

## **How to monitor exercise training – safety aspects of CR**

**安全监测：如何监测心脏康复中的运动训练**

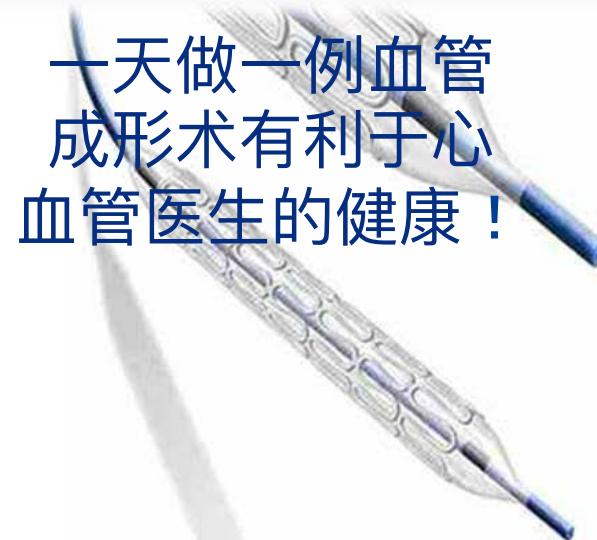
**Roland Nebel, Cardiology 罗兰德·尼贝尔，心脏病学  
SiegReha Rehabilitation Centre, SiegReha 康复中心  
Hennef, Germany 德国，亨内夫**

# The aim ?

目标?



*An angioplasty a day  
keeps the cardiologist  
healthy !*



一天做一例血管  
成形术有利于心  
血管医生的健康！

[drsvenkatesan.com](http://drsvenkatesan.com)

## Goals of CR and (secondary) cardiovascular prevention 心脏康复和二级心血管预防的目标

- 1. preventing disability from CVD especially in elderly persons and those with physical exertion involved in occupation
- 预防心血管疾病导致的残疾，尤其是在年老人群和工作中从事体力活动的人群  
(meaning 意义: 2. unlimited return to work 不受限地回归工作岗位)
- 3. preventing subsequent cardiovascular events, 预防后续的心血管事件
- 4. subsequent hospitalization 随后的住院治疗 and 和
- 5. death from CVD 心血管疾病导致的死亡



Saner 2010

# Indications for CR

## 心脏康复适应症

### Coronary Artery Disease (CAD) 冠状动脉疾病

after myocardial infarction  
(ACS, NSTEMI, STEMI)  
心肌梗死后(ACS, NSTEMI,  
STEMI)

after revascularization (PCI,  
CABG)  
血管再形成后 (PCI, CABG)

stable angina  
持续的心绞痛

### other cardiac conditions 其他的心血管状况

Valvular heart disease (prothesis,  
reconstruction, TAVI, Mitra-Clip™, ...)  
心脏瓣膜病 (假体, 重建, 经导管主  
动脉瓣植入术, , Mitra-Clip™)

after ICD- /CRT-Implantation  
除颤器/起搏器植入术后  
Myocarditis 心肌炎  
Congenital heart disease  
先天心脏病  
Hypertension (severe)  
严重高血压  
Cardiac transplant (HTX, HLTX, VAD)  
心脏病移植 (HTX, HLTX, VAD)  
Chronic heart failure (CHF)  
慢性心脏衰竭  
Peripheral artery disease (PAD)  
外周动脉疾病

### "healthy" subjects “健康”主体

high-risk subjects  
(metabolic syndrome,  
DM2,...)  
高风险主体 (新陈代谢综  
合征, DM2, ...)



EUROPEAN  
SOCIETY OF  
CARDIOLOGY

# Contraindications for CR

## 心脏康复禁忌症

### Cardiac 心脏相关的

Unstable angina

不稳定的心绞痛

Advanced heart failure

晚期心脏衰竭

(Uncontrolled) high blood pressure

(不可控制的) 高血压

Left ventricular outflow tract obstruction

左室流出道梗塞

Grade 2 and 3 AV block

二级和三级动静脉堵塞

Acute Myocarditis

急性心肌炎

Active Pericarditis

急性心包炎

Severe valvular disease

严重的瓣膜疾病

Severe ventricular arrhythmias

严重的心室心律不齐

### Others 其他

Aortic dissection

主动脉剥离

Acute thrombophlebitis

急性血栓性静脉炎

Pulmonary or systemic embolism

肺栓塞或全身栓塞

Severe psychological disorders

严重的精神或心理疾病

Severe mobility limitations

严重活动受限



接受以运动训练为基础的心脏康复病人死亡率下降：有多少归于心血管风险因素的改善？

the mortality risk in CAD patients is reduced: 冠状动脉病死亡率下降：

- by > 36% or more by cessation of smoking or decrease of total cholesterol  
大于36%得益于戒烟或者胆固醇总含量的降低
- by > 20% from a decrease in blood pressure  
大于20%得益于血压降低
- by > 40% by tailored exercise training  
大于40%得益于个性化制定的运动训练



Taylor et al 2006

- **Essential Staff 核心人员**

- **Cardiologist 心脏病专家**
- **Nurse 护士**
- **Physiotherapist 物理治疗师**
- Dietician 饮食学家

with **basic life support** and **advanced life support** (ILCOR guidelines) classes each year –

每年提供基本的和高等的**生活支持**(ILCOR 指南)课程

external coach preferred 有外部教练最好

- **Optional Staff**

- 其他人员

- Psychologist 心理学家
- **Sports scientist**运动科学家
- Stress / Relaxation Specialist  
减压/放松专科医生
- Smoking cessation 戒烟
- Social worker 社工
- Researcher 调查员

### • Equipment / Quality management 设备/质量管理

- 12-canal ECG, Troponin- and d-Dimer – testing 十二导心电图, 肌钙蛋白和二聚体检测
- cycle or treadmill ergometer 功率车或者运动平板测试
- doppler echocardiography 多普勒超声
- emergency equipment and room incl. defibrillator and AEDs (each level of CR centre) 应急设备和应急室, 包括除颤器和自动体外除纤颤器 (心脏康复中心每层都要配)
- chest X-Ray (optional) 胸部X射线 (非强制)
- emergency concept (quality management handbook)  
急救概念 (质量管理手册指南)

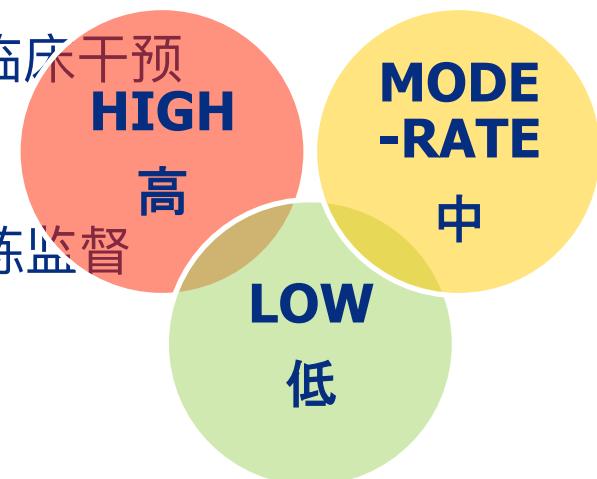
**within these structural and staff-related aspects of CR**

在结构和人员相关的 心脏康复的方面范围内，

- **Risk stratification of a cardiac patient as a base for**

- 心脏病病人的危险分层是以下的基础：

- individual therapeutic interventions 个性化临床干预
- exercise prescription 训练处方
- appropriate exercise supervision 适当的 训练监督
- educational interventions 教育方面的干预
- behavioral interventions 行为方面的干预



# CR – safety through risk stratification – high risk

## 心脏康复-通过危险分层确保安全性-高风险



Patient is at **HIGH RISK** if ANY ONE OR MORE of the following factors are present:

如果出现下列一种或者几种以上的因素，是高风险病人

- Left ventricular ejection fraction < 40% 左心室射血分数<40%
- Survivor of cardiac arrest or sudden death 心脏骤停或猝死后的幸存者
- Complex ventricular dysrhythmias (ventricular tachycardia, frequent [> 6/min] multiform PVCs) at rest or with exercise 复杂的心室性心律失常
- MI or cardiac surgery complicated by cardiogenic shock, CHF, and/or signs/symptom of post-procedure ischemia 心肌梗死或心脏手术后伴随心源性休克、慢性心衰和/或心肌缺血后的症状或指标
- Abnormal hemodynamics with exercise, especially flat or decreasing systolic blood pressure or chronotropic incompetence with increasing workload 运动中异常的血流动力学，尤其收缩压压低或下降或负荷增加时心脏变性时机能不全
- Significant silent ischemia (ST depression 2mm or greater without symptoms) with exercise or in recovery 训练时或训练后恢复期明显的无症状心肌缺血（无症状ST段压低2mm或更多）
- Signs/symptoms including angina pectoris, dizziness, lightheadedness or dyspnea at low levels of exercise (< 5.0 METs) or in recovery 在低负荷运动中出现心绞痛、眩晕、头晕或呼吸困难
- Maximal functional capacity less than 5.0 METs\* 最大运动能力小于5MET
- Clinically significant depression or depressive symptoms 有临床抑郁或抑郁症状

AACVPR 2012 Stratification Algorithm for Risk of Event



Patient is at **LOW RISK** if ALL of the following factors are present:

- Left ventricular ejection fraction > 50%
- No resting or exercise-induced complex dysrhythmias
- Uncomplicated MI, CABG, angioplasty, atherectomy, or stent:
  - Absence of CHF or signs/symptoms indicating post-event ischemia
- Normal hemodynamic and ECG responses with exercise and in recovery
- Asymptomatic with exercise or in recovery, including absence of angina
- Maximal functional capacity at least 7.0 METs\*
- Absence of clinical depression or depressive symptoms

满足以下所有条件的是低危病人

- 左室射血分数>50%
- 无休息或者训练诱发的复杂心律失常
- 不复杂的心梗、冠状动脉旁路移植术、血管成形术、经皮腔内斑块旋切术或支架介入
  - 无慢性心衰或心肌缺血事件后症状或标志
- 正常的血液动力学和运动中和运动后恢复心电信号反应
- 无临床症状的运动或运动后的恢复，包括无心绞痛症状
- 最大运动能力最少7MET
- 无临床抑郁或抑郁性的症状

AACVPR 2012 Stratification Algorithm for Risk of Event



Patient is at **MODERATE RISK** if they meet neither High Risk nor Low Risk standards:

- Left ventricular ejection fraction = 40–50%
- Signs/symptoms including angina at “moderate” levels of exercise (60–75% of maximal functional capacity) or in recovery
- Mild to moderate silent ischemia (ST depression less than 2mm) with exercise or in recovery

如果既不符合高危也不符合低危标准，则病人是中危程度

- 左室射血分数=40%-50%
- 症状包括心绞痛，“中度”训练水平（运动能力最大值的60%-75%）
- 在训练中或训练后的恢复阶段，出现轻度或者中度无症状心肌缺血（ST压低少于2mm）

AACVPR 2012 Stratification Algorithm for Risk of Event

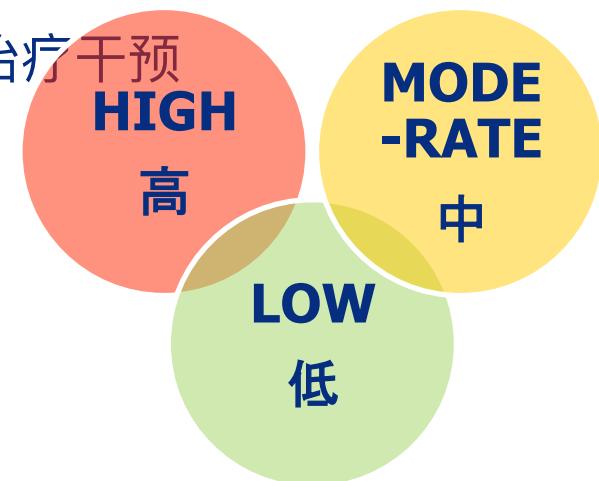
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在结构和人员相关的 心脏康复的方面范围内，

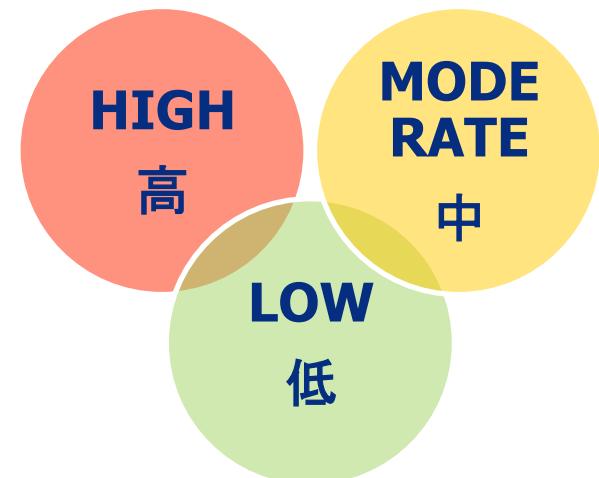
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- 在结构和人员相关的 心脏康复的方面范围内
  - Exercise prescription 训练处方



# Risk stratification of a cardiac patient as a base for exercise prescription for aerobic endurance training

心脏病病人的危险分层是有氧耐力训练处方的基础



# Risk stratification of a cardiac patient as a base for exercise prescription for aerobic endurance training

## 心脏病病人的危险分层是有氧耐力训练处方的基础

Table I. Implementation of aerobic endurance exercise training in patients with cardiological diseases

Stage 阶段	Aim and intensity
Initial 初始	<p>Low intensity, i.e.:</p> <p>40–50% <math>\text{VO}_{2\text{peak}}</math></p> <p>60% <math>\text{HR}_{\text{max}}</math></p> <p>40% HRR</p> <p>Below 1st VAT</p> <p>RPE &lt; 11</p>
Improvement 提高	<p>Gradually increase the exercise intensity from low to moderate up to target values, depending on exercise tolerance and clinical status</p> <p>50, 60, 70 (80%) <math>\text{VO}_{2\text{peak}}</math></p> <p>65, 70, 75 <math>\text{HR}_{\text{max}}</math></p> <p>45, 50, 55, 60% HRR</p> <p>1st to 2nd VAT</p> <p>RPE 12–14</p>
Maintenance 维持	<p>Long-term stabilization of the exercise intensity and exercise duration achieved during the improvement stage; gradually increase exercise duration and frequency and thereafter intensity</p>

HR, heart rate; HRR, heart rate reserve; RPE, rate of perceived exertion; VAT, ventilatory (an)aer

Vanhees et al 2012



EACPR  
European Association for  
Cardiovascular Prevention  
and Rehabilitation  
A Registered Branch of the ESC



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# Risk stratification of a cardiac patient as a base for exercise prescription for aerobic endurance training

## 心脏病病人的危险分层是有氧耐力训练处方的基础

**Table I.** Implementation of aerobic endurance exercise training in patients with cardiovascular disease

Stage	Aim and intensity	Duration
Initial	Low intensity, i.e.: 40–50% $\text{VO}_{2\text{peak}}$ 60% $\text{HR}_{\text{max}}$ 40% HRR Below 1st VAT RPE < 11	Starting with 5 minutes (in the exercise phase) and progress up to 10 minutes
Improvement	Gradually increase the exercise intensity from low to moderate up to target values, depending on exercise tolerance and clinical status 50, 60, 70 (80%) $\text{VO}_{2\text{peak}}$ 65, 70, 75 $\text{HR}_{\text{max}}$ 45, 50, 55, 60% HRR 1st to 2nd VAT RPE 12–14	Gradually prolong the exercise training from 10 to 20 (up to 30–45) minutes
Maintenance	Long-term stabilization of the exercise intensity and exercise duration achieved during the improvement stage; gradually increase exercise duration and frequency and thereafter intensity	Gradually prolong the exercise training from 20–45 (up to >60) minutes, if tolerated

HR, heart rate; HRR, heart rate reserve; RPE, rate of perceived exertion; VAT, ventilatory (an)aerobic threshold.

Vanhees et al 2012

# Risk stratification of a cardiac patient as a base for exercise prescription for aerobic endurance training

心脏病病人的危险分层是有氧耐力训练处方的基础



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# Risk stratification of a cardiac patient as a base for exercise prescription for aerobic endurance training

## 心脏病病人的危险分层是有氧耐力训练处方的基础

**Table 2.** Implementation of dynamic strength training in patients wi

Stage 阶段	Aim
Initial (pre-training) 初始(训练前)	Implementation of exercise; improvement of self-perception and coordination; learning to correctly perform exercise
Improvement stage I 提高阶段一	Improvement of aerobic endurance and coordination
Improvement stage II 提高阶段二	Increase muscle mass; improvement of coordination
Improvement stage III 提高阶段三	Increase in muscle strength

General recommendations: if possible training should include all muscle groups  
be a pause of more than 1 minute; 1-RM, one repetition maximum; RPE, rate



Vanhees et al 2012

# Risk stratification of a cardiac patient as a base for exercise prescription for aerobic endurance training

## 心脏病病人的危险分层是有氧耐力训练处方的基础

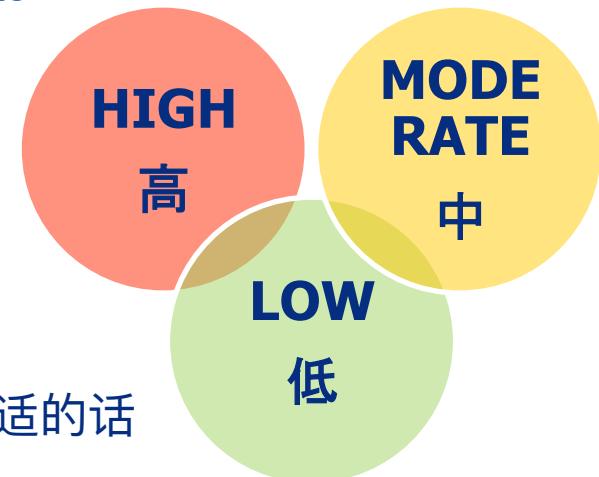
**Table 2.** Implementation of dynamic strength training in patients with cardiovascular disease

Stage	Aim	Intensity	Repetitions per muscle group
Initial (pre-training)	Implementation of exercise; improvement of self-perception and coordination; learning to correctly perform exercise	<30% I-RM RPE $\leq 11$	5–10
Improvement stage I	Improvement of aerobic endurance and coordination	30–50% I-RM	10–15
Improvement stage II	Increase muscle mass; improvement of coordination	40–60% I-RM ( $>60\%$ in selected patients)	10–15
Improvement stage III	Increase in muscle strength	60–80% I-RM (in selected patients in good clinical condition and with heavy physical employment or those returning to sport)	8–10

General recommendations: if possible training should include all muscle groups. Training should change between agonist and antagonist muscle groups. There should be a pause of more than 1 minute; I-RM, one repetition maximum; RPE, rate of perceived exertion; Information modified according to Bjarnason et al 2012

Vanhees et al 2012

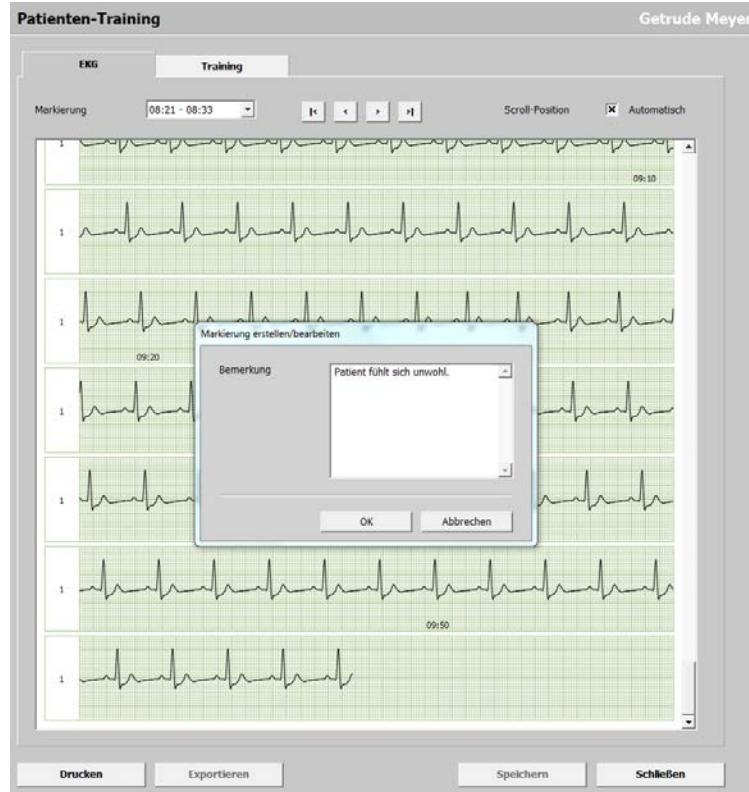
- **Risk stratification of a cardiac patient as a base for**
- 心脏病病人的风险分层是以下的基础：
  - Appropriate exercise supervision 适当的训练监管
  - clinical status at beginning of each training status 每次训练状态开始的临床状态
  - precise information about exercise for participants
  - 参与者训练的精确的信息
  - ECG monitoring, HR, BP, Borg RPE  
心电图监测, HR, BP, Borg RPE
  - ECG telemetry monitoring 心电遥测监护
    - if available and appropriate 如果可以并且合适的话



# CR – how to monitor exercise training

## 心脏康复-如何监测运动训练

- Appropriate exercise supervision 适当的训练监测



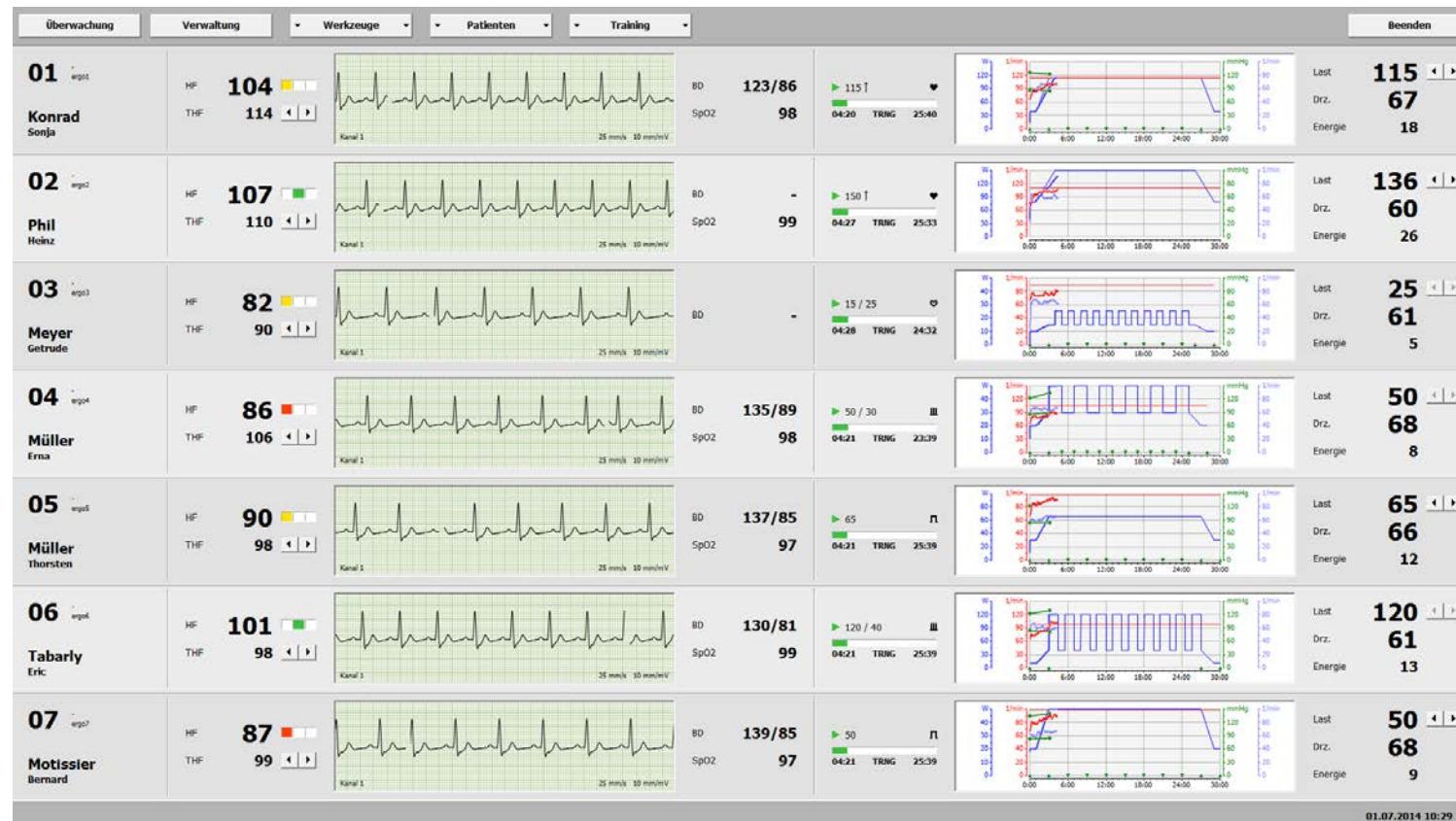
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MOVING TO HEALTH



# CR – how to monitor exercise training

## 心脏康复-如何监测运动训练

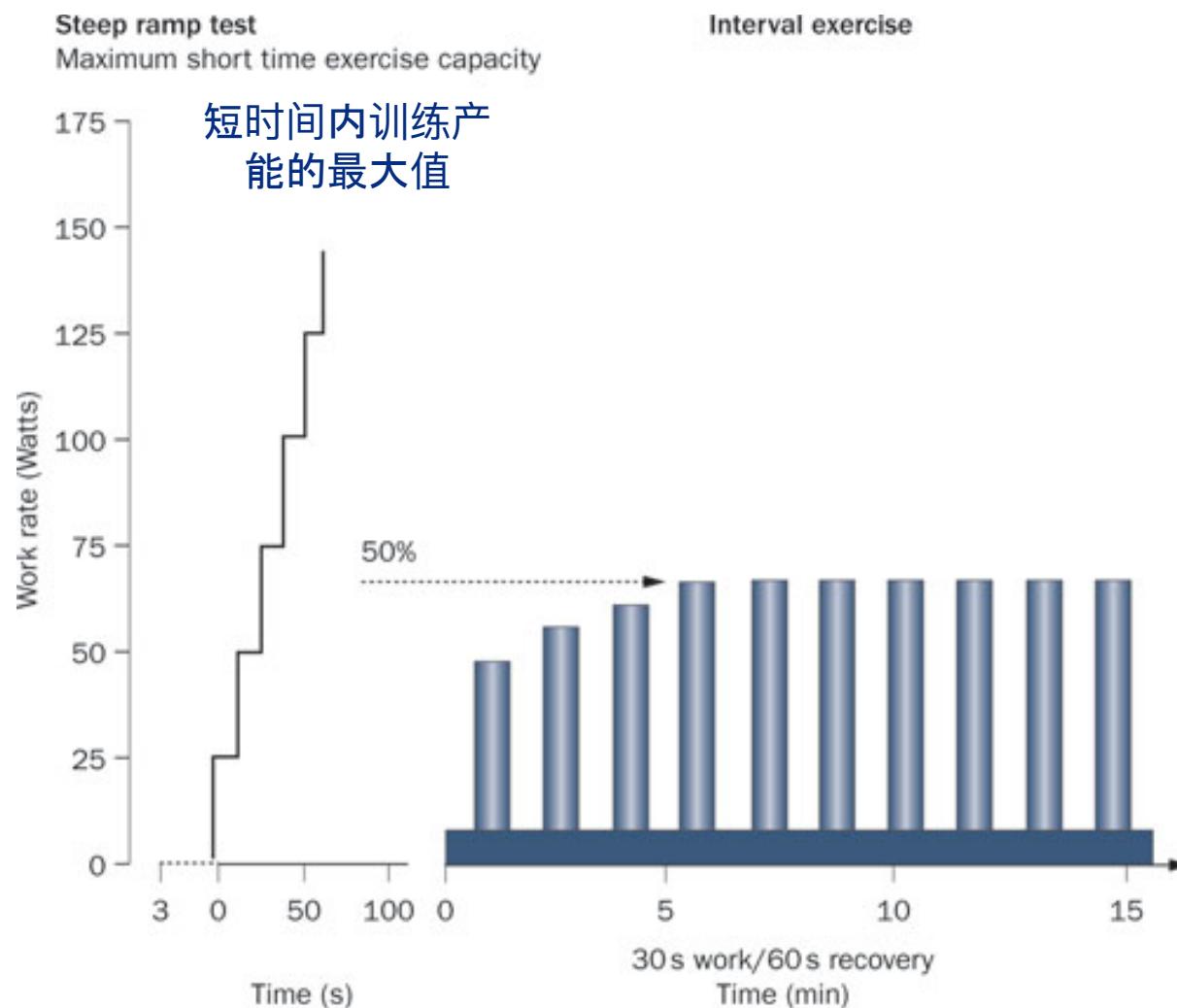
- Appropriate exercise supervision 适当的训练监测



**ergoline**  
MOVING TO HEALTH

# CR – how to monitor exercise training – interval training

## 心脏康复-如何监测运动训练-间隔训练



Meyer et al. 1997

## Endurance vs. Interval Training 耐力vs.间隔训练



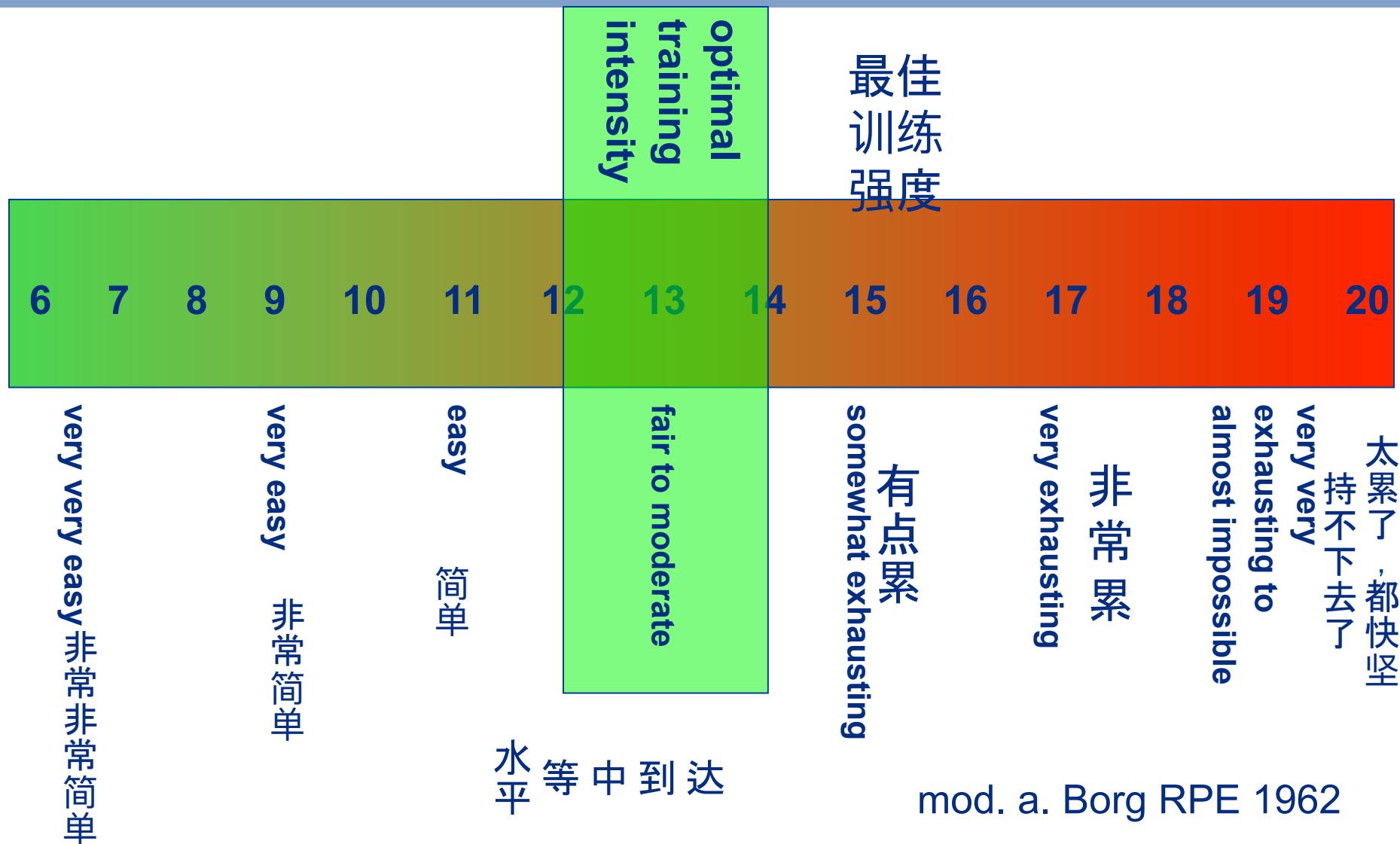
Fig.  
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Academy

**CR – how to monitor exercise training – Borg scales**

**SIEG REHA**

SIEG PHYSIO-SPORT

# 心脏康复-如何监测运动训练-borg量表

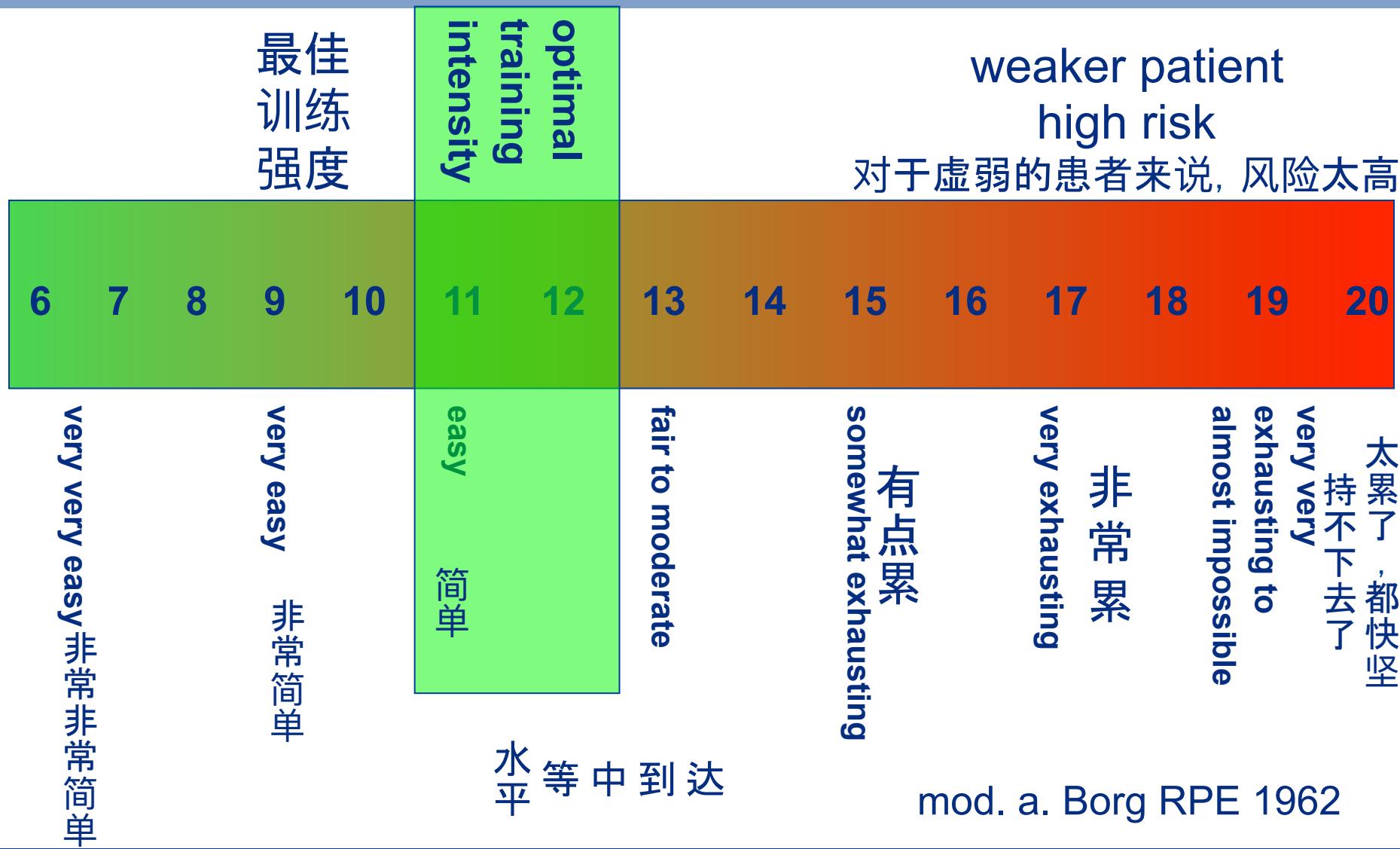


# CR – how to monitor exercise training – Borg scales

心脏康复-如何监测运动训练-borg量表

SIEG REHA

SIEG PHYSIO-SPORT

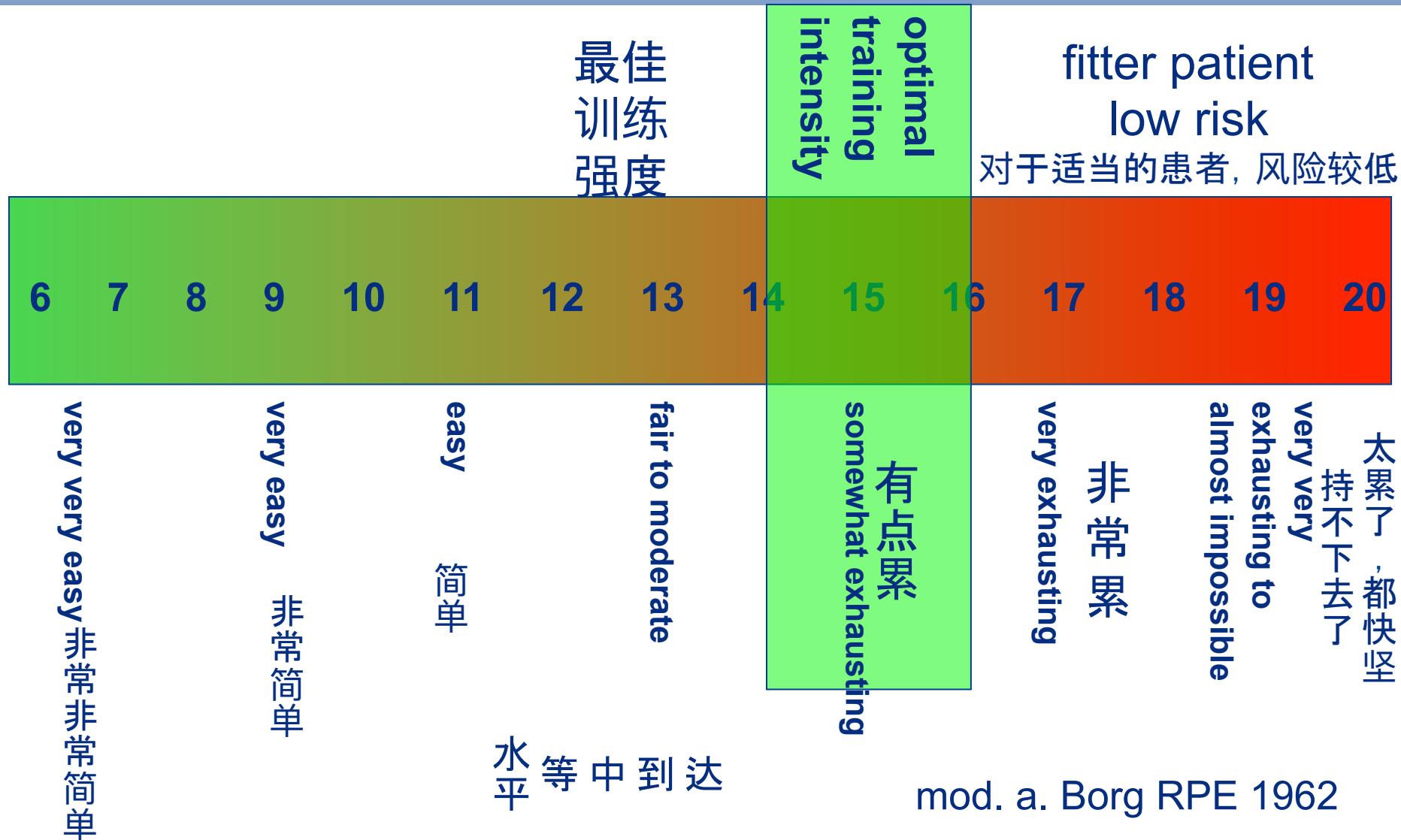


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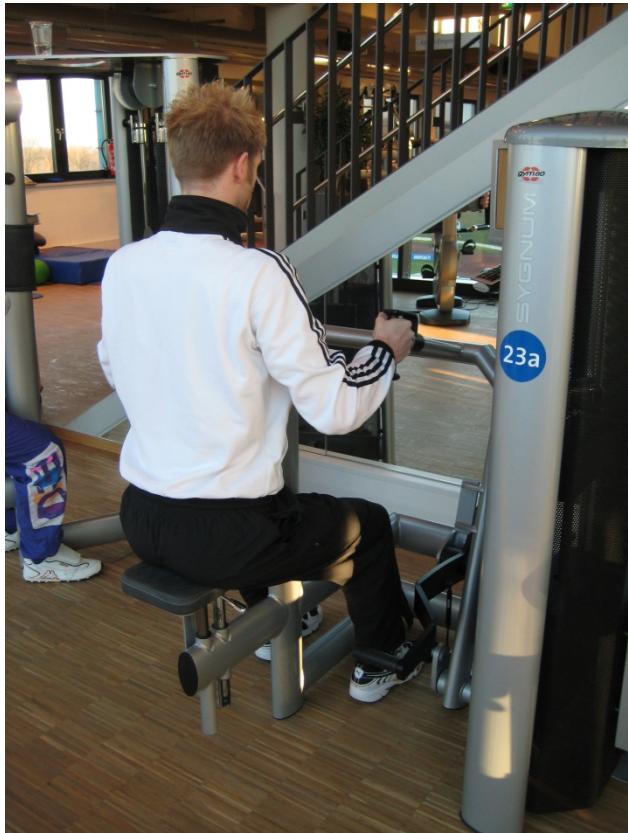
心脏康复-如何监测运动训练-borg量表

SIEG REHA

SIEG PHYSIO-SPORT







- **maximum voluntary contraction (MVC) or syn.**

最大随意收缩或者 (MVC)

## 1-repetition maximum (1-RPM) 一次重复最大力量

- intraarterial blood pressure measurements in cardiac patients have demonstrated that during low-intensity resistance training [40–60% MVC] with 15 to 20 repetitions, only modest elevations in blood pressure are revealed, similar to those seen during moderate endurance training 心脏病患者 动脉血压测量显示，在低强度的抗阻力训练 [40%-60% MVC] 15至20次重复，只有血压的中度升高，类似中等强度耐力训练中看到。

Bjarnason-Wehrens el al 2004

## Implementation of dynamic strength training in patients with cardiovascular disease

Stage	Aim	Intensity	Repetitions per muscle group	Training frequency
Initial (pre-training)	Implementation of exercise; improvement of self-perception and coordination; learning to correctly perform exercise	<30% I-RM RPE $\leq 11$	5–10	2–3 training units per week, 1–3 sets each unit
Improvement stage I	Improvement of aerobic endurance and coordination	30–50% I-RM	10–15	2–3 training units per week; 1–3 sets each unit
Improvement stage II	Increase muscle mass; improvement of coordination	40–60% I-RM (>60% in selected patients)	10–15	2–3 training units per week; 1–3 sets each unit
Improvement stage III	Increase in muscle strength	60–80% I-RM (in selected patients in good clinical condition and with heavy physical employment or those returning to sport)	8–10	2–3 training units per week; 1–3 sets each unit

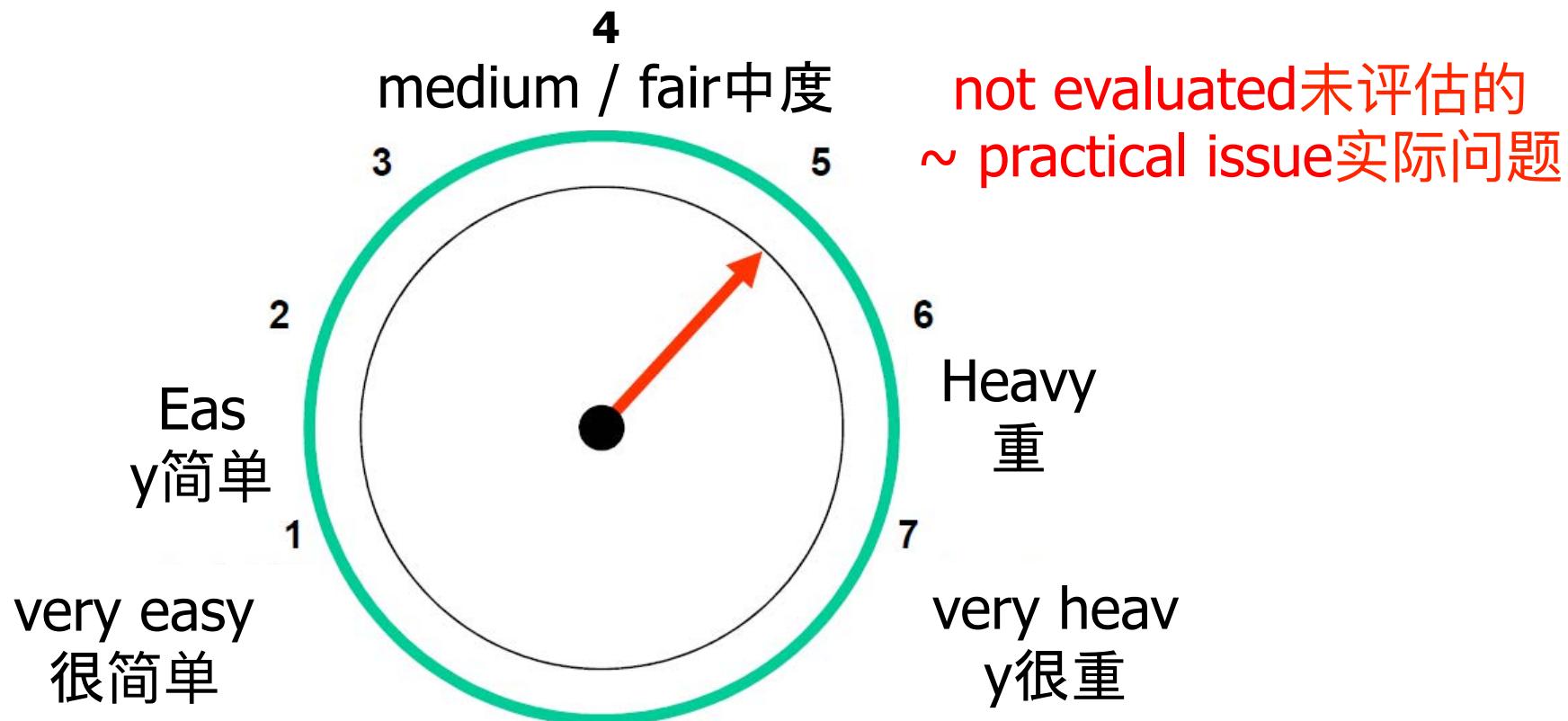
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- always **dynamic** stress-form 永远都是动态压力形式
- **beginning with less than 30% of MVC / 1-RPM**  
开始时，要低于30%MVC / 1-RPM
- gradually building intensity up to 50 (80 in stage III) % 逐渐增加强度至50%(第三阶段80%)
- muscle **build-up training** finally possible (less repetitions) 最终练习肌肉是可能的（较少的重复）

Bjarnason-Wehrens el al 2004, Vanhees et al 2012



- “speedometer” of resistance training 阻力训练速度计



- **Exercise for cardiac patients in CR phase II and III as safe as exercise for „healty“ subjects**
- 对心脏病患者做向对健康”主体“一样的阶段二和阶段三的训练
- **the results outline the potential risks!**结果概述了潜在的风险
- in modern, supervised CR centres: 在现代，监控下的心康中心
- 1/50.000 bis 1/120.000 side effects / training hours  
1/50.000 到1/120.000副作用/训练时间
- 2 deaths in 1.500.000 training hours 1.500.000训练时间内有2人死亡



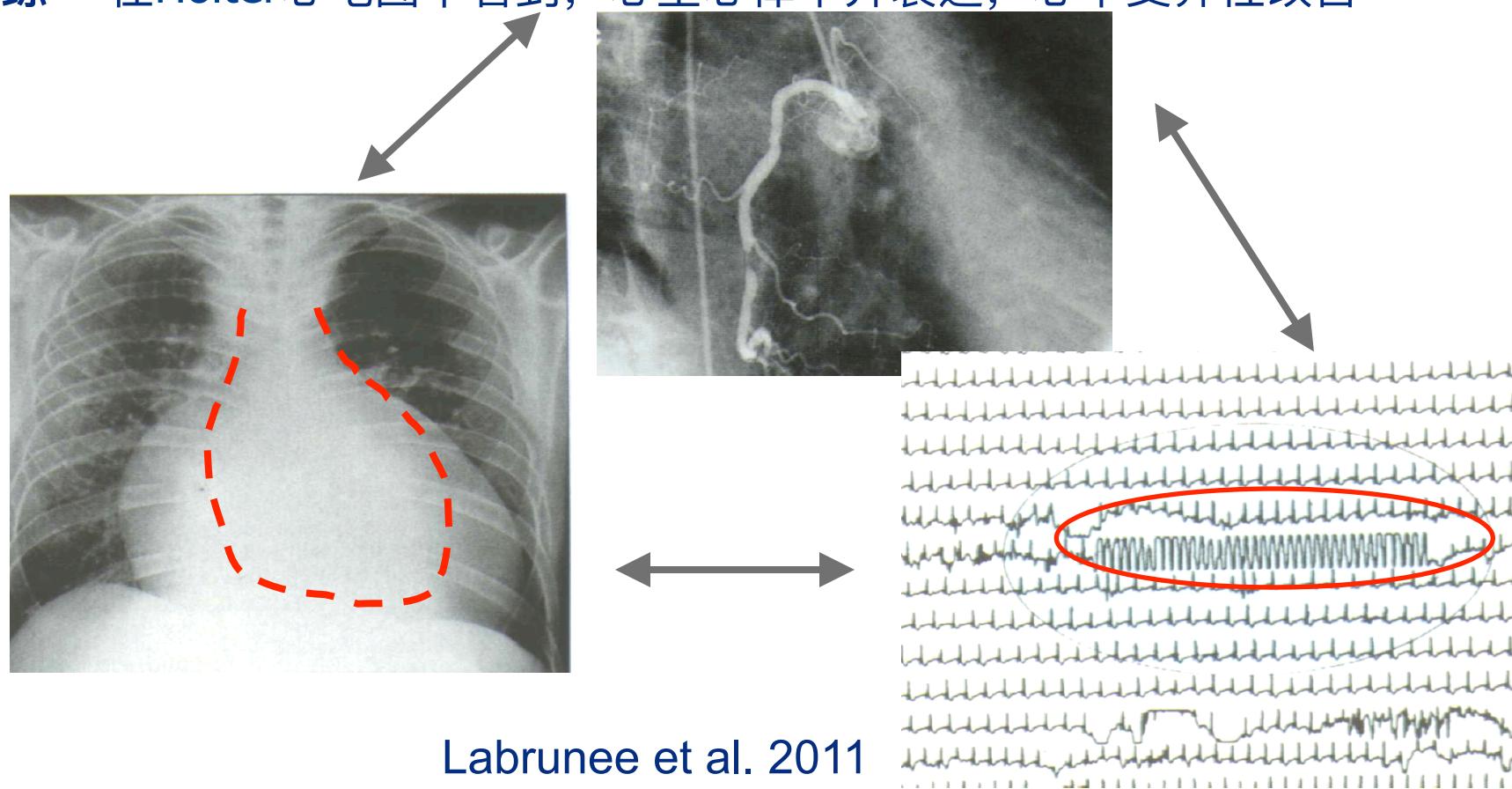
Franklin et al., Chest 114 (1998): 902-906

- 1/2200 traumatic side effects / training hours in CR phase III  
1/2200创伤性副作用/在心脏康复阶段三训练时间

Wenger et al. Clinical practice guidelines 17: Cardiac Rehabilitation as Secondary Prevention (1995) AHCPR Publ. 96-0672

### exercise: regression of ventricular arrhythmia and improvement of heart rate variability (HRV) in Holter-ECG

训练： 在Holter心电图中看到，心室心律不齐衰退，心率变异性改善



Labrunee et al. 2011



### 心血管疾病风 险在冠心病患 者中高强度和 中强度有氧训 练的对比



#### **Cardiovascular Risk of High- Versus Moderate-Intensity Aerobic Exercise in Coronary Heart Disease Patients**

Oivind Rognmo, Trine Moholdt, Hilde Bakken, Torstein Hole, Per Mølstad, Nils Erling Myhr,  
Jostein Grimsmo and Ulrik Wisloff

*Circulation.* 2012;126:1436-1440; originally published online August 9, 2012;  
doi: 10.1161/CIRCULATIONAHA.112.123117

- n = 4846 patients in 3 Norwegian CR centres
- n=4846 名病人，在挪威心脏康复中心
- 175820 training units (TU) in 7 years 七年内175820个训练单元

# Circulation

JOURNAL OF THE AMERICAN HEART ASSOCIATION



## Cardiovascular Risk of High- Versus Moderate-Intensity Aerobic Exercise in Coronary Heart Disease Patients

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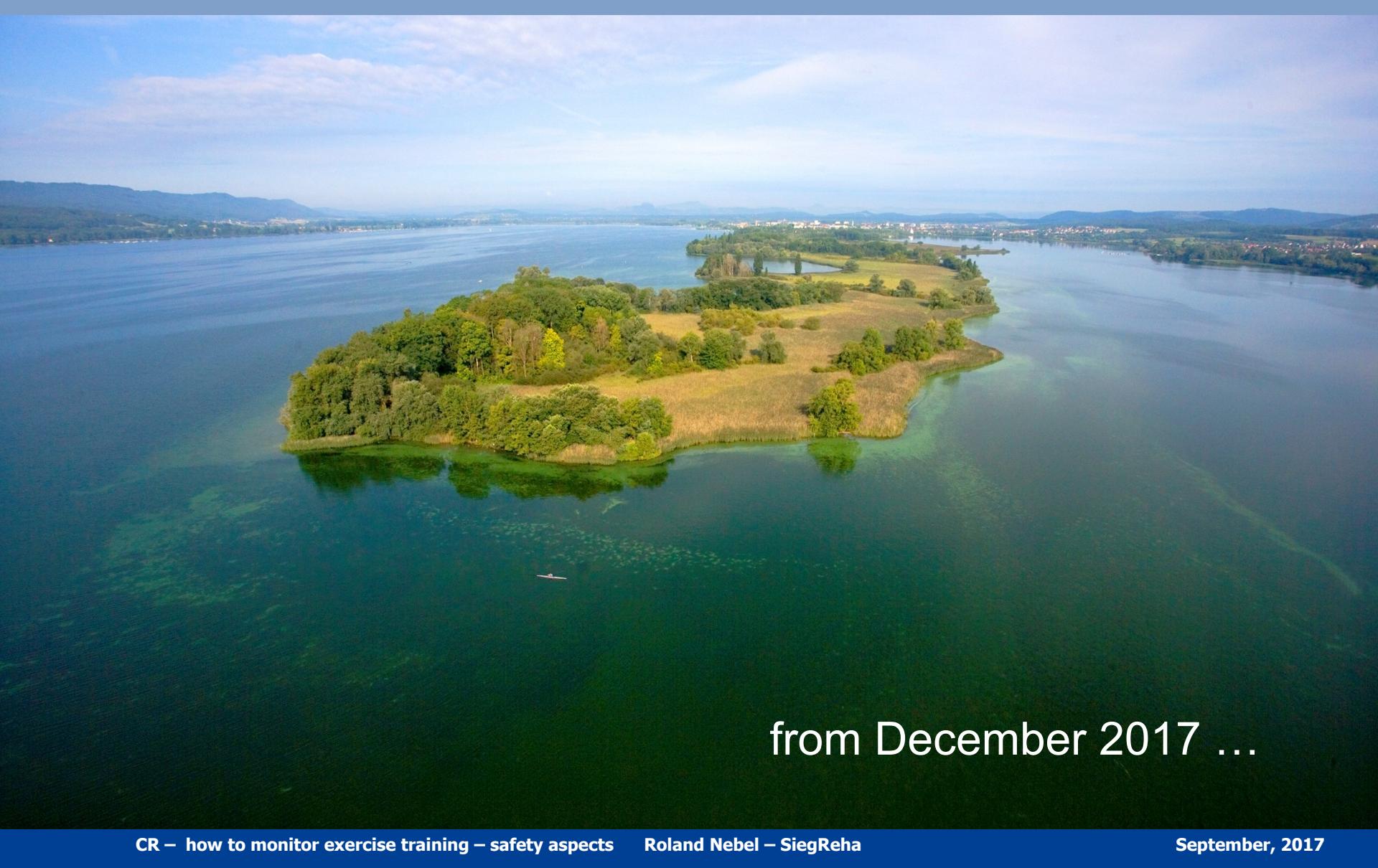
- **risk of a cardiac arrest 1:58607 TU  
(total)心脏骤停的风险： 1:58607训练单元**
- 1 patient with MCT / moderate training-intensity (letal, estimated risk 1:129.456 TU)  
一名患者MCT /中度训练强度 (致命的， 预计风险1:129.456 训练单元)
- 2 patients with HIIT / high training-intensity (non-lethal, estimated risk 1:23.182 TU)  
两名患者HIIT / 高训练强度 (非致命的， 预计风险1:23.182 训练单元)

**(3 patients in  
(一共3名病人)**

Rognmo et al. 2012

# Thank you very much for your attention

感谢您的聆听



from December 2017 ...

# Thank you very much for your attention

感谢您的聆听



[roland.nebel@mettnau.com](mailto:roland.nebel@mettnau.com)

