median) follow-up	overall mortality	**cardiovascular mortality**	**hospital admissions**
	RR: 0.96 (0.88 to 1.04)	**RR 0.74** (0.64 to 0.86)	**RR : 0.82** (0.70 to 0.96)
12个月（平均）随访	总死亡率	**心血管病死亡率**	**入院率**
	相对危险度：0.96	**相对危险度：0.74**	**相对危险度：0.82**

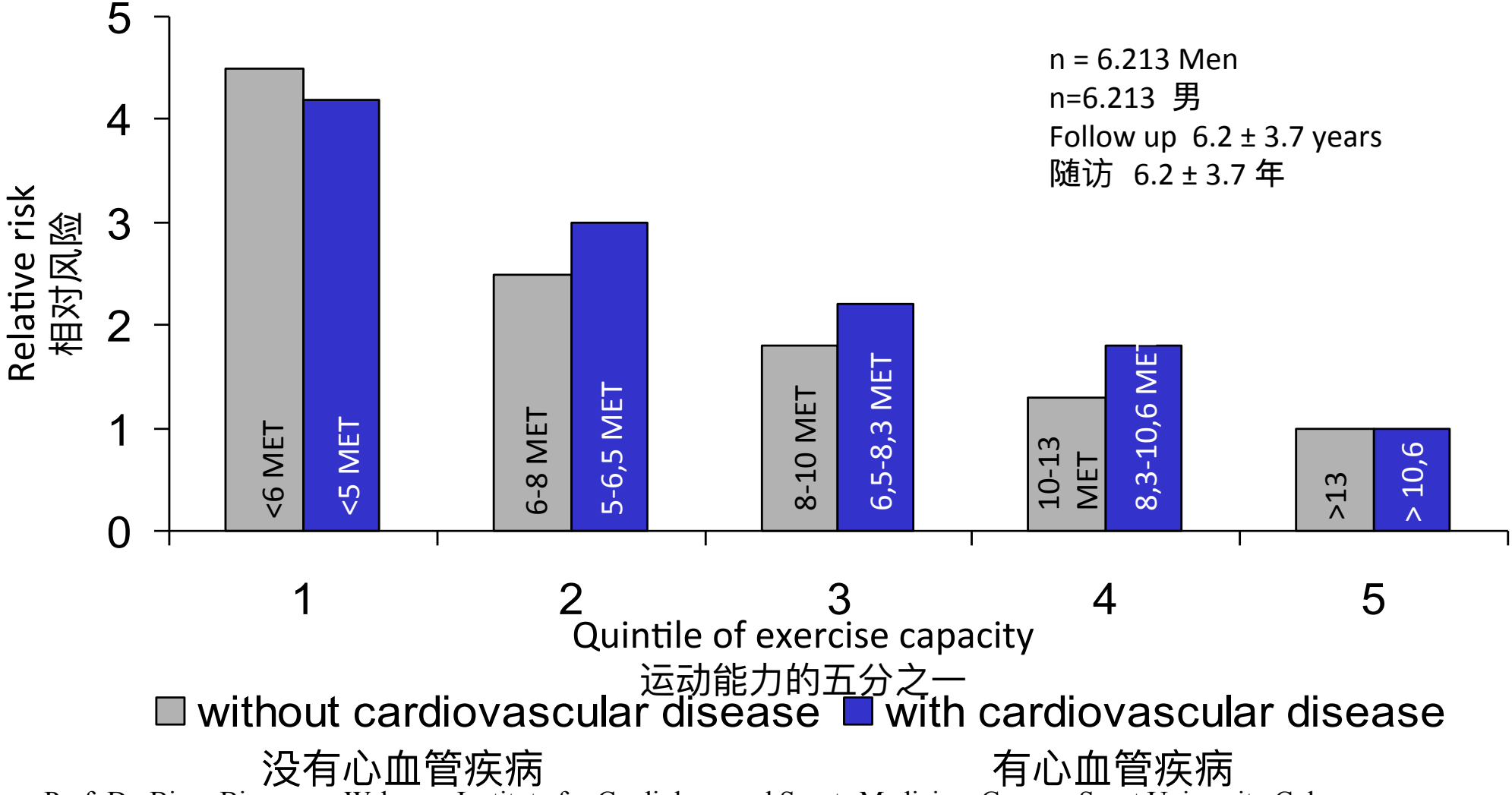
The majority of studies (14 of 20) showed higher levels of health related quality of life in 1 or more domains following exercise-based CR compared with control subjects

大多数的研究(20个中的14个)中，与对照受试者相比，在运动心脏康复后，1个或多个域的健康生活质量更高

The **relative risk of death from any cause** according to quintile of exercise capacity among subjects with and without cardiovascular disease

根据受试者（无论有无心血管疾病）运动能力的五分之一，得出的其任意原因死亡风险

(Myers et al. N Engl J Med 2002;346:793-801)



Peak aerobic capacity predicts prognosis in patients with coronary heart disease
有氧能力峰值可预知冠心病患者的预后
Keteyian et al Am Heart J 2008;156, 292-300

VO_2 peak is a strong predictor of all-cause death,
every 1 mL/ kg^{-1}/ min^{-1} increase in peak VO_2 associated with 15% decrease in risk of death - determined in a cohort of 2.812 patients with CHD
耗氧量峰值是全因死亡的一个很好的预报器，耗氧量每1 mL / kg^{-1} / min^{-1}的增加，都意味着15%的死亡风险降低，这在一个有2812名冠心病患者参与的队列研究中得到确认。

Men: every 1 mL/ kg^{-1}/ min^{-1} increase in peak VO_2 associated with an approximate 17% decrease in risk for all-cause death and a 16% decrease in risk for or cardiovascular disease–specific death.
男性：耗氧量峰值每1 mL/ kg^{-1}/ min^{-1} 的增高，都意味着17%的全因死亡风险减少和16%的心血管疾病死亡风险降低。

Women: every 1 mL/ kg^{-1}/ min^{-1} increase in peak VO2 associated with an ~14% decrease in risk for all-cause and cardiovascular-specific death
女性：耗氧量峰值每1 mL/ kg-1/ min-1的增高，都意味着14%的全因死亡率和心血管疾病死亡风险降低。

Cardiovascular Fitness and Mortality After Contemporary Cardiac Rehabilitation

现代心脏康复后的心血管健康和死亡率

Martin BJ et al. Mayo Clin Proc. 2013;88(5):455-463

Aim: to assess the association between cardiorespiratory fitness and outcomes in a CR cohort.

目标：评估心肺健康和一个心脏康复队列研究结果的联系

A retrospective study of 5641 patients (4282 men, 1359 women; 60.0 ± 10.3 years) with coronary artery disease who participated in CR between July 1, 1996, and February 28, 2009.

对在1996年7月1日和2009年2月28日之间参加过心脏康复的5641例冠心病患者的回顾性研究(4282名男性，1359名女性);60.0±10.3岁)。

Based on peak metabolic equivalents (METs), patients were classified as low fitness (LFit) (<5 METs), moderate fitness (5-8 METs), or high fitness (>8 METs).

根据峰值代谢当量(METs)，患者被归类为低度健康(LFit)(< 5 METs)，中度健康(5 - 8 METs)，或高度健康(> 8 METs)。

Follow up time was ≥ one year up to 15 year

随访时间是1年以上到15年

Cardiovascular Fitness and Mortality After Contemporary Cardiac Rehabilitation

现代心脏康复后的心血管健康和死亡率

Martin BJ et al. Mayo Clin Proc. 2013;88(5):455-463

Baseline fitness predicted long-term mortality:
基线健康预测长期死亡率：
relative to the LFit group;
与低度健康组相关；
moderate fitness hazard ratio of **0.54** (95% CI, 0.42-0.69),
中度健康危险比率为**0.54**（95%心脏指数，0.42-0.69）
high fitness a hazard ratio of **0.32** (95% CI, 0.24-0.44).
高度健康危险比率为**0.32**（95%心脏指数，0.24-0.44）
Improvement in CRF at 12 weeks associated with decreased overall mortality,
12周时病例报告表改善，并与整体死亡率降低有关
13% reduction with each MET increase (P<.001)
代谢当量每增长1点，就会有**13%的下降**
30% reduction in those who started with LFit.
从低度健康开始的那些人，有**30%**的下降

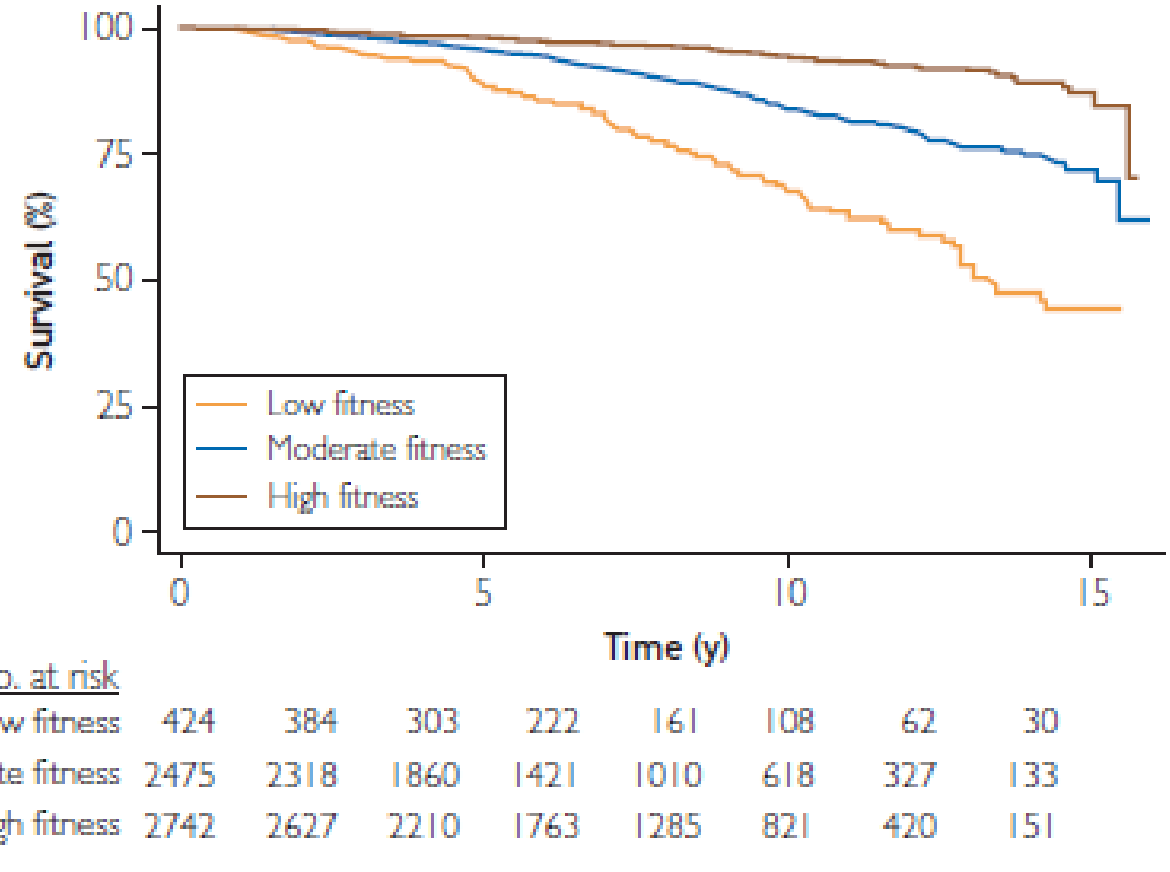


FIGURE. Kaplan-Meier survival by baseline fitness.

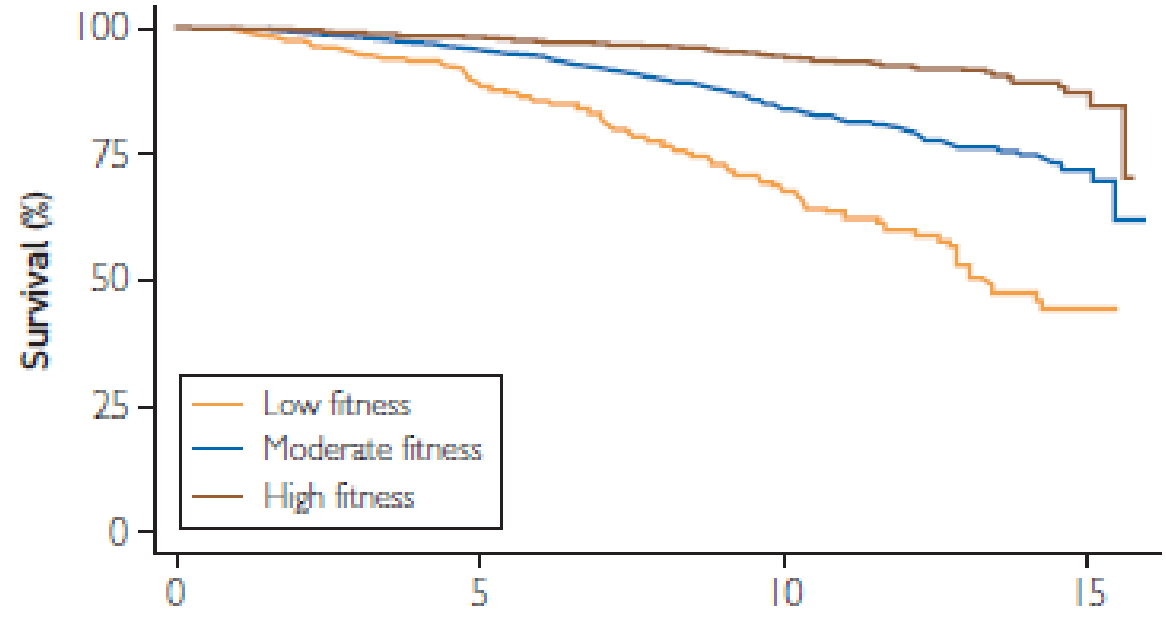
Cardiovascular Fitness and Mortality After Contemporary Cardiac Rehabilitation

现代心脏康复后的心血管健康和死亡率

Martin BJ et al. Mayo Clin Proc. 2013;88(5):455-463

At 1 year, each MET increase in CRF was associated with a 25% reduction in overall mortality in the whole group (p<0.001).

满1年时，病例报告表代谢当量的每一点增长都与全组总体死亡率25%的下降相关



No. at risk								
Low fitness	424	384	303	222	161	108	62	30
Moderate fitness	2475	2318	1860	1421	1010	618	327	133
High fitness	2742	2627	2210	1763	1285	821	420	151

FIGURE. Kaplan-Meier survival by baseline fitness.

Objectives of exercise based training interventions in cardiac rehabilitation
心脏康复中运动训练干预的目标

Secondary objectives
次要目标

- overcoming cardiovascular and musculoskeletal limitations caused by inactivity
- 克服由不运动导致的心血管和肌肉骨骼状态受限问题

- **to improve**
- **来改善**
  - ✓mobility
  - ✓活动性
  - ✓independence
  - ✓ 独立性
  - ✓psychological well-being
  - ✓心理健康
  - ✓social and occupational re-integration
  - ✓社会和职业方面的再度融入
  - ✓cardiovascular risk factors
  - ✓心血管风险因素

- **to reduce the need for future home-care**
- **减少患者未来对家庭护理的需要**

Objectives of exercise based training in cardiac rehabilitation
心脏康复中运动训练的目标

These goals will only be achieved if we manage to motivate the patient to change his attitude and take up a regular physical activity and exercise training, optimally to continue this for the rest of his life.

只有当我们设法激励患者改变他的态度，并进行常规的体育活动和运动训练时，这些目标才会实现；最好的情况，是使患者在余生中继续保持这种状态

A reverse J-shaped association of leisure time physical activity with prognosis in patients with stable coronary heart disease:
evidence from a large cohort with repeated measurements
休闲体育活动和稳定性冠心病患者预后的 倒J形联系：一个大型队列研究中的证据，并有重复测量
Mons U, et al. Heart 2014;0:1–7. doi:10.1136/heartjnl-2013-305242

prospective cohort study; n= 1038 stable CHD Patients; Mean follow-up time was 8.1 ± 3.1 years: frequency of strenuous leisure time physical activity was assessed
前瞻性队列研究;n = 1038 稳定性冠心病患者;平均随访时间为8.1±3.1年:大运动量的休闲体育活动频率被评估

highest hazards were consistently found in the least active patient group, with a roughly **twofold risk** for **major cardiovascular events** and a roughly **fourfold** risk for both **cardiovascular and all-cause mortality** in comparison to the reference group of moderately frequent active patients.
最不活跃的病人群体的危险程度最高，与中度频繁的活跃患者的参照组相比，其主要心血管疾病的患病风险大约有两倍，心血管疾病死亡和全因性死亡的风险大约是四倍。

Table 2 Event numbers, person-years and crude event rates per 1000 person-years by frequency of strenuous physical activity at baseline

	Events	Person-years	Incidence/mortality rate (95% CI) per 1000 person-years
Major cardiovascular events			
Daily	24	1287.3	18.6 (12.5 to 27.8)
5–6×/week	29	1395.5	20.8 (14.4 to 29.9)
2–4×/week	61	3538.2	17.2 (13.4 to 22.2)
1–4×/month	39	1496.0	26.1 (19.1 to 35.7)
Rarely/never	29	624.5	46.4 (32.3 to 66.8)
Non-fatal cardiovascular events			
Daily	11	1211.7	9.1 (5.0 to 16.4)
5–6×/week	24	1351.3	17.8 (11.9 to 26.5)
2–4×/week	42	3382.6	12.4 (9.2 to 16.8)
1–4×/month	26	1372.1	19.0 (12.9 to 27.8)
Rarely/never	9	476.0	18.9 (9.8 to 36.3)
Cardiovascular mortality			
Daily	14	1481.9	9.5 (5.6 to 16.0)
5–6×/week	10	1617.9	6.2 (3.3 to 11.5)
2–4×/week	19	4188.1	4.5 (2.9 to 7.1)
1–4×/month	15	1849.8	8.1 (4.9 to 13.5)
Rarely/never	23	789.8	29.1 (19.4 to 43.8)
All-cause mortality			
Daily	24	1481.9	16.2 (10.9 to 24.2)
5–6×/week	14	1617.9	8.7 (5.1 to 14.6)
2–4×/week	32	4188.1	7.6 (5.4 to 10.8)
1–4×/month	26	1849.8	14.1 (9.6 to 20.6)
Rarely/never	35	789.8	44.3 (31.8 to 61.7)

Exercise training should be planned in three stages …
运动训练应被规划为三个阶段

The initial stage 初始阶段

4-6 exercise units during 1-2 weeks 一周到两周中训练4-6次

Exercise duration: short (i.e. 15-30 min) 训练时常：短

Exercise intensity: low 训练强度：低

- Preparation, 准备
- Adaptation, 适应
- Verifying the individual response and tolerability 检验患者的个体反应与适应能力

The improvement stage 强化阶段

Exercise duration: gradually prolonged up to ≥ 30-60 min 训练时常：逐渐延长到大30分钟到60分钟

Exercise intensity: gradually increased up to target values 训练强度：逐步增加到目标值训练强度

- Increase exercise capacity and physical fitness 提高运动能力和体能
- Improve muscular strength and endurance 改善肌力和耐力
- Improve flexibility and coordination 改善柔韧和协调

The maintenance stage 稳健维持阶段

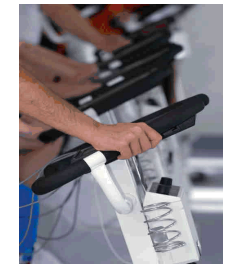
Gradually increase exercise intensity and/ or exercise time if tolerated 如果耐受逐步增加训练强度和/或训练时常

-Long term stabilisation of improvements achieved 达到长期稳定状态的目标

-Stabilize adherence to regular physical activity and exercise training 坚持履行形成的运动训练习惯，使其稳定化

Components of exercise based training interventions
训练干预中的内容

Aerobic endurance training
有氧耐力训练



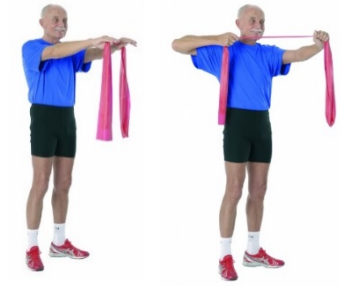
Perception training, body awareness, practical skills of self-control
感知训练、身体意识、自控实际技能

Exercise to improve flexibility, agility coordination, balance, ...

Modified movement games and team games ...

改善灵活性、敏捷性、协调性、平衡性...的运动
修改过的活动游戏和团体游戏

Resistance training
抗阻训练



Implementation of exercise Training in cardiac rehabilitation
运动训练在心脏康复中的应用

Careful clinical evaluation including: risk stratification, symptom limited exercise testing

细致的临床评估，包括：风险分级、症状限制性运动测试

Individual objectives of the exercise program

运动项目的个人目标

Individual exercise prescription and training protocol

个人运动处方和训练方案

Individually dosed and adapted exercise training

基于个人设定剂量的适应性运动训练

Control of efficacy

Modification and adaptation of the exercise prescription and training protocol referring to the patients objective medical and subjective health status

对疗效的控制 参考患者的客观医学情况和主观健康情况调整其运动处方和训练方案

How to set up an exercise program in cardiac rehabilitation

在心脏康复中如何设定运动方案

⇒ Exercise training should be prescribed on an individualized approach after a careful clinical evaluation including

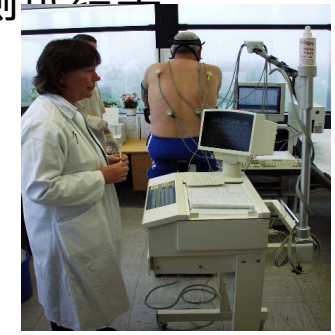
⇒ 应在经过仔细的临床评估后，制定个性化的运动训练，包括：
- risk stratification,

⇒ 风险分级
- symptom limited exercise testing

⇒ 症状限制性运动测试

⇒ Only based on careful clinical evaluation that risk stratification and symptom limited exercise testing exercise training (i.e. aerobic endurance training) can be performed in safe and effective manner.

⇒ 只有在基于细致的临床评估的前提下，并考虑到风险分级和症状限制性运动测试结果后制定训练（比如有氧耐力训练），才能以安全有效的方式进行。



Implementation of exercise Training in cardiac rehabilitation
心脏康复中运动训练的应用

Individual exercise prescription and training protocol
个性化运动处方和训练方案

Based on the results of the clinical evaluation every person should receive individualized exercise training recommendations:
根据临床评估的结果，患者应得到个性化运动训练建议：

- training goals (i.e. improve exercise capacity, muscular strength)
  训练目标（比如提高运动能力和肌力）
- training mode (i.e. aerobic endurance training, moderate resistance training …)
  训练模式（比如有氧耐力训练，中等抗阻训练…）
- training content (i.e. cycle ergometer, treadmill, nordic walking, resistance training using weight machines and elastic bands, …)
  训练内容（比如蹬功率车、跑台、越野行走、使用负重设备和弹力带的抗阻训练 …）
- training method (i.e. steady-state-training , interval training …)
  训练方法 （比如 稳定状态训练，间歇性训练）
- training intensity (i.e. % HRmax , % VO2peak, % 1RM …)
  训练强度（ 比如 最大心率百分比，耗氧量峰值百分比，一次最大肌力百分比
- training duration (individual training unit (i.e. 30-60 min) and supervised training program (i.e. 3-6 months)
  训练时常（单次个体化训练（30-60分钟）并且此阶段是在监护下的训练项目（例如持续3-6个月）
- training frequency (i.e. 3-7 exercise units per week)-
  训练频率（ 比如 每周训练3-7次）

Exercise testing on cycle ergometer – variable obtained and documented
功率车运动测试-多样化取值/监护并记录

- ⇨ maximal workload achieved variable obtained „maximal exercise capacity“ 最大负荷获得多重数据，最大运动耐受力，
- ⇨ heart rate **and 心率和**
- ⇨ ECG are monitored throughout the exercise test 心电图在整个运动测试中都被监控
  - ⇨ heart rate max (HRmax) 最大心率
  - ⇨ signs of ischemia 心肌缺血迹象
  - ⇨ Arrhythmia 心率不齐
  - ⇨ …

At rest and in the last minute of every stage 休息和每一阶段的最后一分钟

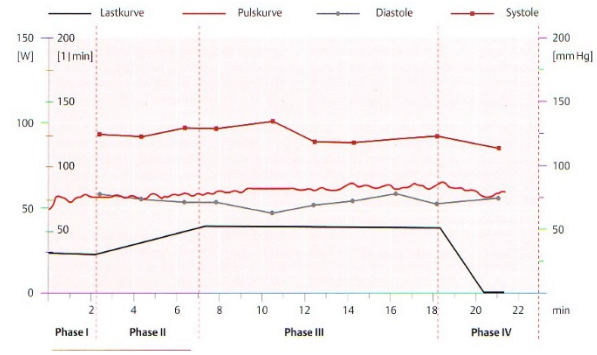
- ⇨ blood pressure 血压
- ⇨ Borg scale for rating perceived exertion 主观疲劳感伯格量表
- ⇨ symptoms (chest pain dyspnea, dizziness, discomfort …) 症状（胸痛，呼吸困难，眩晕，不适。。。）
- ⇨ Exhaustion 筋疲力尽
- ⇨ …

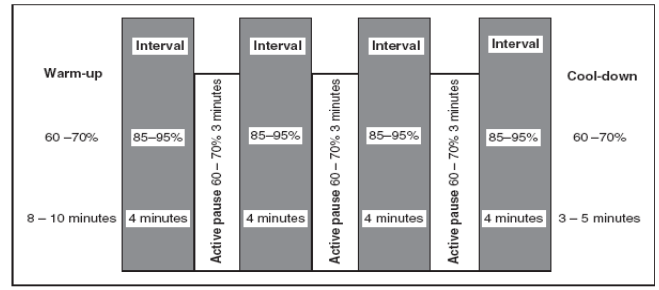
Implementation of aerobic exercise training in cardiac rehabilitation

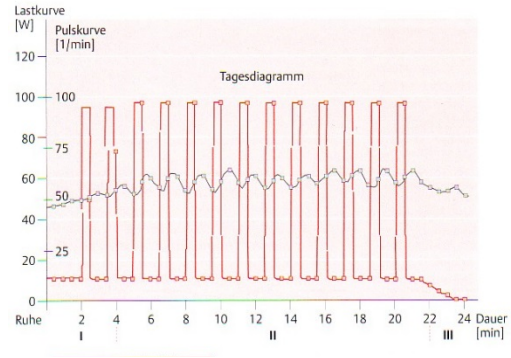
mode of exercise training

心脏康复模式中有氧训练的实施应用

- ✓ continuous aerobic endurance exercise training is the **standard method**
- ✓ 持续性有氧耐力训练是**标准方法**
- ✓ Aerobic interval training
- ✓ 有氧间歇性训练
  - ✓ High intensity interval training
  - ✓ 高强度间歇性训练
  - ✓ Sprint or short (term) interval training
  - ✓ 间歇性冲刺训练或短期间歇性训练







Continuous aerobic endurance exercise training
- exercise prescription -
持续性有氧耐力运动训练
-运动处方-

Intensity
强度

⇨% of maximal heart rate (HRpeak)

⇨最大心率百分比
- 65-75% Hrpeak （心率峰值） ➡ *75-85%*

⇨% of heart rate reserve (HRR)

⇨心率储备百分比
- 40-60% of HRR （心率储备） ➡ *60-70%*

⇨exercise workload based on % of maximal workload achieved

⇨基于达到的最大运动负荷设定的训练量
- 40-60% wattmax（瓦特峰值） ➡ *60-80%*

⇨Borg scale for rating perceived exertion

⇨Borg量表得出的主观疲劳感评定
- 12-14 RPE （主观疲劳感评定） ➡ *> 15*

⇨% VO2peak *if available*

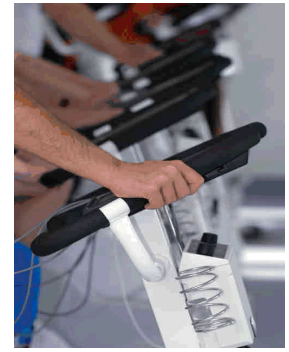
⇨最大耗氧量峰值（如有）
40-80% VO2peak（最大耗氧量峰值）

Duration
时长

> 5 up to ≥ 60 minutes
从多于5分钟到60分钟以上

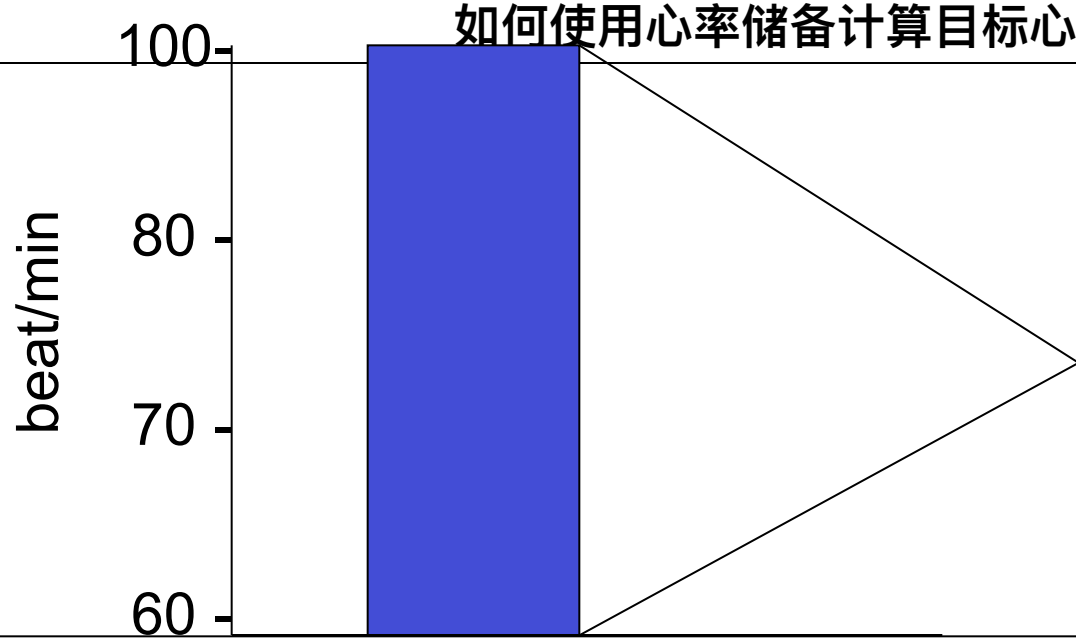
Frequency
频率

3-5 (7) days a week /
most days the week
1周3-5（7）天/1周7天的多数



How to calculate target heart rate using heart rate reserve (Karvonen formula)

如何使用心率储备计算目标心率（卡式公式）



The heart rate reserve (HRR) is the difference between maximal heart rate and resting heart rate, as determined in maximal exercise stress test.

心率储备(HRR)是最大心率和静息心率之间的差异，在最大运动负荷测试中确定。

Example calculation – target intensity 60% of heart rate reserve

实例计算-目标强度60%的心率储备

Resting heart rate = 60 beats/min

静息心率 = 60 次/每分钟

Maximal heart rate in exercise test = 100 beats/min

运动测试中的最大心率 = 100 次/分钟

Target heart rate for exercise training = 60 + (100-60) x 0,6 = 84 beats/min.

运动训练的目标心率 = 84 次/分钟

Aerobic endurance exercise training
- exercise prescription -
有氧耐力运动训练
-运动处方-

Advantage of % of heart rate reserve i.e. in patients with
心率储备比率对以下疾病患者有利
⇨Chrono tropic incompetence,
⇨心率变时性功能不全
⇨Beta blocker therapy
⇨β-受体阻滞剂治疗

Advantage of % of maximal workload achieved i.e. in patients with
最大强度运动负荷比率对以下患者有利
⇨atrial fibrillation
⇨心房纤微性颤动
⇨heart transplant recipient
⇨心脏移植受体
In these patients
对于这些患者
⇨Borg scale for rating perceived exertion and
⇨"Breathing rule" breathing rate should allow speaking
⇨Borg量表评定的主观体力感觉评定和"呼吸规则"呼吸率应该准许讲话

If HR is used for exercise prescription and control
如果心率用于运动处方和控制

⇨medical therapy have to be taken into account (i.e. beta blocker therapy)
⇨必须考虑医学治疗（比如β-受体阻滞剂治疗）

⇨exercise intensity must be defined in as intensity that was achieved in stress test without pathological symptoms
⇨运动强度必须定义为在没有病理症状的负荷测试中所达到的强度

⇨exercise heart rate have to be defined clearly below ischemic threshold (at least 10 beats/ min)
⇨运动心率必须明确定义在缺血阈值以下(至少低于阈值10次/分钟)

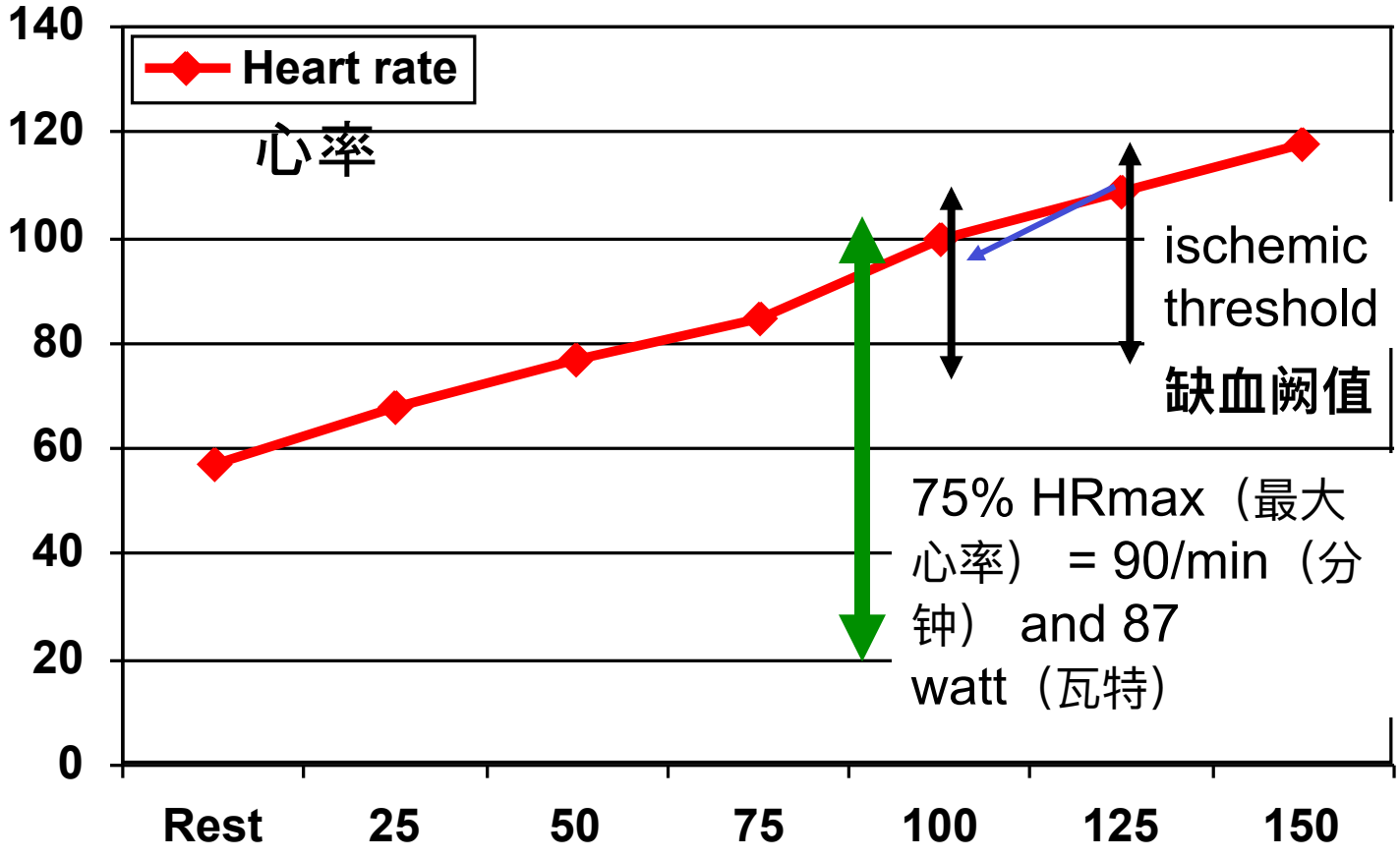
Prof. Dr. Birna Bjarnason-Wehrens Institute for Cardiology and Sports Medicine, German Sport University, Cologne

Patient: 52 years old man post Acute Coronary Syndrome and PCI

患者：52岁男性，急性冠状动脉综合症，经皮冠状动脉介入治疗后

Medication: ß-receptor-blocker, statins and ASS

药物： β-受体阻滞剂、他汀类药物、ASS



Maximal heart rate 118 beats/min

最大心率 118次/分钟

Heart rate at ischemic threshold 109 beats /min

缺血阈值心率：109次/分钟

Exercise heart rate clearly below the ischemic threshold (at least 10 beats/min) maximal at 99 beats/min

运动心率明显低于缺血阈值(至少10下/分钟)时的最大心率为99次/分钟

Target heart rate 75% of maximal heart rate at 90 beats/min

目标心率为最大心率（每分钟90下）的75%

✓To improve practical skills of self-control and adequate handling during physical activity and/or exercise training to the patient 在体育锻炼和/或运动训练中提高自我控制能力和充足的处理能力

TheBorg Scale 量表
(Rate of Perceived Exertion, RPE) 主观疲劳感

20	
19	**extremely hard 及其困难**
18	
17	**very hard 非常困难**
16	
15	**hard / heavy 困难**
14	
13	**somewhat hard 有点难**
12	
11	**light 轻松**
10	
9	**very light 很轻松**
8	
7	**extremely light 特别轻松**
6	

The *Borg scale* (rate of perceived exertion (RPE)) is used to subjectively assess how the individual perceives the intensity of the performed exercise on a scale from6 to 20 points

Borg量表(主观疲劳感评定(RPE))用于主观评估个体如何感知自己所从事运动的强度，范围是6到20分。

It can be used as a supplement to other training regulation options, as well as to facilitate developing body awareness to the exercise load.

它可以作为其他训练调节选项的补充，也可以促进身体对运动负荷认识的发展。

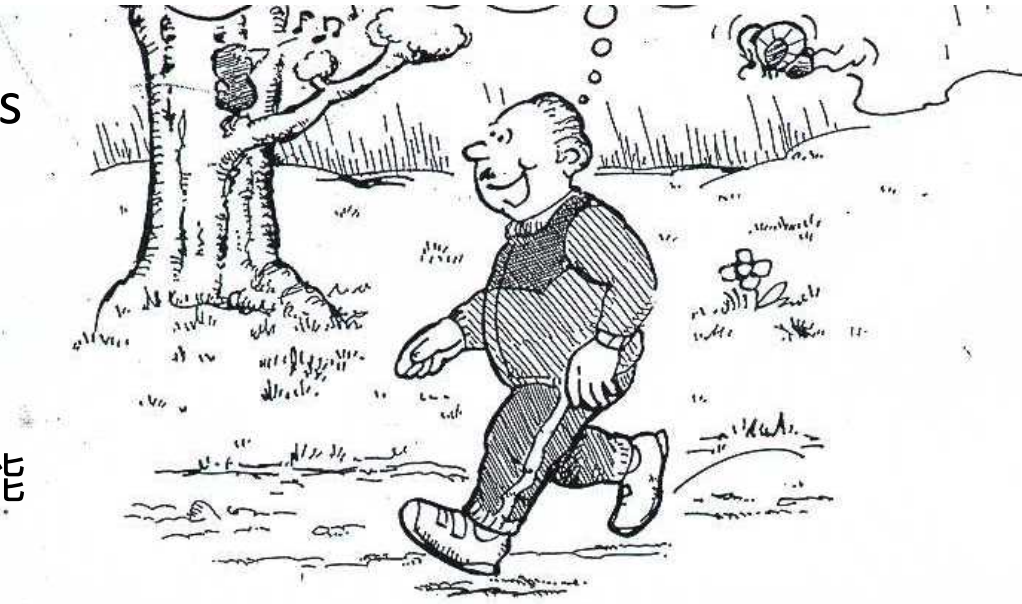
Target values are RPE 11–14, comparable to light to moderate exercise intensity .

目标值为RPE 11 - 14，相当于轻度到中度的运动强度。

„ The ‘breathing rule’,“
“呼吸规则”

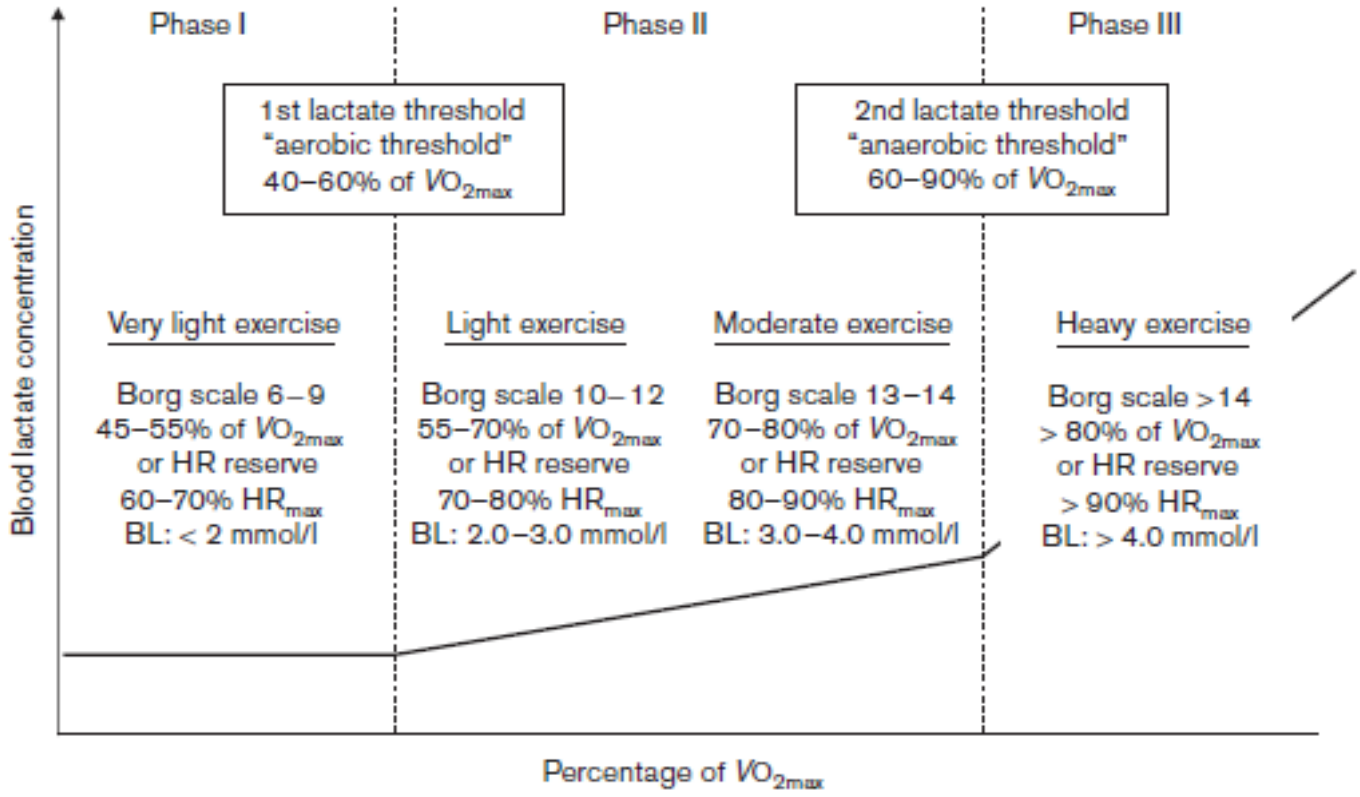
The ‘breathing rule’,
an activity which can be carried out as long as breathing still permits comfortable speech, may also be helpful

“呼吸规则”，一项只要呼吸仍然允许个体能舒适地讲话，就可以进行的活动，也可能是有帮助的



Methodological approach to the first and second lactate threshold
in incremental cardiopulmonary exercise testing
递增心肺运动测试中第一个和第二个乳酸阈值的方法论
Binder et al. European Journal of Cardiovascular Prevention and Rehabilitation 2008, 15:726–734
Binder 等.《欧洲心血管疾病预防和康复杂志》， 2008, 15:726–734

Fig. 1



The three-phase model according to Skinner *et al.* [9]: relation between blood lactate concentration (BL) and exercise intensity. HR, heart rate; V_{O_2}, oxygen consumption; Borg scale: subjective rating of perceived exertion.

Importance of characteristics and modalities of physical activity and exercise in the management of cardiovascular health in individuals with cardiovascular disease (Part III) **在心血管疾病患者的心血管健康管理中，体育活动和运动特点及其方式的重要性 (第三部分)**
Vanhees et al. European Journal of Preventive Cardiology, 2012 19; :1333-1356

Table 1: Implementation of aerobic endurance exercise training in patients with cardiovascular disease有氧耐力训练在心血管疾病患者身上的实施应用

Stages阶段	Intensity强度	Duration时常	Frequency频率
initial stage 初始阶段	low intensity i.e. 低强度 → 40-50% $VO_{2peak,}$ 最大摄氧量 → **60% Hr_{max}** 最大心率 → **40% HRR 心率储备** → **RPE < 11 主管疲劳感评分小于11**	starting with 5 minutes (in the exercise phase) and progress up to 10 minutes 从5分钟开始(在运动阶段)，并逐渐延长至10分钟	Minimum: 3-5 days per week Target: Daily 至少: 每周3-5天 目标: 每天
improvement stage 强化阶段	gradually increase the exercise intensity from low to moderate up to target values, depending on exercise tolerance and clinical status 保持改善阶段达到的运动强度和运动持续时间的长期稳定，并逐渐分别增加运动持续时间和频率，之后是运动强度。 → 50, 60, 70, (80%) VO_{2peak} → **65, 70, 75 HR_{max}** → **45, 50, 55, 60% HRR 心率储备** →RPE 12-14**主管疲劳感评分12-14**	gradually prolong the exercise training from 10 to 20 (up to 30-45) minutes 逐渐将运动时间从10分钟延长至20（直至30-45）分钟	Minimum: 3 – 5 days per week Target: ≥ 5 days a week 至少: 每周3-5天 目标: 每周多于5天
maintaining stage 稳健维持阶段	Long-term stabilisation of the exercise intensity and exercise duration achieved during the improvement stage, respectively gradually increase exercise duration and frequency and thereafter intensity. 保持改善阶段达到的运动强度和运动持续时间的长期稳定，并逐渐分别增加运动持续时间和频率，之后是运动强度。	gradually prolong the exercise training from 20-45 (up to > 60) minutes, if tolerated 如果可以耐受，逐渐将运动时间从20分钟延长至45（直至60分钟以上）分钟。	Target: most days a week 目标：1周的多半天数

HR = heart rate; HRR = heart rate reserve; RPE = rate of perceived exertion

Changes in cardiorespiratory fitness in cardiac rehabilitation patients: A meta-analysis
心脏康复患者心肺适能的改变:荟萃分析
Sandercock, et al.

Meta analysis: 31 studies, 48 exercise groups (n=3827)

荟萃分析：31项研究，48个运动组（n=3827）

Results:

结果：

Exercise capacity improved by 1.55 METs (95% CI 1.21–1.89), (p<0.001)

运动能力有1.55个代谢当量的改善(95% 心脏指数 1.21–1.89), (p<0.001)

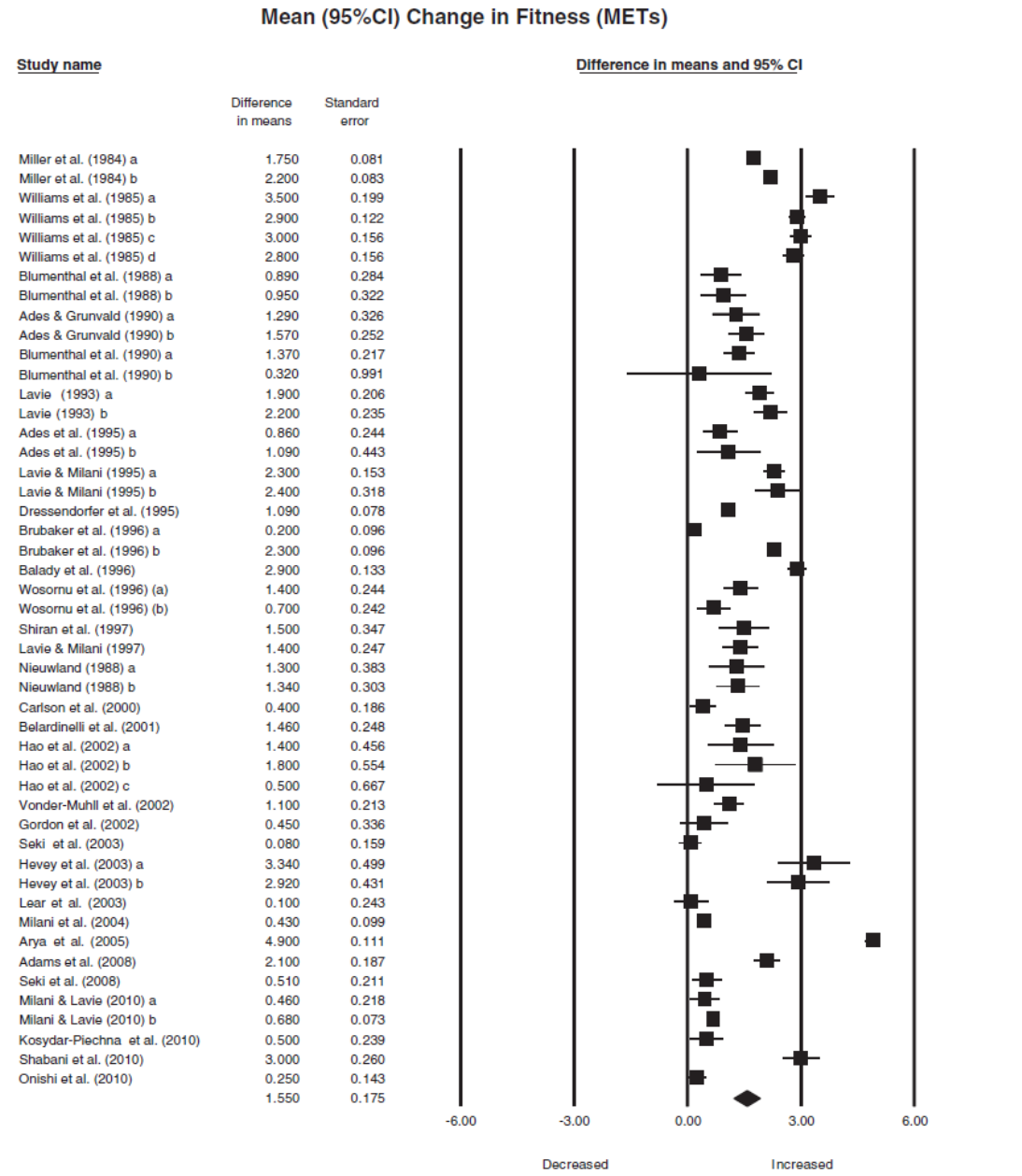


Fig. 1. Forest plot for mean point estimate of change in fitness due to cardiac rehabilitation. Legend: Points are mean point estimate (squares) with upper and lower 95% confidence intervals for the difference between pre- and post-cardiac rehabilitation measures of cardiorespiratory fitness (in metabolic equivalents). The overall mean point estimate (±95% CI) is based on a random effects model. Miller et al. [27]; Williams et al. [31]; Adams et al. [32]; Ades et al. [33]; Ades and Grunvald [34]; Arya et al. [30]; Balady et al. [16]; Blumenthal et al. [35,36]; Brubaker et al. [29]; Carlson et al. [37]; Dressendorfer et al. [38]; Gordon et al. [39]; Hao et al. [40]; Hevey et al. [41]; Kosydar-Piechna et al. [42]; Lavie [43]; Lavie and Milani [44]; Milani et al. [45]; Milani and Lavie [46]; Lear et al. [47]; Wosornu et al. [48]; Shiran et al. [49]; Nieuwland et al. [50]; Ayra et al. [30]; Adams et al. [32]; Seki et al. [51]; Seki et al. [52]; Milani and Lavie [45]; Shabani et al. [53]; Onishi et al. [54].

Minimum amount of physical activity for reduced mortality and extended life expectancy:
a prospective cohort study.
减少死亡率和延长预期寿命的最低运动量:一个前瞻性队列研究。
Wen et al. Lancet 2011; 378: 1244–53

Higher activity levels associated with higher relative risk reduction
较高的活动水平与较高的相对风险降低有关

Vigorous activity leads to greater risk reduction than moderate or low intensity activity
剧烈运动比中度或低强度运动能降低更多风险

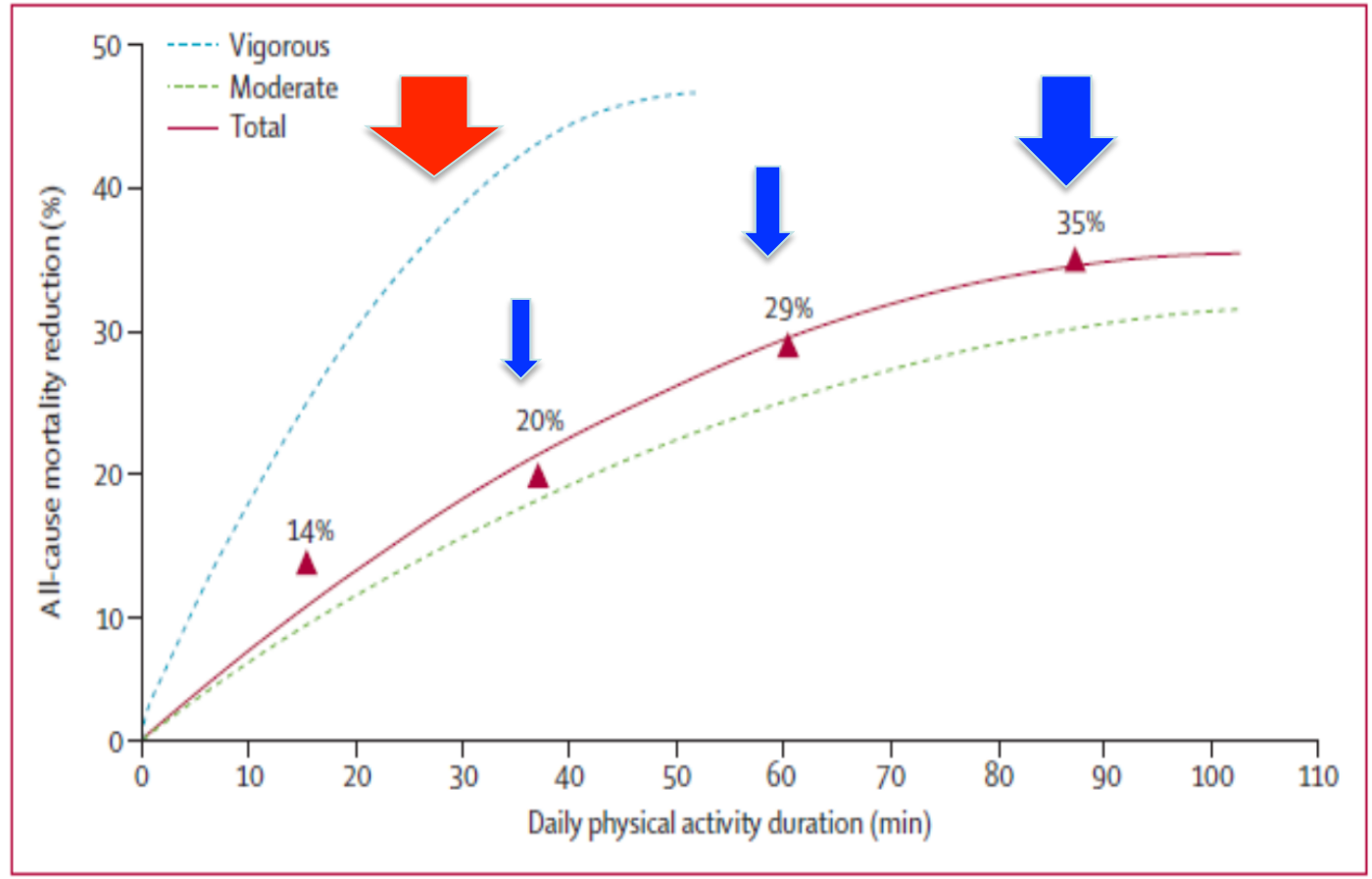


Figure 2: **Daily physical activity duration and all-cause mortality reduction**

In primary prevention it is well known that higher exercise volume aerobic exercise training is more effective to improve exercise capacity and to reduce overall mortality. On the other hand by increasing the intensity similar effects can be achieved by shorter exercise boots.
众所周知，在初级预防中，高运动量的有氧运动训练对提高运动能力和降低整体死亡率更有效。
另一方面，通过增加强度，时程更短的运动也能实现相似效果

Interval training
间歇性训练

An Interval training mode is characterized by a alternately short bouts of high intensity and phase of recovery.

间歇性训练模式的特点是交替性的短暂高强度训练和恢复阶段。

Thus an interval training mode would allow to exercise with at least short high-intensity alternating to bouts of low or moderate intensity.

因此，间歇性训练模式将至少允许短暂的高强度训练和低中等强度训练的交替进行。

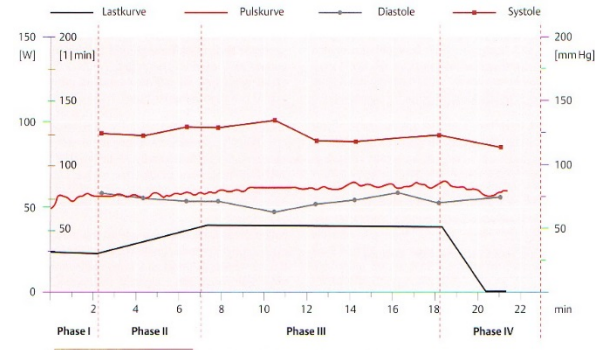
In cardiac rehabilitation mainly two types of interval trainings protocols have been in focus of science and implementation:

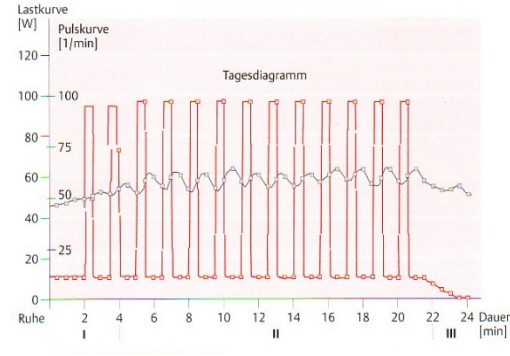
在心脏康复中，主要有两种类型的间歇训练方案是科学上和具体实施的重点:

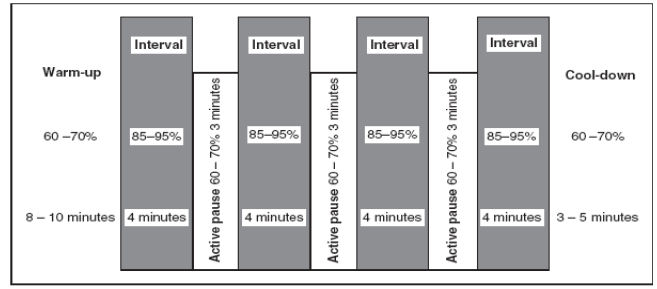
- *sprint or short-term interval training*
- 间歇性冲刺训练或短期间歇性训练
- and *high-intensity interval training (HIIT).*
- 和高强度间歇性训练

Implementation of aerobic exercise training in cardiac rehabilitation
mode of exercise training
心脏康复中有氧运动训练的实施应用
运动训练模式

- ✓ Continuous aerobic endurance exercise training is the **standard method**
- ✓ 连续有氧耐力运动训练是标准方法
- ✓ **Aerobic interval training**
- ✓ **间歇性有氧训练**
  - ✓ Sprint or short (term) interval training
  - ✓ 间歇性冲刺训练或短期间歇性训练
  - ✓ High intensity interval training
  - ✓ 高强度间歇性训练







Sprint or short (term) interval training间歇性冲刺训练或短期性间歇训练

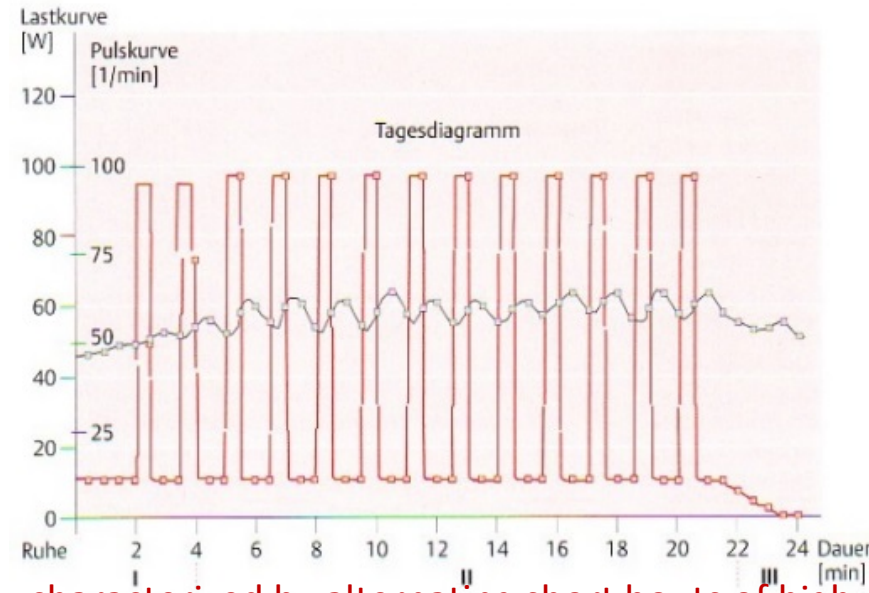
Phase I (warm-up) 热身
two-minute warm-up on the cycle ergometer 2分钟蹬功率车
with no or with very low resistance 零负荷或非常低的负荷

Phase II (interval training) 间歇训练
alternately 交替进行
- short (20–30s) high load phases at 85-100% of maximal achieved exercise load/heart rate and 短暂的（20-30秒）高强度训练阶段，已达到最大运动负荷/心率的85-100%。
- recovery phases with no or with low load (40–60s) 没有或只有很小负荷的恢复期（40-60秒）

➢10 repetitions of these intervals

重复这样的交替训练10次以上

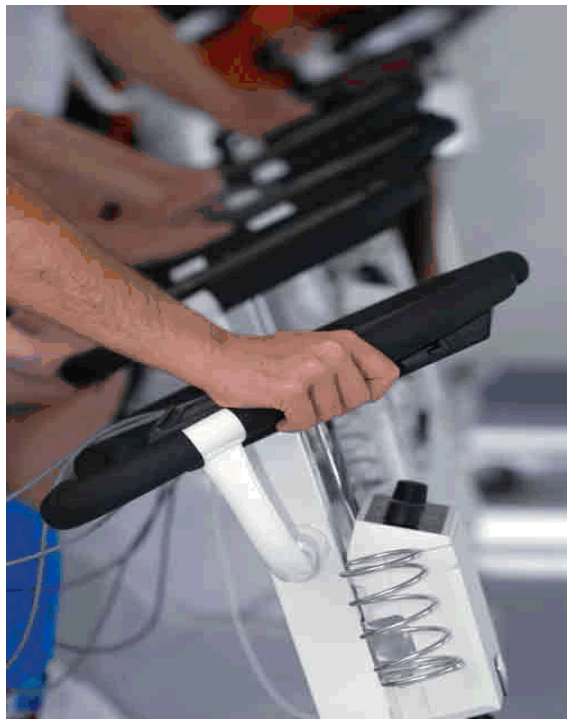
Phase III (cool-down) 整理阶段
three minutes of cycling without or with very low resistance 3分钟零负荷或低负荷蹬功率车

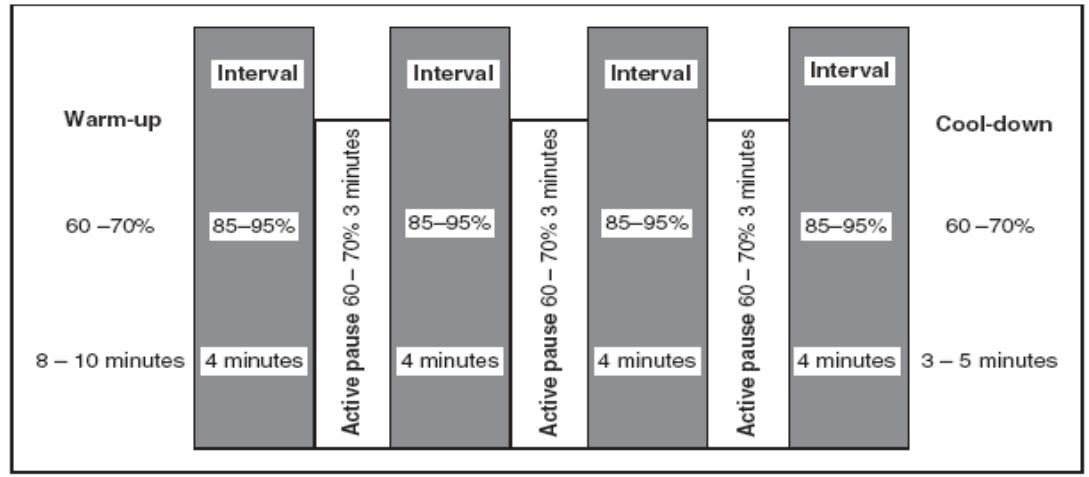


characterized by alternating short bouts of high-intensity exercise followed by a long recovery phase at minimal load typically twice the length of the exercise bout 特点是交替性的短暂高强度运动和其后的一个长期恢复阶段，恢复阶段负荷最小，并且通常是运动时长的两倍。

High intensity interval training

高强度间歇性训练





Aerobic exercise intensity assessment and prescription in cardiac rehabilitation:... Mezzani et al. Eur J Prev Cardiol. 2012

Table 2 Protocol recommendations for HIIT

Frequency	3×/Week
Duration	40 min
Modality	Treadmill/hill, cycle ergometer. Increasing speed or incline
Intensity	Interval=85–95% PHR Rest=passive–70% PHR
Interval times	4×4 min intervals 3×3 min recovery
Warm-up	10 min at 60% PHR
Cool-down	5 min at 50% PHR

HIIT, homeostasis model assessment-insulin resistance; PHR, peak heart rate.

High-Intensity interval training in patients with lifestyle-induced cardiometabolic disease: a systematic review and meta-analysis *Weston KS, Wisløff U, Coombes JS.* Br J Sports Med 2014:48: 1227-1234

Aerobic Interval Training vs. Moderate Continuous Training in Coronary Artery Disease Patients: A Systematic Review and Meta-Analysis

对冠心病患者的间歇性有氧训练 vs中等强度持续性训练：一个系统性回顾和荟萃分析

Pattyn N et al. Sports Med 2014 DOI 10.1007/s40279-014-0158-x

A meta-analysis = 9 studies; including 206 CAD-patients

1个荟萃分析=9项研究；包括206名冠心病患者

Results: Aerobic Interval Training results in a 1.60 ml/kg/min larger benefit in peak VO_2 compared to Moderate Continuous Training in patients with CAD.

结果：对于冠心病患者，间歇性有氧训练相比中等强度持续性训练，能使耗氧量峰值增加1.60 毫升/千克/分钟

Aerobic Interval Training	→	20.5% increase in peak VO_2
间歇性有氧训练		耗氧量峰值增加20.5%
Moderate Continuous Training		12.8% increase in peak VO_2
中等强度持续性训练	→	耗氧量峰值增加12.8%

Limitations: small sample sizes and the large inconsistency and heterogeneity between the study results in the included studies

局限性:样本容量小，研究结果中存在较大的不一致性和异质性

Interval Training Versus Continuous Exercise in Patients with Coronary Artery Disease: A Meta-Analysis
冠心病患者的间歇性训练和持续性训练对比：一个荟萃分析

Elliot et al. Heart, Lung and Circulation (2015) 24, 149–157

Six studies including, 229 patients with CAD (EF < 40) 99 (randomized to INTERVAL) were analyzed

6项研究，包括229名冠心病患者（射血分数< 40），其中99名患者（随机组到间隔组）被分析

- Patients in the INTERVAL group improved their VO2peak by 1.53 ml/kg/min (95% CI 0.84 to 2.23) more than the CONTINUOUS group (Overall Z = 4.33, P = 0.0001).
- 间歇训练组的患者（95% 心脏指数 0.84 - 2.23）相比持续训练组的患者，耗氧量峰值多了1.53毫升/千克/分钟（总体 Z = 4.33, P = 0.0001）
- Patients in the INTERVAL group improved their VO2peak at anaerobic threshold by 1,95 ml/kg /min (95% CI 1,24 to 2.67) more than the CONTINUOUS group (p = 0.0001).
- 间歇训练组患者（95% 心脏指数 1.24 - 2.67）相比持续训练组患者，无氧阈下的耗氧量峰值增加了1.95毫升/千克/分钟.(p = 0.0001).

- This is important in the context of a 10-25% survival advantage with every 3.5 ml/kg/min improvement in VO2peak.
- 这在耗氧量峰值每3.5 毫升/千克/分钟的改善，会带来生存优势增长10 - 25%的背景下，很重要。

Cardiovascular risk of high- versus moderate-intensity aerobic exercise in coronary heart disease patients.
冠心病患者高强度有氧训练与低强度有氧训练的心血管疾病风险对比

Rognmo et al. Circulation 2012;126: 1436-1440

Aim to evaluate the risk of cardiovascular events during organized high-intensity interval exercise training (HIIT 85-95% HRpeak) and moderate-intensity training (MCT 60-70% HRpeak among 4846 patients with coronary heart disease

目的是评估4846名冠心病患者在有组织的高强度间歇性有氧训练（高强度间歇性训练 85-95% 心率峰值）和中等强度训练（中等强度持续性训练 60-70% 心率峰值）的心血管疾病风险。

Results:

结果：

MCT: 1 fatal cardiac arrest during moderate-intensity exercise (129 456 exercise hours)

中等强度持续性训练： 出现1次致命的心脏骤停(129456运动小时)

- rates of complications to the number of patient-exercise hours were 1 per 129 456 hours

病人运动时间的并发症发生率为1 / 129 456小时

HIIT: 2 nonfatal cardiac arrests During high-intensity interva exercise (46 364 exercise hours)

高强度间歇性训练：共出现2次非致命的心脏骤停（46364运动小时）

- rates of complications to the number of patient-exercise hours were 1 per 23 182 hours

病人运动时间的并发症发生率为1 / 23182小时

Table 2. Major Cardiovascular Complications During Medically Supervised Exercise in Cardiac Rehabilitation

Patient	Sex (♂/♀)	Age, y	Rehabilitation Center	Event (Year)	Exercise-Related Complication	Exercise Intensity
1	♂	60	Feiring Clinic	2007	Cardiac arrest, F	Moderate
2	♂	58	Feiring Clinic	2008	Cardiac arrest, NF	High
3	♂	61	Ålesund	2010	Cardiac arrest, NF	High

♂ indicates male; ♀, female; F, fatal; and NF, nonfatal.

Prof. Dr. Birna Bjarnason-Wehrens,
Institute for Cardiology and Sports

Aerobic interval training and continues training equally improve aerobic exercise capacity in patients with coronary artery disease: The SAINTEX-CAD study
间歇性有氧训练和持续性有氧训练能同样改善冠状动脉疾病患者的有氧运动能力：SAINTEX-CAD 研究

Conraads et al. Int J Cardiology 179 (2015) 203-210

Randomized study to compare the effects of 4 x 4 min protocol 85-95% HR_{max} (HIIT) compared to moderate endurance training 70-75% HR_{max}(MCT)

对比4 x 4分钟方案 85-95% 最大心率（高强度间歇性训练）和中等强度耐力训练70-75%最大心率（中等强度持续性训练）效果的随机研究

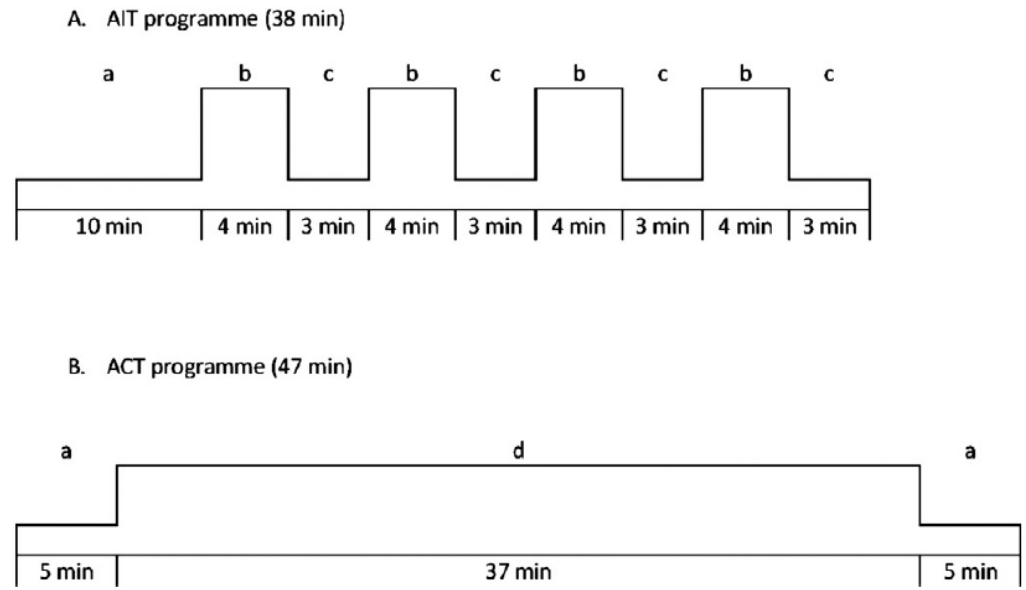


Fig. 1. Visual presentation of the AIT (A) and ACT (B) programme. a = 50–60% of peak VO_2, 60–70% of peak heart rate, 11–13 Borg scale, no shortness of breath. b = 85–90% of peak VO_2, 90–95% of peak heart rate, 15–17 Borg scale, shortness of breath. c = 50–70% of peak heart rate. d = at least 60–70% of peak VO_2, at least 65–75% of peak heart rate.

N= 200 CAD-Patients;
数量=200名冠状动脉疾病患者
EF > 40%;
射血分数> 40%；
3 exercise units/week
3个运动单元/周
12 week CR
12周心康

Aerobic interval training and contious training equally improve aerobic exercise capacity in patients with coronary artery disease: The SAINTEX-CAD study
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Conraads et al. Int J Cardiology 179 (2015) 203-210

Results:
结果:
no advantage for one of the exercise modalities was found
未发现两种运动方式之一更有优势。

VO_2peak
耗氧量峰值
HIIT.（高强度间歇性训练）: 23.5 ± 5.7
vs. 28.6 ± 6.9 mL/kg^{-1}/min^{-1} +22,7%
MCT（中等强度持续性训练）: 22.4 ± 5.6
vs. 26.8 ± 6.7 mL/kg^{-1}/min^{-1} +20,3%;
p (time) 0,001; p (interaction) ns.
p (时间) 0,001; p (交互) ns.

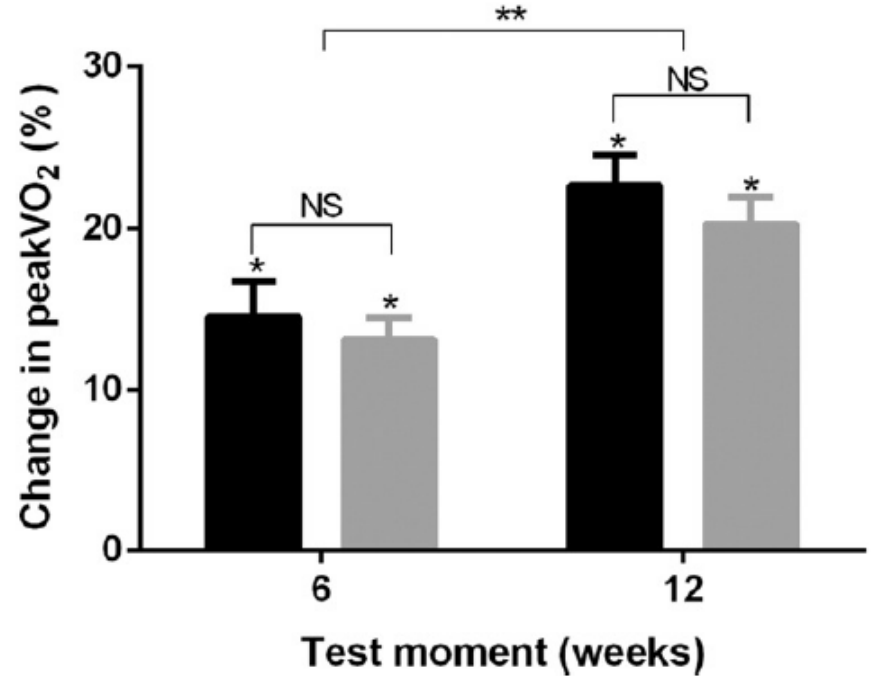

Fig. 3. Percent changes in peak VO_2 in AIT and ACT after 6 and 12 weeks. Data are means ± SEM; * = significantly different from baseline ($p < 0.001$); ** = 6 weeks differs significantly from 12 weeks ($p = 0.0231$); NS = not significant; black bars = AIT; grey bars = ACT.

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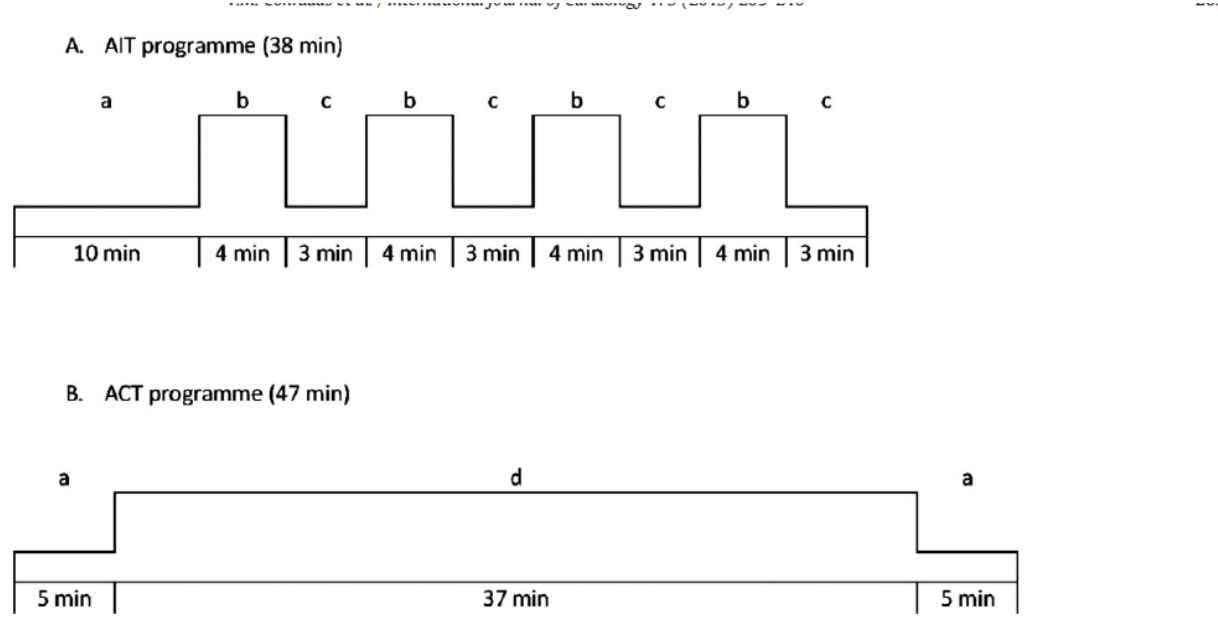
Conraads et al. Int J Cardiology 179 (2015) 203-210

Mean training intensity
平均训练强度

AIT group: 88% of peak HR
AIT组：心率峰值的88%
ACT group 80% of peak HR
ACT组：心率峰值的80%
during the 12 week intervention
12周的介入中

Overall **compliance**
总体依从性

AIT group 35.7 ± 1.1 training sessions
AIT组 35.7 ± 1.1 训练环节
ACT group 35.6 ± 1.5 training sessions.
ACT组 35.6 ± 1.5 训练环节



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No adverse events were reported during the training sessions.
训练环节中未发现不良反应。

Aerobic interval training and contious training equally improve aerobic exercise capacity in patients with coronary artery disease: The SAINTEX-CAD study
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Conraads et al. Int J Cardiology 179 (2015) 203-210

Conclusion:
结论：
−a 12-week AIT and ACT intervention equally improve peak VO2, peripheral endothelial function, QoL and some cardiovascular risk factors in CAD patients.
-为期12周的间歇性有氧训练和持续性有氧训练同样会改善冠状动脉疾病患者的耗氧量峰值、周边内皮功能、生活质量和一些心血管疾病风险因素。
-both programs seem to be safe for CAD patients.
-两个方案似乎对于冠状动脉疾病患者都是安全的。

-sustained AIT at 90–95% of peak HR during 4 min is hardly feasible in CAD patients.
-对于冠状动脉疾病患者，持续4分钟的间歇性有氧训练（90-95%心率峰值）几乎不可行。
-when using continuous exercise training, a sufficient training intensity should be performed, which may be more than the 70–75% of peak HR of the baseline evaluation as used in a number of previous studies.
-在患者进行持续性运动训练时，应在足够的训练强度下进行，这可能比之前许多研究中使用的基线评估的心率峰值的70 - 75%强度更高。

The long-term effects of a randomized trial comparing aerobic interval versus continuous training in coronary artery disease patients: 1-year data from the SAINTEX-CAD study.
比较间歇性有氧训练和持续性有氧训练分别对冠状动脉疾病患者长期效果的研究：SAINTEX-CAD研究的1年数据
Pattyn et al. Eur J Prev Cardiol 2016 pii: 2047487316631200.

- nine patients had an adverse event during the follow-up period
在随访期中，共有9名患者出现不良反应
- the number of adverse events was unrelated to the training intervention arm.
不良反应的次数与训练干预手段无关
- both peak and submaximal exercise capacity parameters remained stable at 1-year of follow-up compared to post-intervention
与介入后相比，随访1年时的运动能力峰值和次最大运动能力参数均保持稳定
- physical activity behavior remained constant from post-intervention to 1-year of follow-up
从介入后到随访1年这段时间，体育锻炼行为不变

For both physical fitness and physical activity parameters, the AIT and ACT interventions were equally effective.
对于身体健康和体力活动参数，间歇性有氧训练和持续性有氧训练同样有效

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- significant correlation between the changes in physical fitness during the intervention and the physical activity levels after the 1-year follow-up, was found,
  suggesting that those who improved their physical fitness more had a higher motivation to adopt a physically active lifestyle.
- 介入时身体健康的变化，与随访1年后的体力活动水平被发现有显著联系，这表明那些身体健康状况改善更多的患者，会更有动力选取一种更活跃的生活方式。

Aerobic interval training versus continuous moderate exercise after coronary artery bypass surgery: a randomized study of cardiovascular effects and quality of life.

冠状动脉支架手术后间歇性有氧训练和持续性中等强度训练的对比：一项关于心血管影响和生活质量的随机研究

Moholdt et al. Am Heart J 2009; 158: 1031-1037

4周

AIT（间歇性有氧训练）: 27.1 ± 4.5 vs 30.4 ± 5.5 mL/kg^{-1}/min^{-1}, P < .001

MCT（持续性中等强度训练）: (26.2 ± 5.2 vs 28.5 ± 5.6 mL/kg^{-1}·min^{-1}, P < .001

（group difference, not significant).

（小组差异并不明显）

Between 4 weeks and 6 months

4周和6个月之间

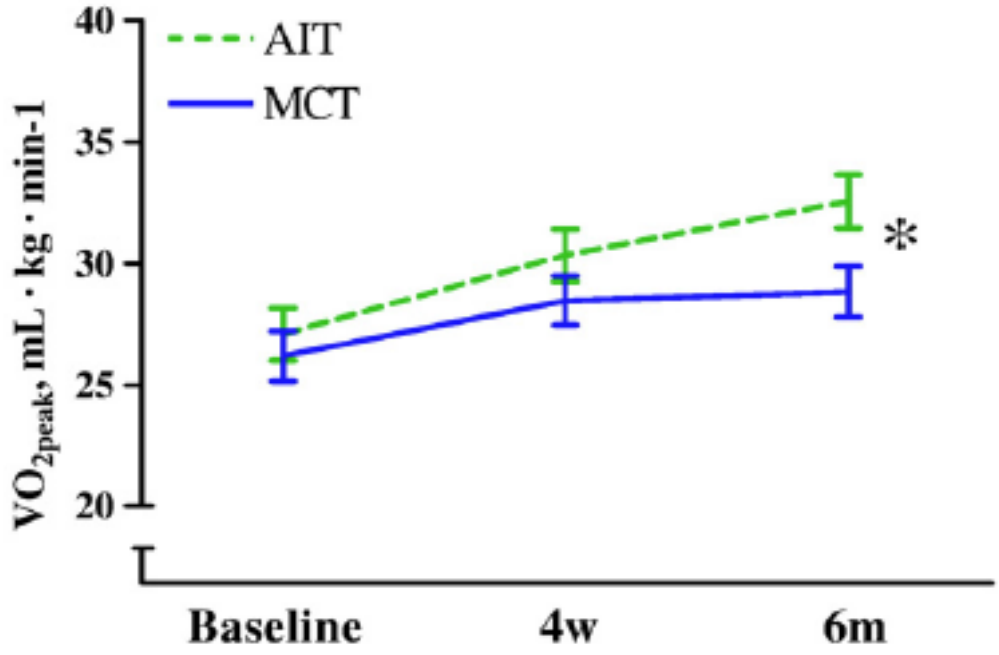
AIT: 30.4 ± 5.5 vs 32.2 ± 7.0 mL/kg^{-1}/min^{-1}, P < .001,

MCT: 28.5 ± 5.6 vs 29.5 ± 5.7 mL/kg^{-1}/min$^{-1;}$ ns

The results indicate that AIT and MCT increase VO2peak similarly in the short term, but with better long-term effect of AIT after CABG.

结果表明间歇性有氧训练和持续性中等强度训练都会在短期内增加耗氧量峰值，但冠状动脉支架手术后，间歇性有氧训练的长期效果更好。

Figure 2



VO_{2peak} in AIT and MCT at baseline, 4w, and 6m. The bars represent ± SEM. *$P < .05$, group comparison.

High Intensity Interval Training in Heart Failure Patients with Reduced Ejection Fraction

射血分数减少的心力衰竭患者的高强度间歇训练

Ellingsen et al. 10.1161/CIRCULATIONAHA.116.022924

261 patients with LVEF <35% and NYHA II-III were randomly assigned to HIIT at 90-95% of maximal heart rate (HRmax), MCT at 60-70% of HRmax or RRE.

261名左心室射血分数小于35%和NYHA 心功能分级ii - iii级的患者被随机分配到高强度间歇训练组，（最大心率的90 - 95%）和中等强度持续训练组（60% - 70%的最大心率）。

Results

结果

Change in left ventricular end-diastolic diameter from baseline to 12 weeks was not different between HIIT and MCT, P=0.45;

从基线至第12周，HIIT组与MCT组相比，左心室舒张期直径变化无差异，P = 0.45。

There was no difference between HIIT and MCT in peak oxygen uptake, P=0.70, none of these changes were maintained at follow-up after 52 weeks.

HIIT组与MCT组的摄氧量峰值无差异，P=0.70，在52周后的随访中，这些变化均未能保持。

Serious adverse events were not statistically different during supervised intervention or at follow-up at 52 weeks (HIIT 39%, MCT 25%, RRE 34%, P=0.16).

监督期和52周后的随访相比，严重不良反应事件并无数据上的不同（HIIT 39%, MCT 25%, RRE 34%, P=0.16）

Conclusions—HIIT was not superior to MCT in changing left ventricular remodeling or aerobic capacity, and its feasibility remains unresolved in heart failure patients.

结论：HIIT在改变左室重构或有氧能力方面并不优于MCT，其对心力衰竭患者的可行性问题仍

Aerobic endurance training in phase II cardiac rehabilitation
第二阶段心脏康复的有氧耐力训练

Individually dosed and monitored training on the **cycle ergometer** is the standard method

个人化剂量的踏车测力监控训练是标准方法

Advantages of this form of training are:

这种训练形式的优势是:

- the load can be precisely dosed and graded

- 负荷的剂量和级别可以很精确

- the ECG can be registered and arterial blood pressure controlled throughout training

-整个训练期间，可以实时记录心电图并控制动脉血压

-the use of pulsoxymeter is possible if necessary

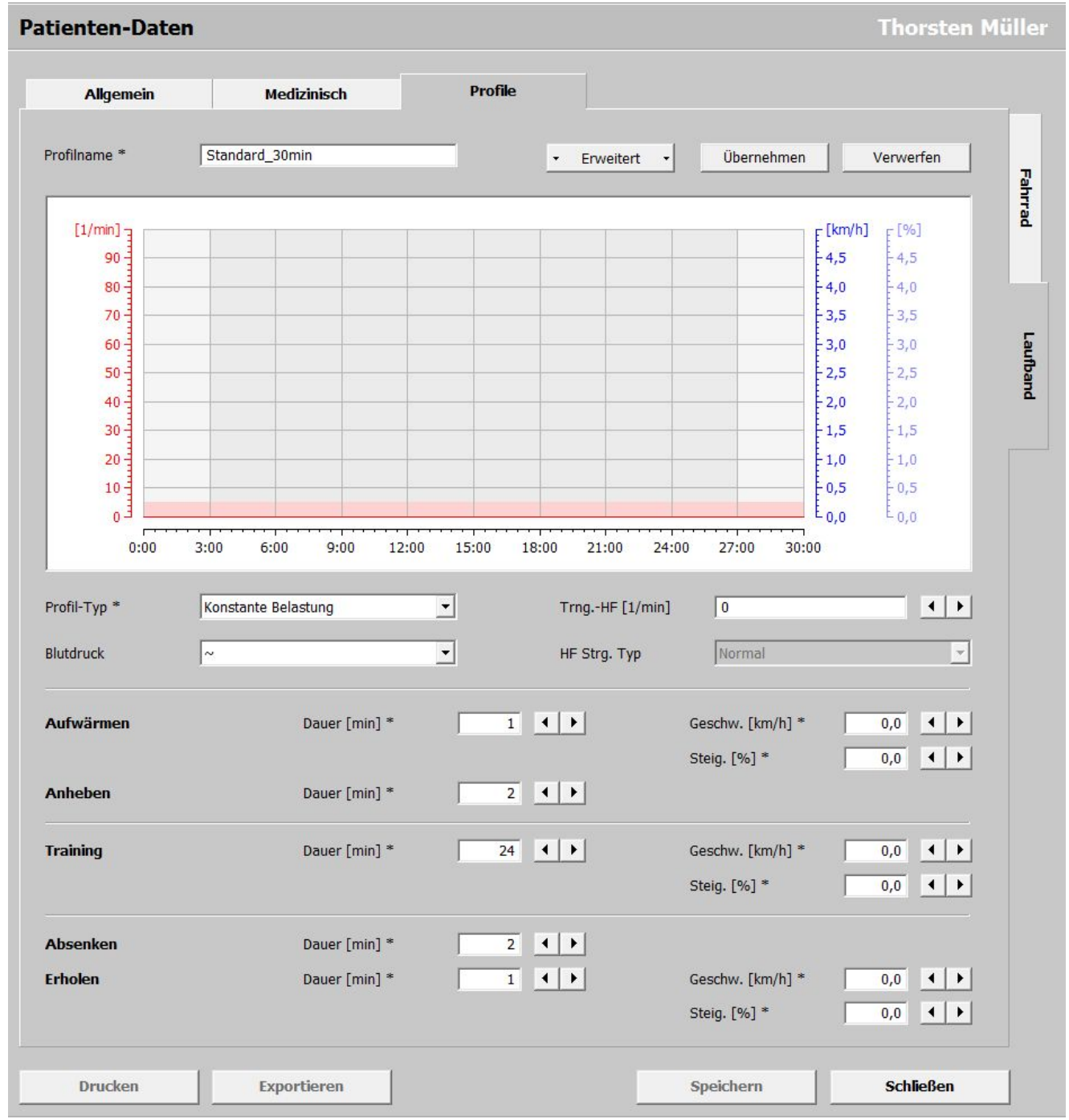
-如有必要，可以使用脉搏血压测量仪

Aerobic endurance training on a cycle ergometer.

踏车测力计上的有氧耐力训练

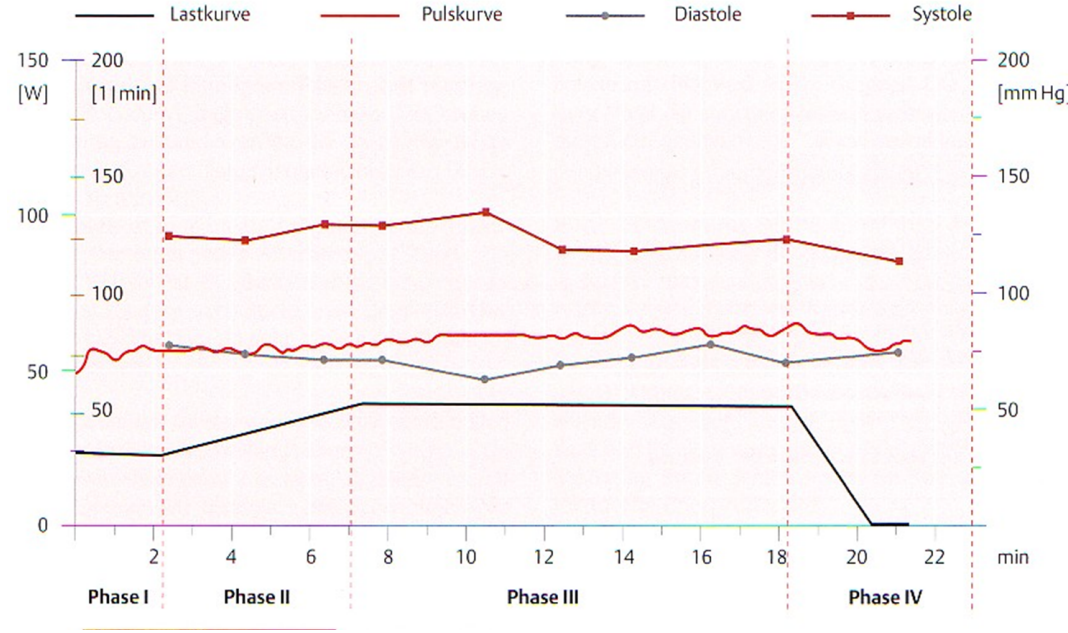
Definition of the Patients individual exercise program

患者个人运动项目定义



Training program on a bicycle ergometer

Phase I (warm-up and adaptation phase)
Exercise Intensity: 50 % of the optimal training workload
Duration: 2-5 minutes



Phase II (gradual increase in workload)
Exercise Intensity: gradual increase in the workload by 5-10 watt steps every minute until the optimal exercise workload was reached
Duration: at least 5 minutes

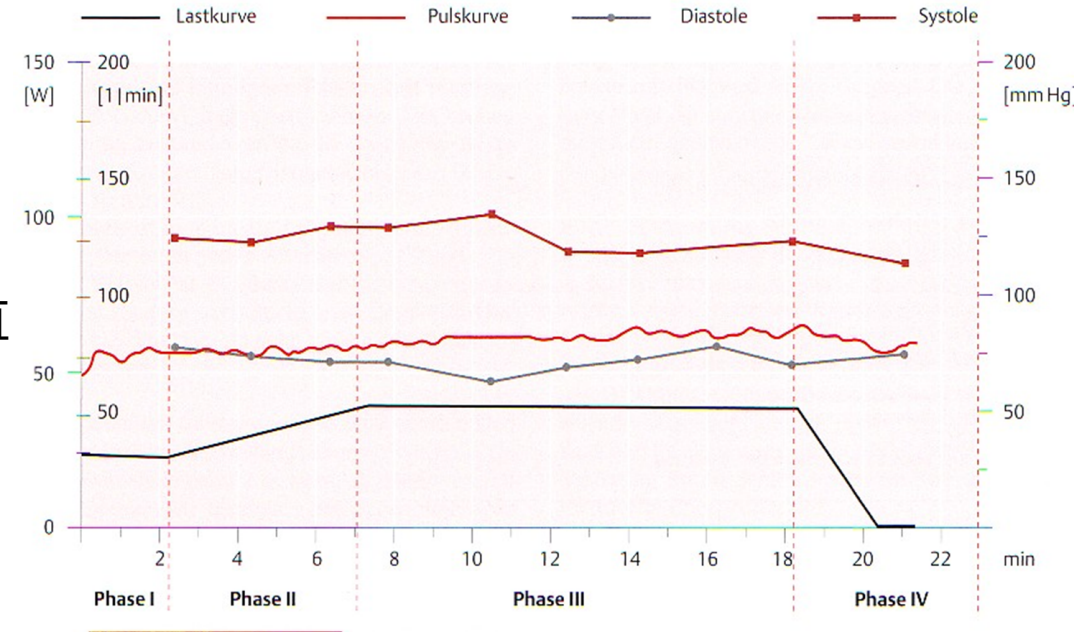
Phase III (training)
Exercise Intensity: 100 % of the optimal exercise workload
Duration: > 5-10 minutes in the first week of the rehabilitation program, starting in the second week the exercise duration is gradually extended by approx. 3-5 minutes each week

Phase IV (cool-down)
Exercise Intensity: between 0 and 25 watts depending on patient´s tolerance
Duration: 3 minutes

踏车测力计上的训练项目

第一阶段（热身和适应期）
运动强度：50%的最优训练量
时长：2-5分钟

第二阶段（训练量逐渐增加）
运动强度：每分钟增加5-10瓦特的训练量，直
时长：至少5分钟



第三阶段（训练）
训练强度：100%的最优训练量
时长：康复计划第一周，5 - 10分钟，
从第二周开始，运动时间逐渐延长，每周约3 - 5分钟。

第四阶段（冷却期）
训练强度：0-25瓦特，根据患者的耐受情况
Duration: 3 minutes
时长：3分钟

Exercise training on cycle ergometer with monitoring variable observed and documented
踏车测力计上的监控运动训练并有变量观察和记录

monitored throughout the exercise training
整个运动训练过程中都有监控

⇨Exercise workload achieved
⇨完成 运动量
⇨heart rate **and** ECG are monitored throughout the exercise training
⇨在整个运动训练过程中，心率和心电图都被监控
⇨*Pulsoxymetry (in selected patients if necessary)*
⇨脉搏血氧测定（在必要情况下对入选患者进行）

At rest and every three minute
休息时每隔3分钟

⇨blood pressure measurement (in selected patients)
⇨血压测量 （入选患者）
⇨Borg scale for rating perceived Exertion
⇨使用Borg 量表对观察到的患者努力情况评级

Exercise training on cycle ergometer – in cardiac patients

踏车测力计上的运动训练 - 心脏病患者

The most attention is paid to ECG response to exercise

最关注的是运动后的心电图反应

- **signs of ischemia** (ST depression/ ST elevation), chest pain, dyspnea, arrhythmias …), -

心肌缺血的体征（ST段压低/ST段上升），胸痛、呼吸困难、心律失常 ...）

- **arrhythmias** (new, not yet known, occurring during the exercise training …)

心律失常（新的、尚且未知、运动训练时出现）

as well as blood pressure response to exercise

还有运动后的血压反应

- inadequate blood pressure rise (systolic BP 230-260； diastolic BP ≥ 115 mmHg)

血压上升不足（收缩压230-260；舒张压≥ 115 mmHg)

- drop in systolic blood pressure (> 10mmHg)

收缩压下降 (> 10mmHg)

Other symptoms (chest pain dyspnea, dizziness, discomfort … Borg-scale?)

其他症状（胸痛、呼吸困难、头晕、不适...Borg量表？）

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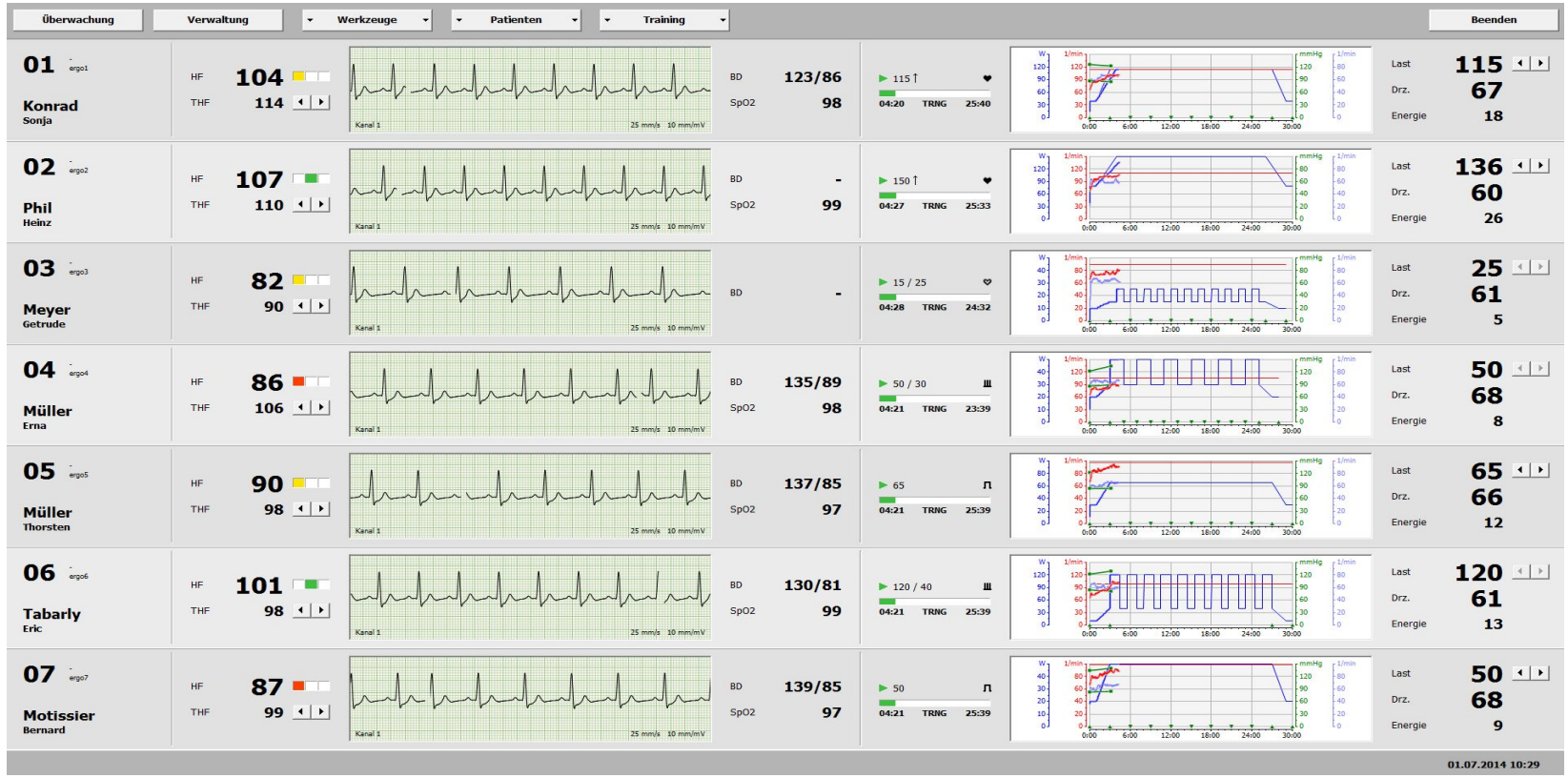
Individually dosed and monitored training on the **cycle ergometer**

个人化剂量的踏车测力监控训练

Advantages: -the program can be adapted to the special needs of the patient

优势：该项目能适应患者的特殊需求



Thank you for your attention

感谢您的认真听讲