Resistance Training in Cardiac Rehabilitation

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Introduction

- Aerobic exercise has been recommendations for cardiac rehabilitation for more than 30 years
- Only in recent years have recommendations for a resistance training in cardiac rehabilitation
- Scientific recommendation in AHA, AACVPR and ACSM have been published in the last few years for CAD patients

Pollock ML, 2000 ; Fletcher GF, 2001 ; Shephard RJ, 1999. Circulation

AHA Science Advisory for Resistance Exercise

AHA Science Advisory

Resistance Exercise in Individuals With and Without Cardiovascular Disease

Benefits, Rationale, Safety, and Prescription

An Advisory From the Committee on Exercise, Rehabilitation, and Prevention, Council on Clinical Cardiology, American Heart Association

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Position paper endorsed by the American College of Sports Medicine

Although exercise programs have traditionally emphasized dynamic lower-extremity exercise, research increasingly suggests that complementary resistance training, when appropriately prescribed and supervised, has favorable effects on muscular strength and endurance, cardiovascular function, metabolism, coronary risk factors, and psychosocial well-being. This advisory reviews the role of resistance training in persons with and without cardiovascular disease, with specific reference to health and fitness benefits, rationale, the complementary role of stretching, relevant physiological considerations, and safety. Participation criteria and prescriptive guidelines are also provided.

Aerobic endurance training weighs higher in the development of maximum oxygen uptake ($\dot{V}O_2max$) and associated cardiopulmonary variables, and it more effectively modifies cardiovascular risk factors associated with the development of coronary artery disease. Resistance training offers greater development of muscular strength, endurance, and mass. It also assists in the maintenance of basal metabolic rate (to complement aerobic training for weight control), promotes independence, and helps to prevent falls in the elderly.[5,7] Resistance training is particularly beneficial for improving the function of most cardiac, frail, and elderly patients, who benefit substantially from both upper- and lower-body exercise.[3,4]

Strength needs of cardiac patients

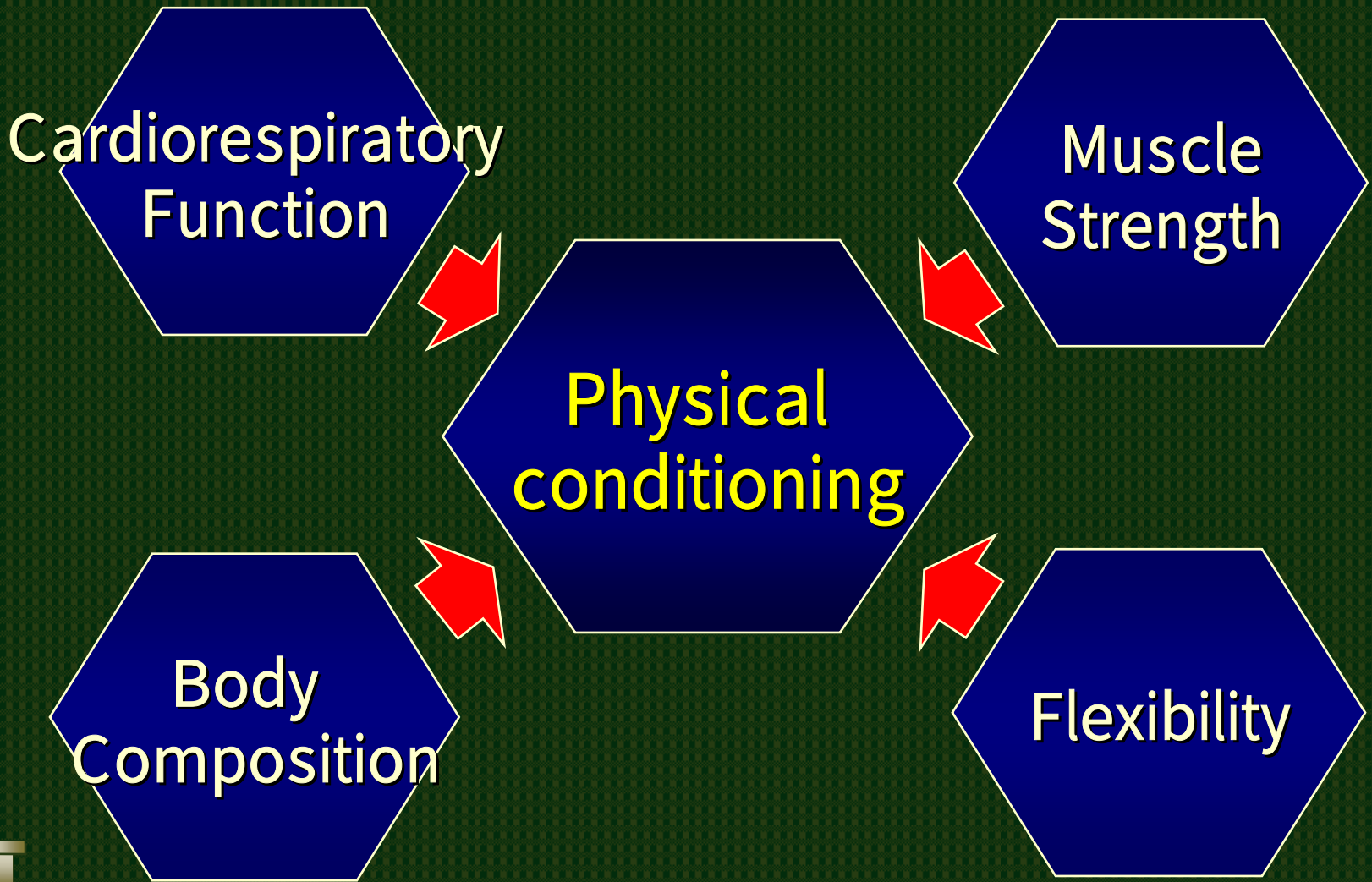
- Muscle strength decrease by about 30% between the third and sixth decades of life
- Decreases of muscle strength can be attributed to long-term bed-rest, physical inactivity, or glucocorticoid therapy(transplanted)
- In elderly cardiac patients, this muscle weakness causes a more significant impairment than the cardiovascular disease itself

Bjarnason et al. Eur J Cardiovasc Prev Rehabil. 2004

Strength needs of cardiac patients

- Occupational task / leisure time activities
- Orthopedic injury prevent
- Self-confidence, psychosocial well-being and quality of life
- Rapid and more efficiently return to Job
- Proprioceptive abilities / coordination
- Other benefits

Well-rounded exercise-based cardiac rehabilitation

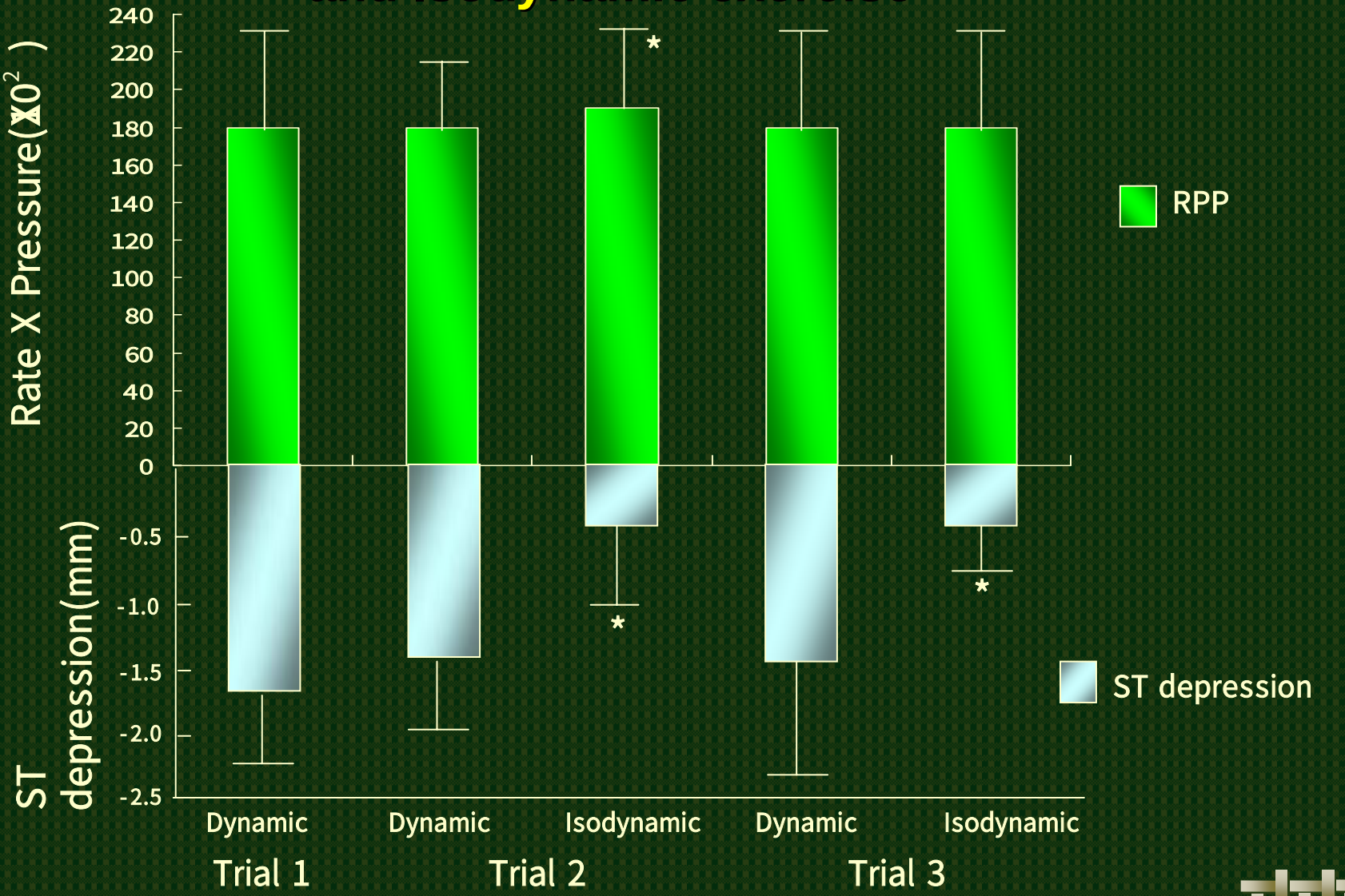


Safety of resistance training

- In the early years of cardiac rehab, most patients with CHD were told to avoid resistance training or lifting anything
- Concerns about exaggerated HR and BP responses and potential to induce threatening arrhythmias, transient ventricular dysfunction and myocardial ischemia
- In recent years, scientific information accumulated on the safety and effectiveness of resistance training
- Resistance training as compared with aerobic training at similar levels of metabolic work generally fails to elicit angina pectoris, ST changes, or ventricular arrhythmias

DeBusk, 1978 ; Wenger 1995 ; Squires, 1991 ; Steward, 1998

RPP and ST depression during trials of dynamic and Isodynamic exercise



Bertagnoli. et al Am J Cardiol. 1990

Safety of resistance training

- BP during weightlifting remains within a clinically acceptable range when lifting is performed at 40% of 1 RM
- RPP may be similar to aerobic exercise because higher BP but lower HR responses during resistance training
- Lower HR combined with higher BP may enhance coronary perfusion during diastole
- No deleterious effects on left-ventricular diastolic function and no adverse effects on left-ventricular systolic function in normal LV function at rest

Comparison of effects of aerobic endurance training with strength training on health and fitness variables

Variable	Aerobic exercise	Resistance exercise
Bone mineral density	↑	↑
Body composition		
%BF	↓	↓
LBM	↔	↑
Strength	↔	↑↑
Insulin sensitivity	↑	↑
Lipid profiles		
HDL	↑ ↔	↑ ↔
LDL	↓ ↔	↓ ↔

Pollock et al. 2000 Circulation

Comparison of effects of aerobic endurance training with strength training on health and fitness variables

Variable	Aerobic exercise	Resistance exercise
Resting HR	↓↓	↔
Stroke volume (resting / exercise)	↑↑	↔
BP at resting		
SBP	↓↔	↔
DBP	↓↔	↓↔
VO2max	↑↑↑	↑↔
Maximal endurance time	↑↑↑	↑↑
Basal metabolism	↑	↑↑

Pollock et al. 2000 Circulation

Randomized Controlled Trails of Resistance Training in Patients with Coronary Artery Disease

Keleman et al. JACC 1986

- N : 40
- Cardiac events : MI / CABG / AP
- Weeks after event : > 12 weeks
- Training protocol

- Exp : 20 min aerobic ex + 2 sets of 10-15 reps at 40% of 1RM(8 stations), 3 times/wk for 10 weeks
- Con : 20 min aerobic ex + 20 min game activity, 3 times/wk for 10 weeks

- Results

- Exp : strength 24%, treadmill time 12%
- Con : strength 7%, treadmill time 2%

% Change in maximal strength after 10 weeks of different types of training

Exercise	Combined resistance & aerobic training	Aerobic training alone
Vertical fly	26.9*	9.0
Arm curl	11.8*	0.0
Shoulder press	17.0*	7.0
Leg curl	27.0*	19.0*
Bench press	6.0*	-2.0
Leg extension	52.0*	12.0

**p<0.05*

Kelemen et al. 1986

McCartney et al. Am J Cardiol 1991

- N : 24
- Cardiac events : MI / CABG / AP
- Weeks after event : > 4 weeks
- Training protocol

- Exp : 35 min aerobic ex + 2 sets of 10-15 reps at 50% of 1RM(4 stations), 2 times/wk for 10 weeks
- Con : 35 min aerobic ex + 25 min game activity, 2 times/wk for 10 weeks

- Results

- Exp : strength 29%, treadmill time 15%
- Con : strength 8%, treadmill time 2%

Beniamini et al. J Cardiopul Rehab 1998

- N : 29(M) / 9(F)
- Cardiac events : MI / CABG / PTCA / AP
- Weeks after event : 6 - 16 weeks
- Training protocol

- Exp : 35 min aerobic ex + 3 sets of 8 -12 reps at 50-80% of 1RM, 2 times/wk for 12 weeks
- Con : 35 min aerobic ex + flexibility exercise, 2 times/wk for 12 weeks

- Results

- Exp : strength 67%, treadmill time 28%
- Con : strength 9%, treadmill time 15%

Stewart et al. J Cardiopul Rehab 1998

- N : 23
- Cardiac events : MI
- Weeks after event : 4 - 6 weeks
- Training protocol

- Exp : 8 min aerobic exercise + 2 sets of 10 -15 reps at 40% of 1RM (6 stations), 3 times/wk for 10 weeks
- Con : 25 min aerobic exercise, 3 times/wk for 10 weeks

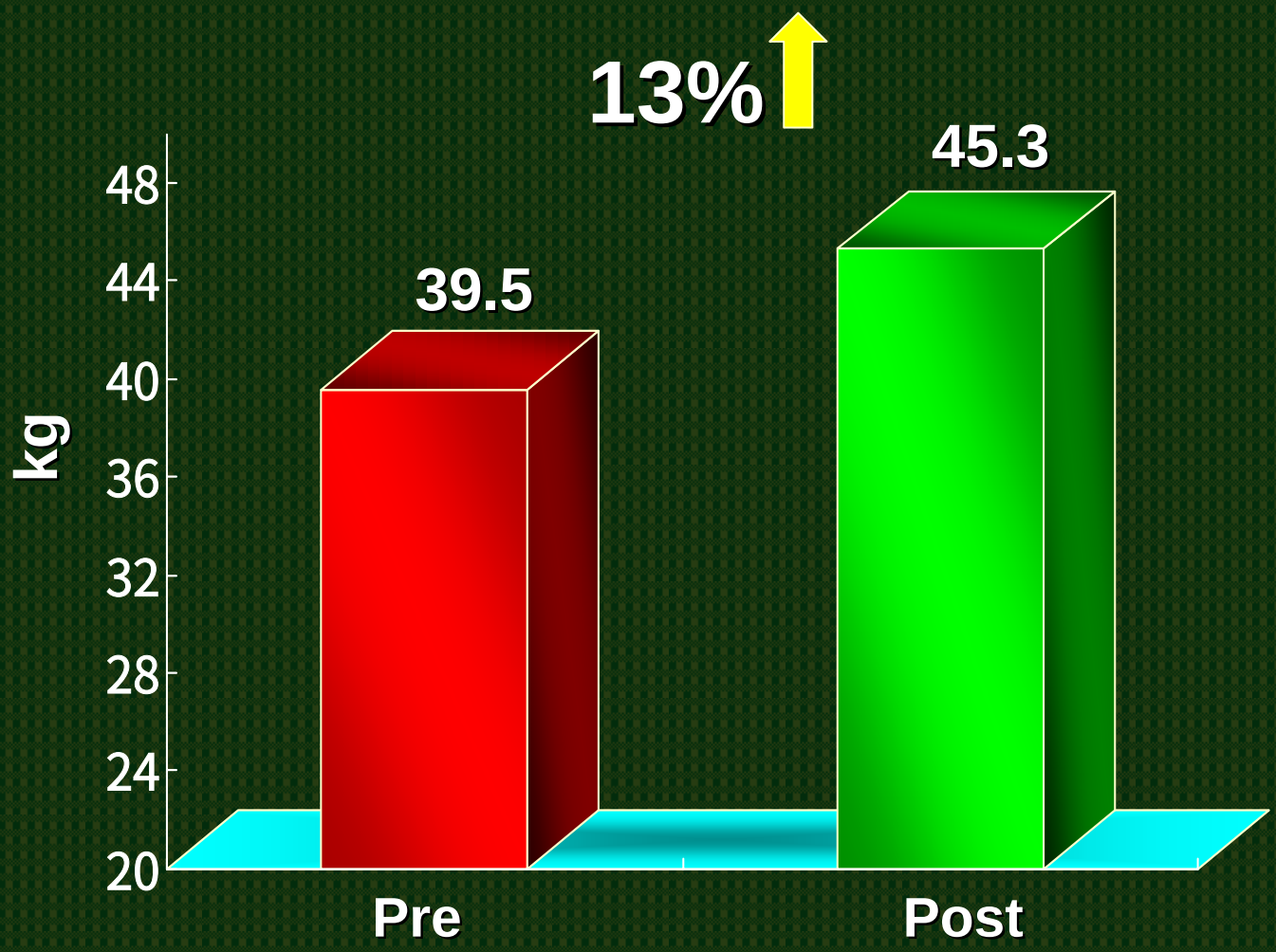
- Results

- Exp : strength 23%, VO2peak 14%
- Con : strength 10%, VO2peak 8%

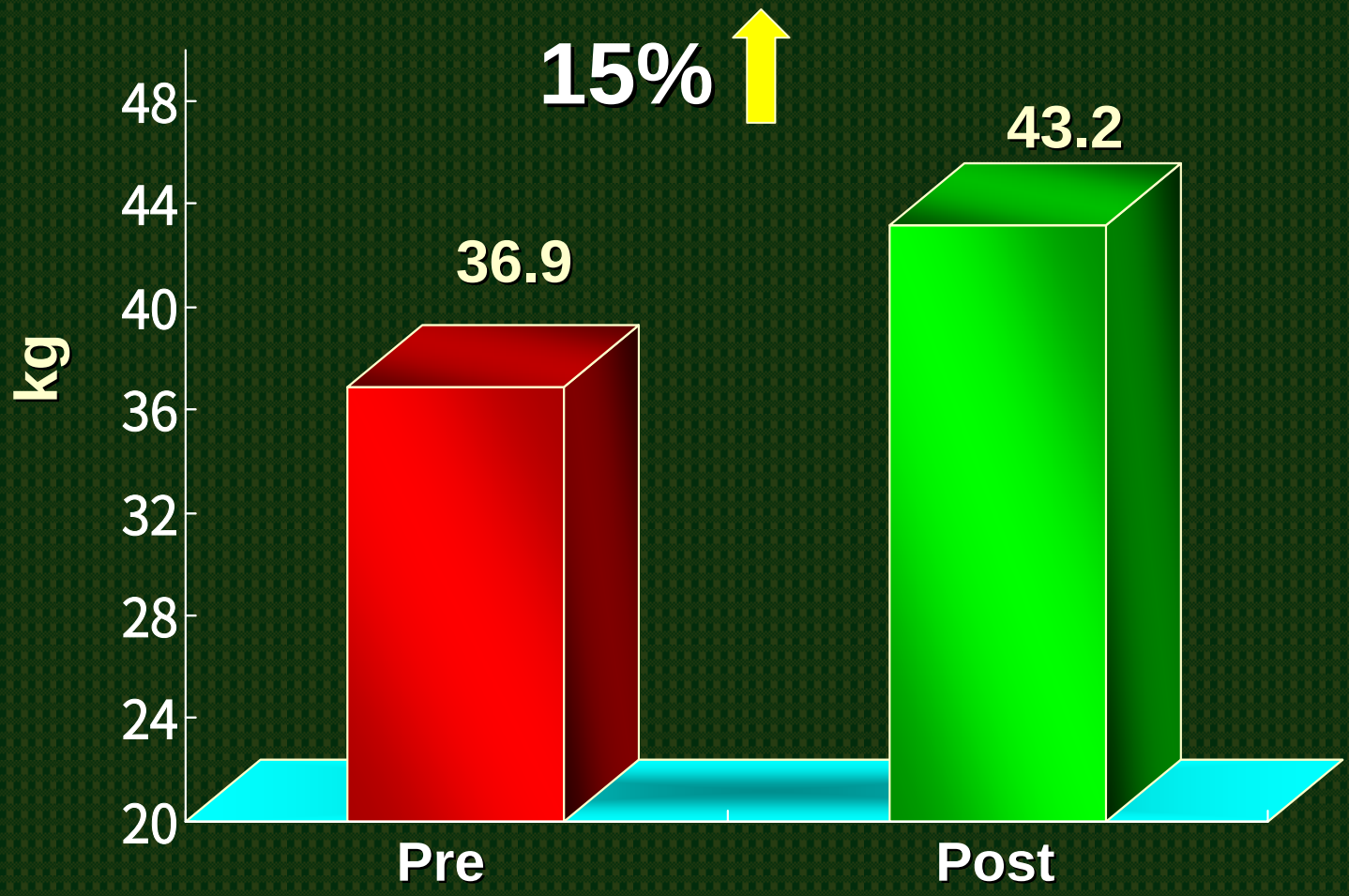
Samsung Medical Center. unpublished 1998

- N : 13(M)
- Cardiac events : MI / AP
- EF : 46%
- Weeks after event : > 5 - 6 wk
- Training protocol
  - 36 min aerobic exercise
  - 2 sets of 10-15 reps
  - 40 - 60% of 1RM
  - 3 stations(chest press, abdominal, knee extension)
  - 3 times / weeks
  - 6 weeks
- No cardiovascular complications during resistance training

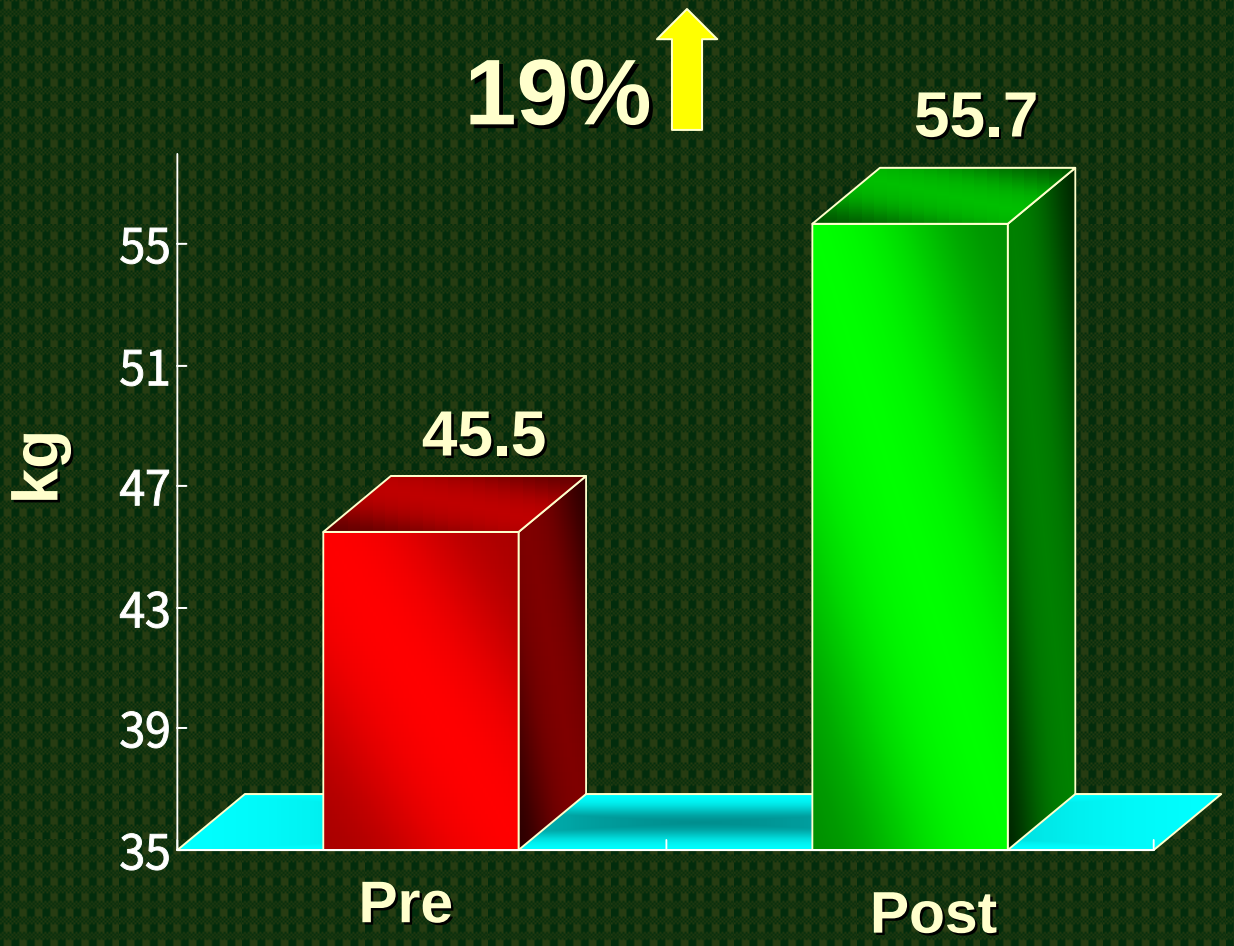
Chest Press



Abdominal



Knee extension



Physiological responses to aerobic exercise

Dynamic exercise ”volume load”

- Large increases in cardiac output

  - stroke volume and heart rate rise

- progressive increase in SBP
- Maintenance or slight decrease in DBP
- Reduce in peripheral vascular resistance

Physiological responses to Isometric exercise

Static exercise "Pressure load"

- Moderate increase in cardiac output
- Minimal change in peripheral vascular resistance
- Substantial rise in systolic, diastolic and mean BP

- combination of vasoconstriction and increased CO

- Pressor response to static exercise depend on the %

MVC, duration, muscle mass and muscle strength

Isodynamic exercise

- Combination of static and dynamic contractions
- Circulatory response to static exercise is diminish as the component of dynamic activity increases
- Mild DBP increase and longer diastolic duration during isodynamic may benefits to enhance coronary perfusion

Resistance training equipment

Inpatient (phase /)

- Use light resistive equipment
- Light dumbbells
- Squeeze balls
- Low-tension elastic bands
- Light resistive calisthenics

Resistance training equipment

Outpatient (phase // - ///)

- Use lighter levels of resistance during the early session to avoid potential injury
- Machine weights
- Free weights
- Hand/wrist/ankle weights
- Walking poles
- Elastic bands/tubes

AACVPR guidelines for beginning resistance training

- Minimum of 5 weeks after MI, including 3 weeks of continuous participation in aerobic exercise
- Minimum of 8 weeks after CABG, including 3 weeks of continuous participation in aerobic exercise
- Minimum of 2 weeks of consistent participation in aerobic exercise following PCI

AACVPR(1999)

Absolute contraindications(I)

- Resting, changing pattern, or new onset of angina pectoris
- Complex supraventricular or ventricular dysrhythmias at rest or dysrhythmias that worsen with exercise
- Uncompensated or symptomatic congestive heart failure
- Recent MI, CABG, or episode of cardiac arrest(< 2 weeks)
- Multiple or complicated MI
- Severe or symptomatic aortic stenosis
- Severely depressed LV function(EF < 30%)
- Severe CAD(left main or triple vessel)
- Exertional hypotension(>15mmHg) or failure of BP to rise during GXT
- Resting SBP > 200mmHg and/or DBP >105mmHg

AACVPR, ACSM, and AHA(1995)

Absolute contraindications (II)

- Recent change in the resting ECG suggesting infarction or other acute cardiac event
- Significant exercise-induced ST segment depression(> 3mm horizontal or downsloping)
- Recent complicated MI or recurrent / persistent ischemic symptoms post-cardiac event
- Active or suspected myocarditis, pericarditis, or endocarditis
- Thrombophlebitis or intracardiac thrombi
- Hypertrophic cardiomyopathy
- Acute pulmonary embolus or pulmonary infarction
- Third-degree or advanced atrioventricular block
- Other

AACVPR, ACSM, and AHA(1995)

Relative contraindications

- Excessive BP rise with resistive exercise : SBP > 220mmHg or DBP > 110mmHg
- Frequent or complex ventricular ectopy
- CHF or congenital heart defects
- Ischemic cardiomyopathy
- Moderate valvular heart disease
- Low exercise capacity(<3METs)
- Recent survivor of cardiac arrest
- Resting SBP > 180mmHg and/or DBP > 100mmHg

AACVPR, ACSM, and AHA(1995)

Determining resistive training workload

- 1 RM method widely used in cardiac rehab program
- How safe is 1 RM testing for cardiac rehab?
- Most study reported that no ST change, serious arrhythmias, abnormal HR/BP responses, sternotomy complications during resistive testing up to 100% of MVC
- Although 1 RM testing may be suitable for many cardiac patients, Inappropriate for certain individuals(older or LV dysfunction patients)
- Caution and screen participants carefully

Exercise mode

- Isometric : Handgrip dynamometer, Sponge type squeeze
- Isotonic : Dumbbells, Barbells, Weighted bags, Machines
- Isokinetic : Cybex, Biodex
- Avoid exercise with pressure on the sternum(heavy bench press) in recent chest surgery
- Cause in prescribing above the shoulder arm exercise(military press) for patients with poor or unknown LV function because high BP responses

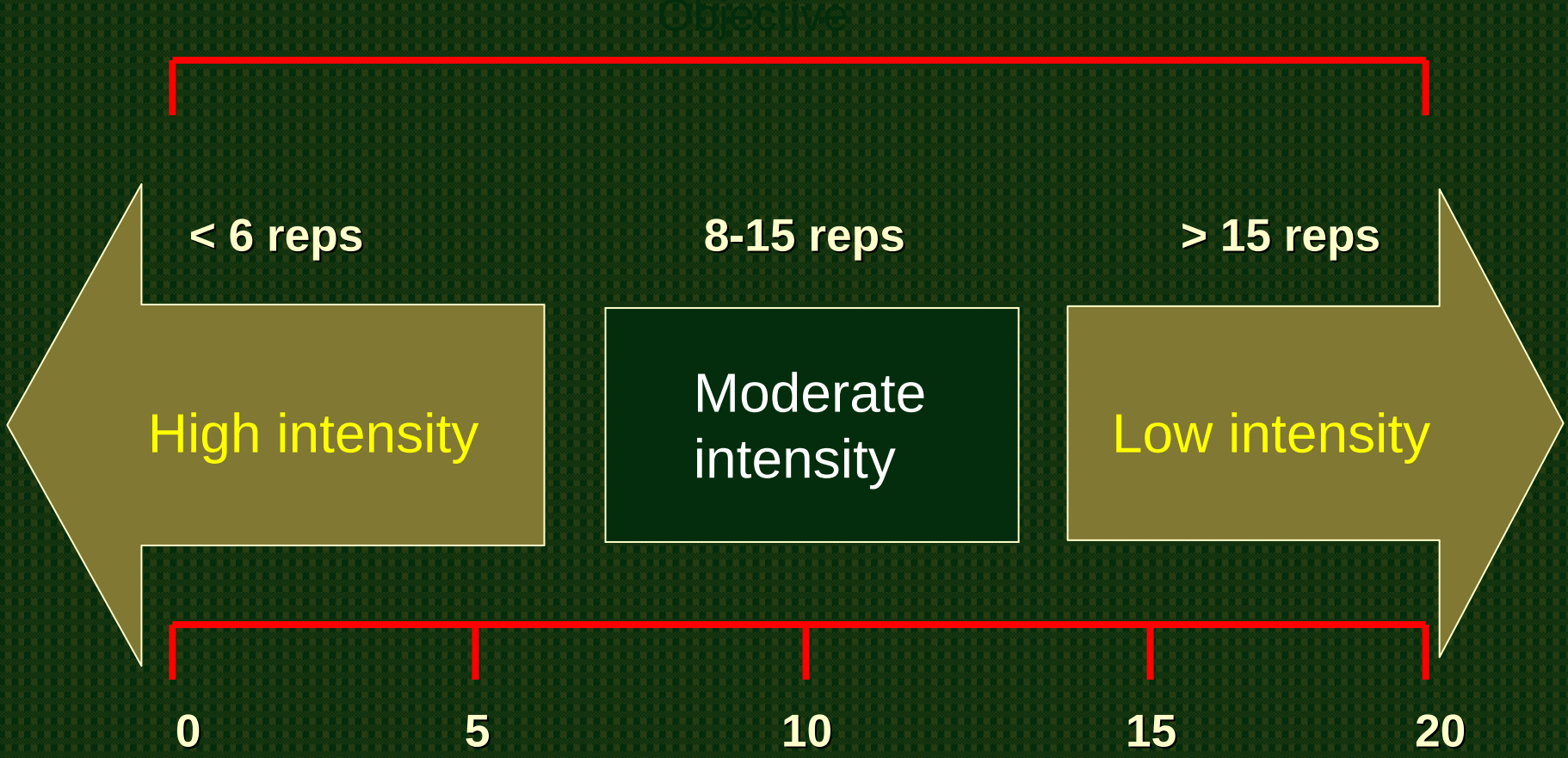
Exercise intensity

- Initially, Use the lightest resistance possible that can be lifted comfortably
- The AACVPR recommended that Workload of 30 – 50% of 1 RM and 8 – 10 reps comfortably
- RPE range from 11 to 14
- Heavy or highly reps resistive training may increase the hemodynamic response and cardiovascular risk
- Lighter resistive training may overall be more beneficial to the patient than heavier, more difficult resistive training

Number of repetitions and sets

- 10 – 15 reps of each exercise at 40 – 80% of 1 RM for strength development
- Initially, lift a light resistance for 8 – 12 reps
- Workload progressive increased up to 15 reps
- Muscular strength is best developed with higher resistance
- Muscular endurance is is best developed with higher reps
- Higher reps with lower resistance may be preferable for weaker, older, or higher-risk patients

Classification of resistance training intensity



Rate of progression

- Achieve overload by first increasing the number of repetitions perform
- Patient Should progress, over time, to no more than 15 reps per exercise
- If elastic bands and hand weight, dumbbells are used, progress by advancing to thicker bands with stronger tension and series of heavier weight over time, respectively
- Be able to progress to an exercise equivalent of 60 – 80% of 1 RM if medically stable

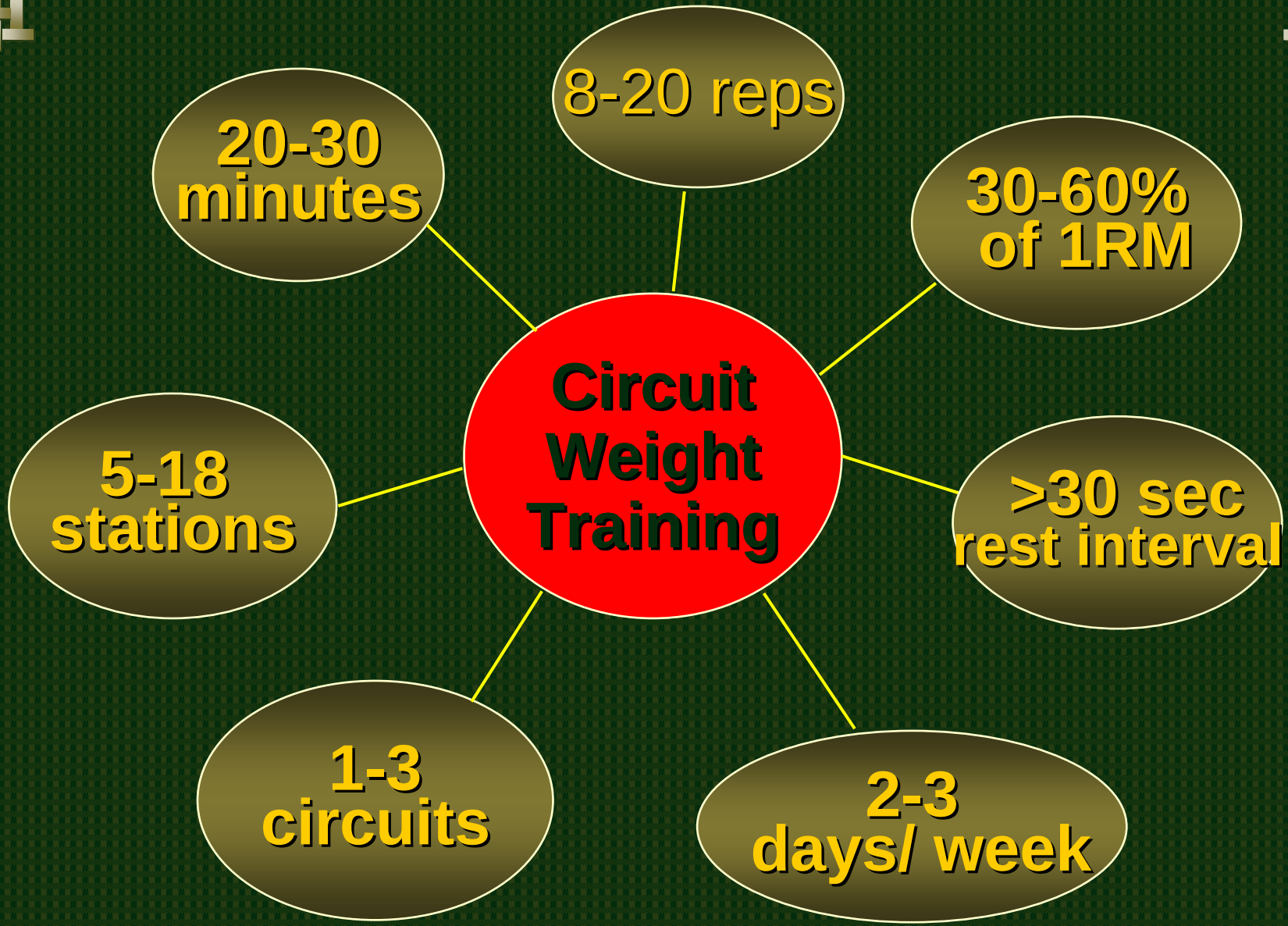
Contemporary standards, guidelines, and position statements regarding resistance training for patients with cardiovascular disease

Reference	Sets;Reps	Stations/devices	Frequency
1995 AHA Exercise standard	1 set; 10 - 15 reps	8 -10 exercises	2 – 3 d/wk
1999 AACVPR guideline	1 set; 12 -15 reps	8 -10 exercises	2 – 3 d/wk
2000 ACSM guideline	1 set; 10 -15 reps	8 -10 exercises	2 – 3 d/wk
2000 AHA advisory	1 set; 10 -15 reps	8 -10 exercises	2 - 3 d/wk

Pollock et al. 1999

Circuit weight training(CWT)

- Widely recommended for cardiac patients because this type of exercise reported to be safer than free weights
- Improve BMD, ROM, cardiovascular endurance and cardiovascular risk factors
- Be able to start with low resistance and then progressively add small, incremental loads
- The overload principle must be apply gradually for the safety and effectiveness of resistance training in cardiac patients


Circuit Weight Training
8-20 reps
20-30 minutes
30-60% of 1RM
5-18 stations
>30 sec rest interval
1-3 circuits
2-3 days/ week

Instructions for cardiac patients

- Participate in the aerobic exercise session or perform at least a 10 minute full-body warm-up before each resistive exercise session
- Breathe normally or exhale during muscle contraction, not hold breath
- Maintain a loose, comfortable grip during muscle contraction
- Perform lifting movements through a complete ROM
- Lift the weight smoothly to a count of two and lower slowly to a count of four
- Exercise all major muscle groups and work large muscles before small muscles

Criteria for termination of a resistive exercise

- Acute MI or suspicion of MI
- Sign of poor perfusion including pallor, cyanosis, or cold and clammy skin
- Central nervous systems including ataxia, verigo, visual or gait problems
- Light-headedness, confusion, nausea, or severe peripheral circulating insufficiency
- Onset of angina with resistive exercise
- Drop in SBP accompanied by signs/symptoms or drop below standing resting pressure
- Excessive BP rise measured during lifting : > 220 / 110mmHg
- Inappropriate bradycardia(decrease in HR > 10beats/min) during resistive exercise

Criteria for termination of a resistive exercise

- Supraventricular tachycardia or exercise-induced complex supraventricular arrhythmias
- Developed ST segment depression(>2 mm)
- Onset of frequent ventricular ectopy and/or V-Tach
- Exercise-induced LBBB that cannot be distinguished from a wide QRS tachycardia
- Discomfort related to past surgery(CABG, rotator cuff)
- Other

After cardiac operations

- Wound healing takes approximately 4 – 6 weeks
- Physical exertion in the sternal area (pressure or sheering stress) should be avoided for 3 months postoperative
- Before resistance training is started, the treating physician must confirm that the sternum is stable
- If there are no complications and the patient has a good cardiac performance capacity, a light and low-dose resistance exercise program focusing on the lower extremities can be carried out earlier

Fletcher GF, 2001. Circulation

After cardiac transplantation

- The continuous postoperative glucocorticoid therapy can lead to muscle atrophy and a decrease in bone mass
- Usually in addition to a previously poor musculoskeletal state and as a consequence, the daily physical stress tolerance in these patients is often extremely low
- Specific exercises designed to increase muscle strength are quite effective in this patient group
- In clinically stable patients, individually adapted, moderate resistance training can begin as soon as possible in the postoperative phase

Braith RW, 1996. JACC

After percutaneous coronary intervention

- No existing studies reporting conclusively how soon physical training can be started after an intervention
- Not be performed earlier than the 2 days to 7 days post-intervention
- Attention must be paid to any symptoms of angina pectoris and to possible complications of any indwelling catheters
- Even if the post-PTCA patient has seemingly good cardiac performance capacity, first take part in a 1–2 week aerobic training program

Patient instruction and safety

- Orients to each equipment by exercise specialist
- Instruct patients to maintain a loose, comfortable grip during muscle contraction or other methods
- Perform each exercise through a full ROM
- Stretching / flexibility exercise before and after resistance training
- Terminate as the same reasons in aerobic exercise
- Emergency equipment readily available
- Do not over of RPE 15 at early resistance training session
- Also supervise the resistance training
- Periodically review the patient’s exercise logs
- Be aware of any musculoskeletal limitations

Hemodynamic monitoring

- HR responses are significantly lower during resistive training than during aerobic exercise
- Clinically acceptable elevations in SBP with some higher DBP responses during CWT in selected cardiac patients
- The RPP(SBP × HR) may be a better indicator of cardiovascular stress during exercise
- SBP and DBP show a rapid decline after a weight lift
- The AACVPR recommends BP and ECG monitoring for selected patients, with more extensive monitoring in higher-risk patients

Conclusions

- Resistance training appears to be safe and effective in patients with CAD for developing muscular strength and cardiovascular fitness
- Strength gains in the range of 20 – 25% for most muscle groups can be expected
- Contemporary exercise-based cardiac rehabilitation have prescribed resistance training in most cardiac patients with clinically stable