BLOOD FLOW RESTRICTION: Scoping Review

Michael Jeanfavre PT, DPT, OCS, CSCS

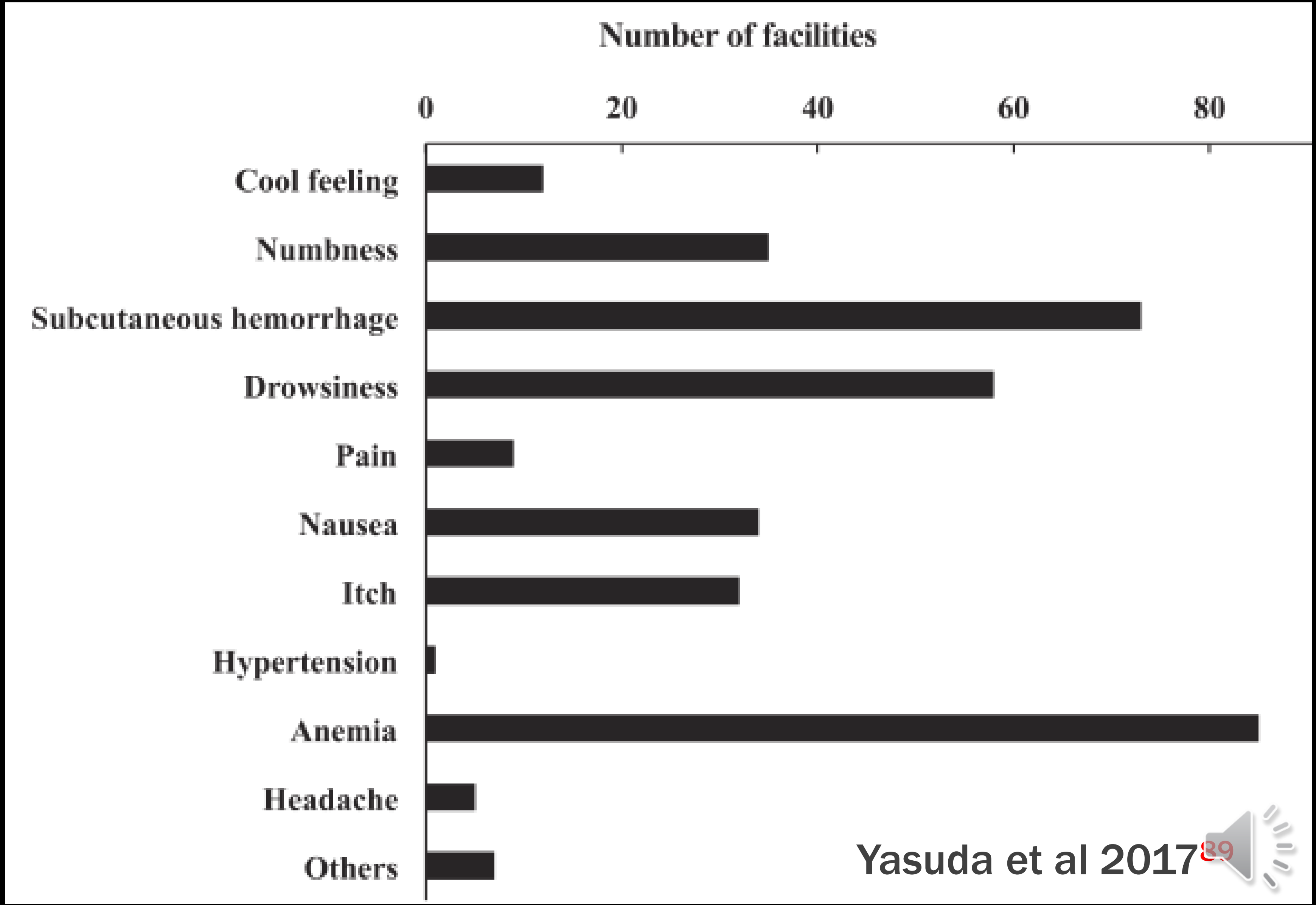
Safety & Side Effects

Safety & Side Effects

1. Systematic Reviews
2. Proposed Screening Processes
3. Study Example

Safety & Side Effects – Most Common

- 232 Facilities in Japan
- 12,827 Subjects
- Nov – Dec 2016
- Male: 30.1%
- Female 69.9%



Yasuda et al 2017

Safety & Side Effects – Rare Adverse Events

- 2006 KAATSU Training Survey sent out to 106 facilities across Japan
- Authors –3500 Subjects (2007-2011)[88]

Adverse Events	N =	Comments
Brain Hemorrhage	1	- Comparable to sudden death during athletic participation - <35 y/o: hypertrophic cardiomyopathy, cardiomegaly, coronary artery malformation aortic rupture, brain hemorrhaging - >35 y/o: Brain hemorrhaging & coronary artery disease
Venous Thrombosis	1	- BFR induces a fibinolytic state (aids in restricting thrombus formation) - Healthy: 1-3/10,000 | Pregnancy: 3-11/10,000 - Post-partum: 30-40/10,000
Transient Numbness	NR	- Subjective reports (no paper; lasts days)
Rhabdomyolysis	1	- Risk Factors: poor hydration, heat & humidity environment - Rare in BFR due to low intensity & minimal muscle damage
Venous Injury and Induration	NR	- F, 30-50 y/o, spontaneous resolution 1-2 mo. Post - Repeat Pressurization & depressurization (get vessels accustom to training) - If sedentary lifestyle, more time needed to acclimate - Adhere to KAATSU training time (15 – 20 min)

Safety & Side Effects – Adverse Events

Case Report

Syncope Episodes and Blood Flow Restriction Training

Juan Martín-Hernández, PhD,* Alejandro Santos-Lozano, PhD,*† Carl Foster, PhD,‡ and Alejandro Lucia, MD, PhD†§

n = 3

- Scientific data indicate the overall safety of BFR, at least in healthy young people.
- Caution is thus needed in the application of BFR, and gentle familiarization with this training modality is also recommended.

Martín-Hernández et al. 2018[129]

Safety & Side Effects – Reviews

Effects of blood flow restriction exercise on

REVIEW ARTICLE

COLIN W. BOND, MS[1-4] • KYLE J. HACKNEY, PhD[4]

REVIEW ARTICLE

DE GRUYTER

Scand J Med Sci Sports 2011: 21: 510–518
doi: 10.1111/j.1600-0838.2010.01290.x

SCANDINAVIAN JOURNAL OF

Blood pressure response between resistance exercise with and without blood flow

Review Article | Integrative Cardiovascular Physiology and Pathophysiology

Clinical safety of blood flow restricted training? A comprehensive review of altered muscle metaboreflex in cardiovascular disease during ischemic exercise.

Michelle Cristina-Oliveira, Kamila Meireles, Marty D. Spranger, Donal S. O'Leary, ... Show all Authors

08 NOV 2019 // https://doi.org/10.1152/ajpheart.00468.2019

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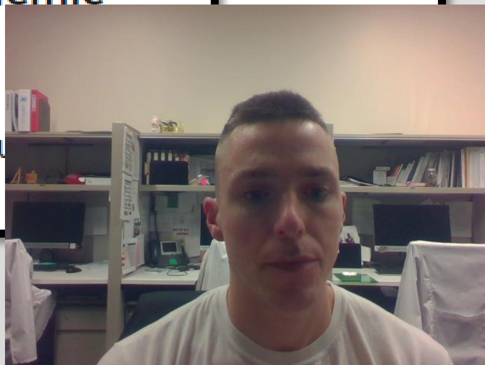


Safety & Side Effects – BFR & Blood Pressure

Blood pressure response between resistance exercise with and without blood flow restriction: A systematic review and meta-analysis

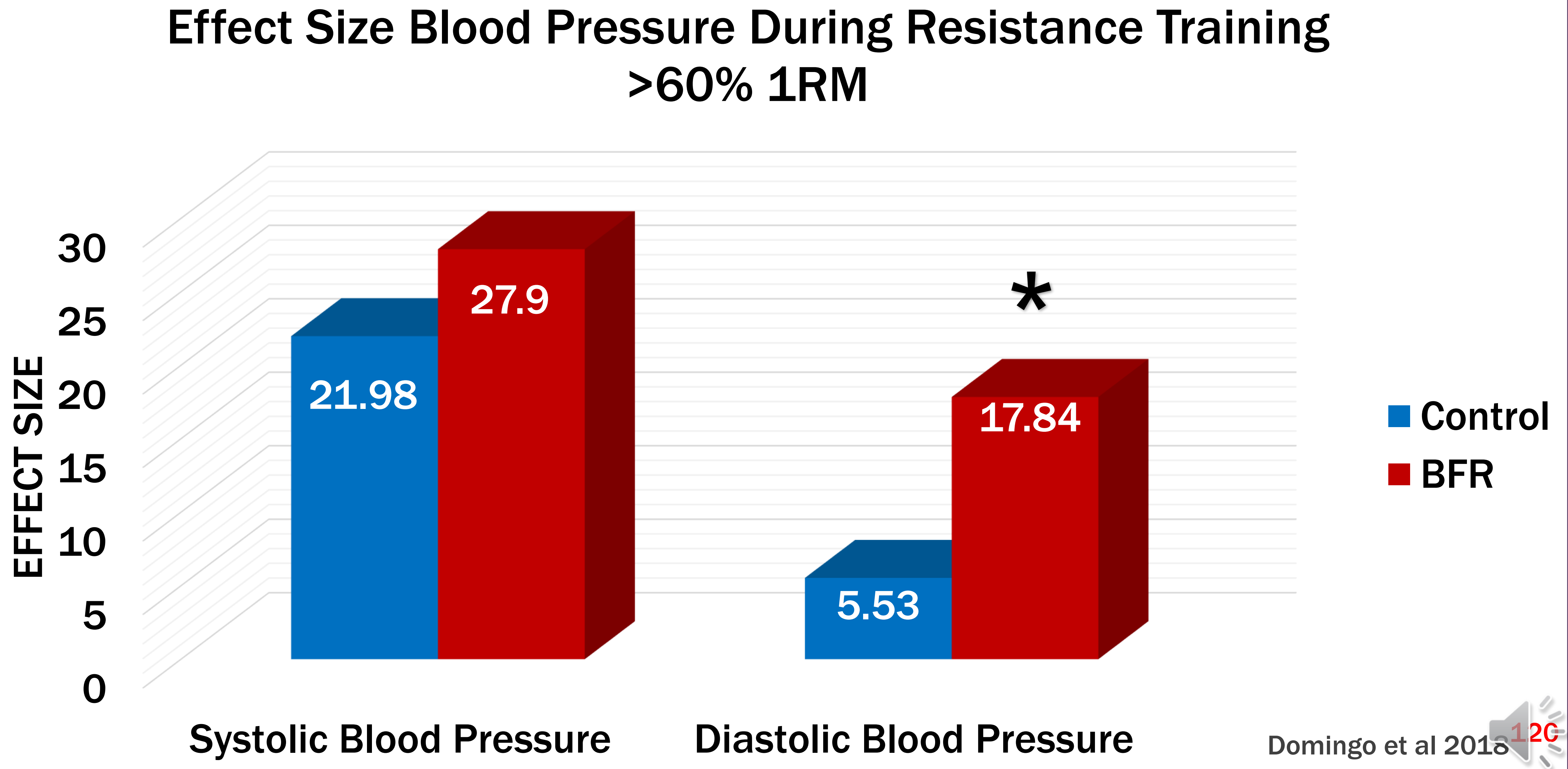
Everton Domingos, Marcos D. Polito*

Research Group of Cardiovascular Response and Exercise, Londrina State University, Londrina, Paraná, PR, Brazil

17 Included Studies

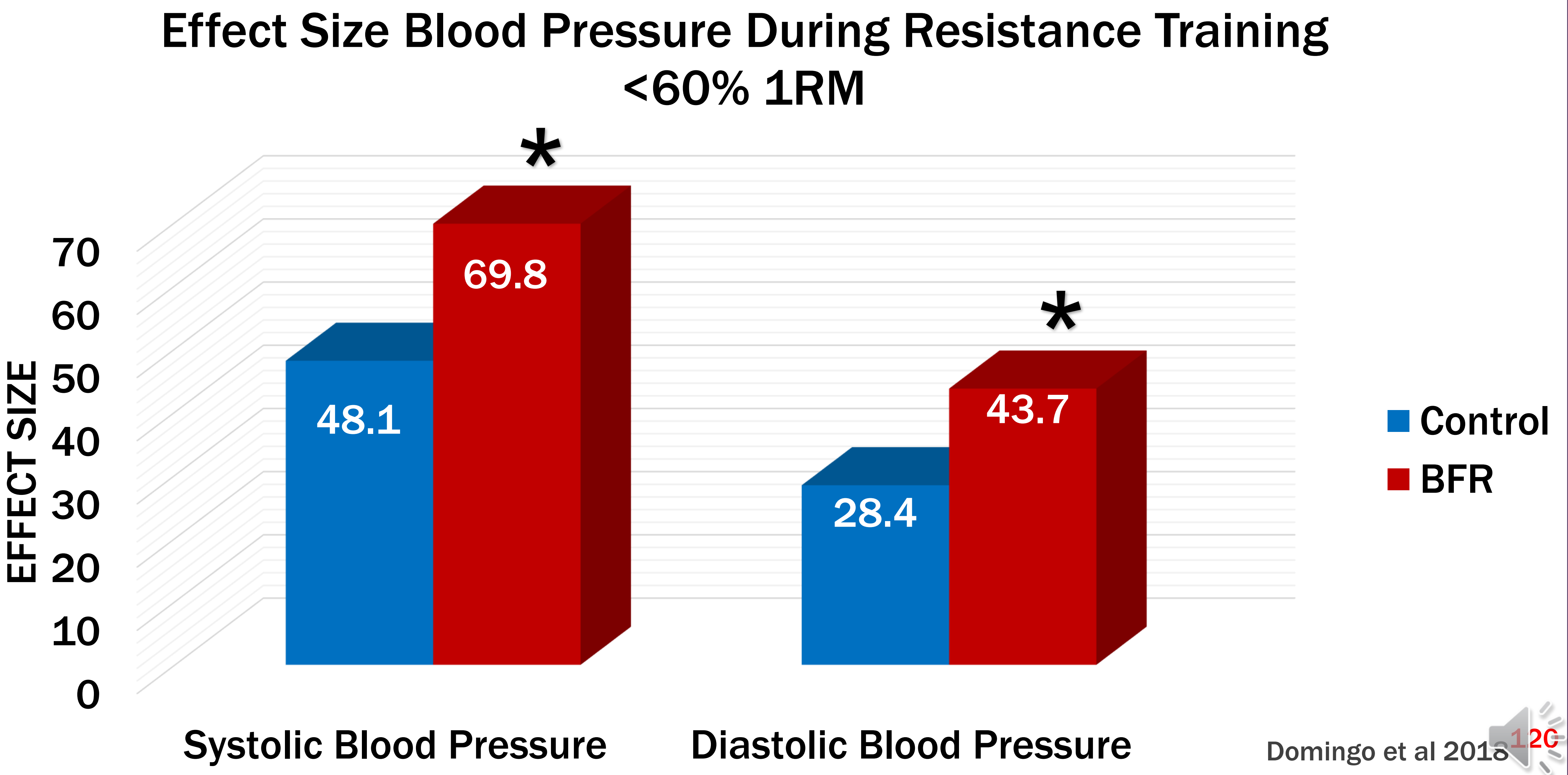
Domingo et al. 2018[120]

Safety & Side Effects – BFR & Blood Pressure



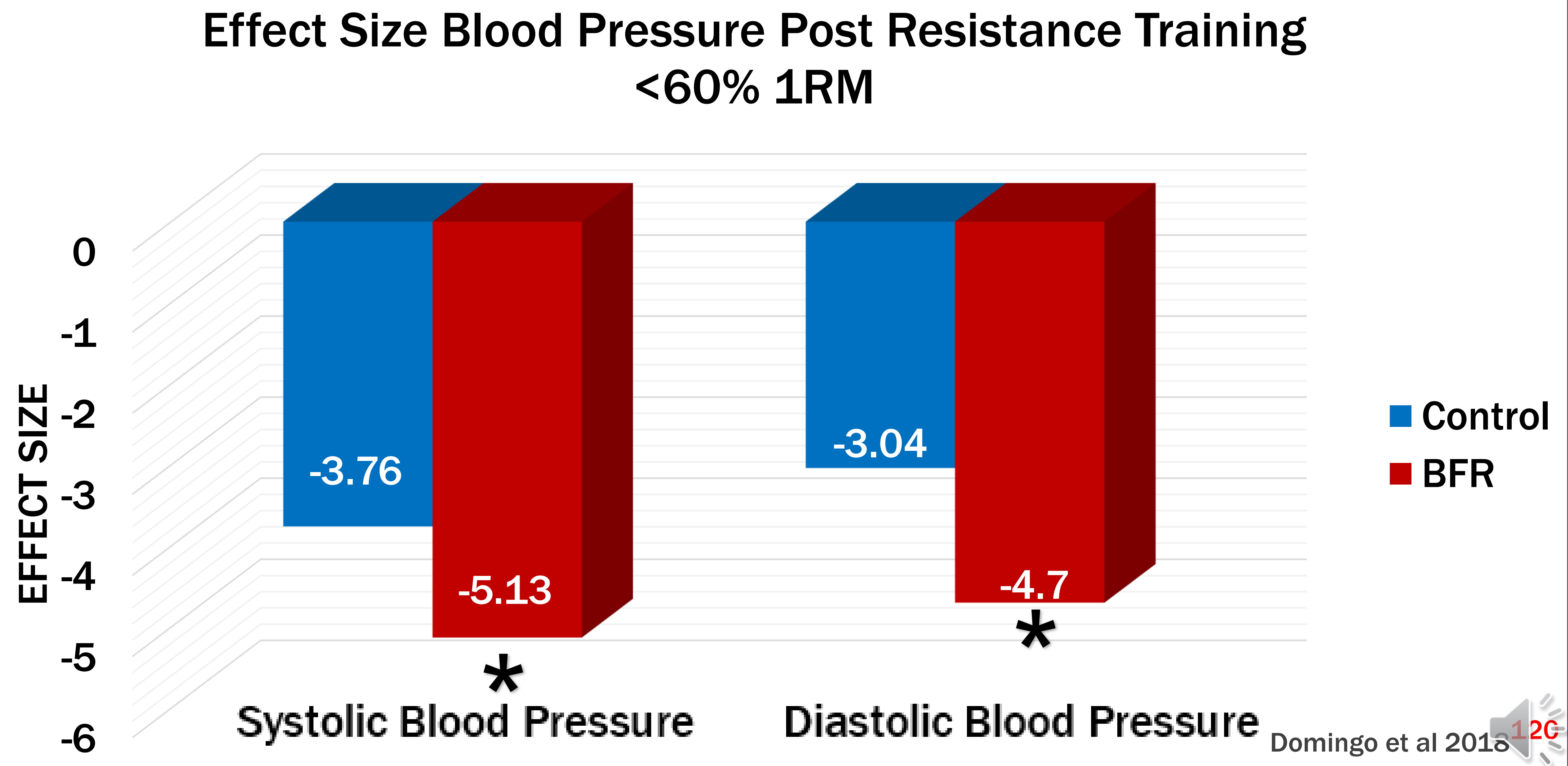
Domingo et al 2018

Safety & Side Effects – BFR & Blood Pressure



Domingo et al 2018

Safety & Side Effects – BFR & Blood Pressure



Domingo et al 2018

Safety & Side Effects – BFR & Blood Pressure

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1. BFR @ >60% 1 RM will result ↑ DBP vs Traditional Resistance Training

2. BFR @ <60% 1 RM will result ↑ **SBP &** DBP vs Traditional Resistance Training

3. BFR will result in greater ↓ SBP & DBP in HTN & Healthy BP patients 60 min post exercise vs Traditional Resistance Training

Domingo et al. 2018[120]

Safety & Side Effects – BFR & Blood Pressure

Blood pressure response between resistance exercise with and without blood flow restriction: A systematic review and meta-analysis

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Research Group of Cardiovascular Response and Exercise, Londrina State University, Londrina, Paraná, PR, Brazil

"Resistance exercise with BFR should be prescribed with caution, especially when BP control during exercise is necessary."

Domingo et al. 2018[120]

Safety & Side Effects – BFR & Blood Pressure

Effects of blood flow restriction exercise on hemostasis: a systematic review of randomized and non-randomized trials

Nascimento et al 2019[130]

4 RCT
5 Non-RCT

Blood Factor	Definition	Normal Range
Tissue plasminogen activation (tPA)	*protein involved in the breakdown of blood clots*	*5-40 µg/l*
Fibrinogen	*soluble protein in blood plasma*	*150-400 mg/dL*
fibrinogen degradation product (FDP)	*commonly used to diagnose disseminated intravascular coagulation (DIC)*	*10 mg/L*
Prothrombin Time	*how quickly your blood clots*	INR < 1.1
D-Dimer	*a blood test that can be used to help rule out the presence of a serious blood clot*	*208-318 ng/ml*

Safety & Side Effects – BFR & Blood Pressure

Effects of blood flow restriction exercise on hemostasis: a systematic review of randomized and non-randomized trials

Nascimento et al 2019[130]

SHORT TERM:

- intervention of BFR exercise **INCREASED** the **FIBRINOLYTIC ACTIVITY** assessed by tPA measures.
- [The] data effectively support the **SAFETY of BFR implementation** for: young, middle-aged with stable ischemic heart disease individuals, OR apparently healthy older subjects.

Safety & Side Effects – BFR & Blood Pressure

Effects of blood flow restriction exercise on hemostasis: a systematic review of randomized and non-randomized trials

Nascimento et al 2019[130]

LONG TERM:

- no longstanding sig effects, indicating that blood CLOTTTING FUNCTION REMAINED UNCHANGED in healthy subjects
- findings were supported in another investigation reporting no adverse effects of BFR with low-load RT (BFR with elastic band) on FDP or D-dimmer in OLDER, HEALTHY ADULTS.

Safety & Side Effects – BFR & Hemodynamics

REVIEW ARTICLE

Effects of resistance training with blood flow restriction on haemodynamics: a systematic review

Gabriel R. Neto[1,2,3], Jefferson S. Novaes[2], Ingrid Dias[4], Amanda Brown[2], Jeferson Vianna[5] and Maria S. Cirilo-Sousa[1,3]

21 Articles

Blood Pressure: n=16
Heart Rate: n=19
Rate of Perceived Exertion: n=4

Neto et al. 2018

Safety & Side Effects – BFR & Hemodynamics

Effects of resistance training with blood flow restriction on haemodynamics: a systematic review

Gabriel R. Neto[1,2,3], Jefferson S. Novaes[2], Ingrid Dias[4], Amanda Brown[2], Jeferson Vianna[5] and Maria S. Cirilo-Sousa[1,3]

"Hemodynamic changes (HR, SBP, DBP, MBP, RPP) promoted by LIRT-BFR do NOT seem to differ between ages and body segments (upper or lower)…

These changes are within the normal range.

Neto et al. 2018

Safety & Side Effects – BFR & Hemodynamics

Effects of resistance training with blood flow restriction on haemodynamics: a systematic review

Gabriel R. Neto[1,2,3], Jefferson S. Novaes[2], Ingrid Dias[4], Amanda Brown[2], Jeferson Vianna[5] and Maria S. Cirilo-Sousa[1,3]

"[LIRT-BFR] may be considered SAFE & VIABLE for special populations, such as the ELDERLY & CARDIAC patients, among others, because it promotes STRENGTH & HYPTERTROPHY without NEGATIVELY CHANGING HAEMODYNAMIC measurements."

Neto et al. 2019

Safety & Side Effects – Exercise Pressor Reflex

Review Article | Integrative Cardiovascular Physiology and Pathophysiology

Clinical safety of blood flow restricted training? A comprehensive review of altered muscle metaboreflex in cardiovascular disease during ischemic exercise.

Michelle Cristina-Oliveira, Kamila Meireles, Marty D. Spranger, Donal S. O'Leary, ... Show all Authors

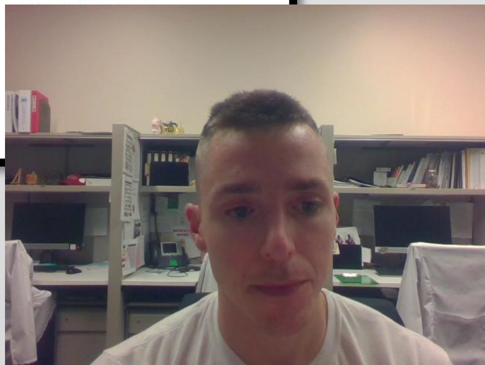
08 NOV 2019 // https://doi.org/10.1152/ajpheart.00468.2019

Blood flow restriction training and the exercise pressor reflex: a call for concern

Marty D. Spranger,[1,2,4] Abhinav C. Krishnan,[2,4] Phillip D. Levy,[2,3] Donal S. O'Leary,[2,4] and Scott A. Smith[5,6]

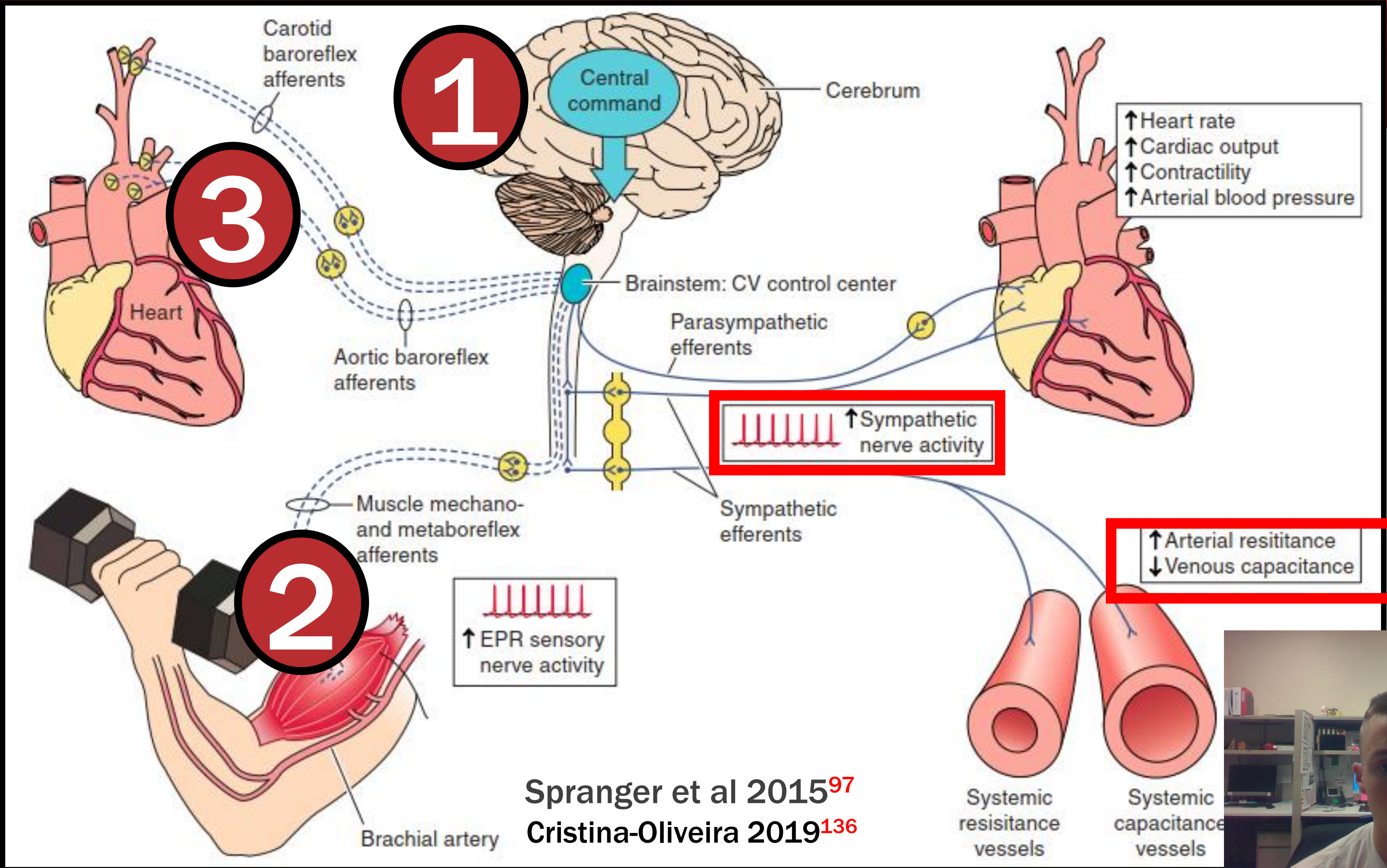
[1]Department of Physiology, Michigan State University, East Lansing, Michigan; [2]Department of Physiology, Wayne State University School of Medicine, Detroit, Michigan; [3]Department of Emergency Medicine, Wayne State University School of Medicine, Detroit, Michigan; [4]Cardiovascular Research Institute, Wayne State University School of Medicine, Detroit, Michigan; [5]Department of Health Care Sciences, University of Texas Southwestern Medical Center, Dallas,
[6]Department of Internal Medicine, University of Texas Southwestern Medical Center, Dallas, Texas

Submitted 20 March 2015; accepted in final form 31 August 2015

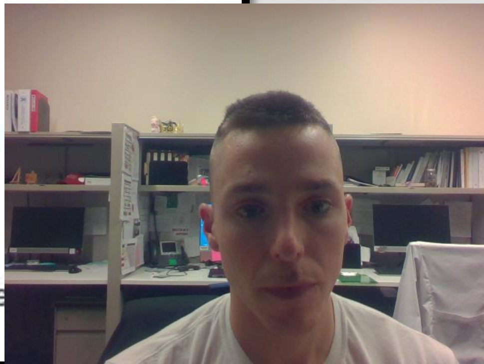


Spranger 2015[97] Cristina-Oliveira 2019[136]

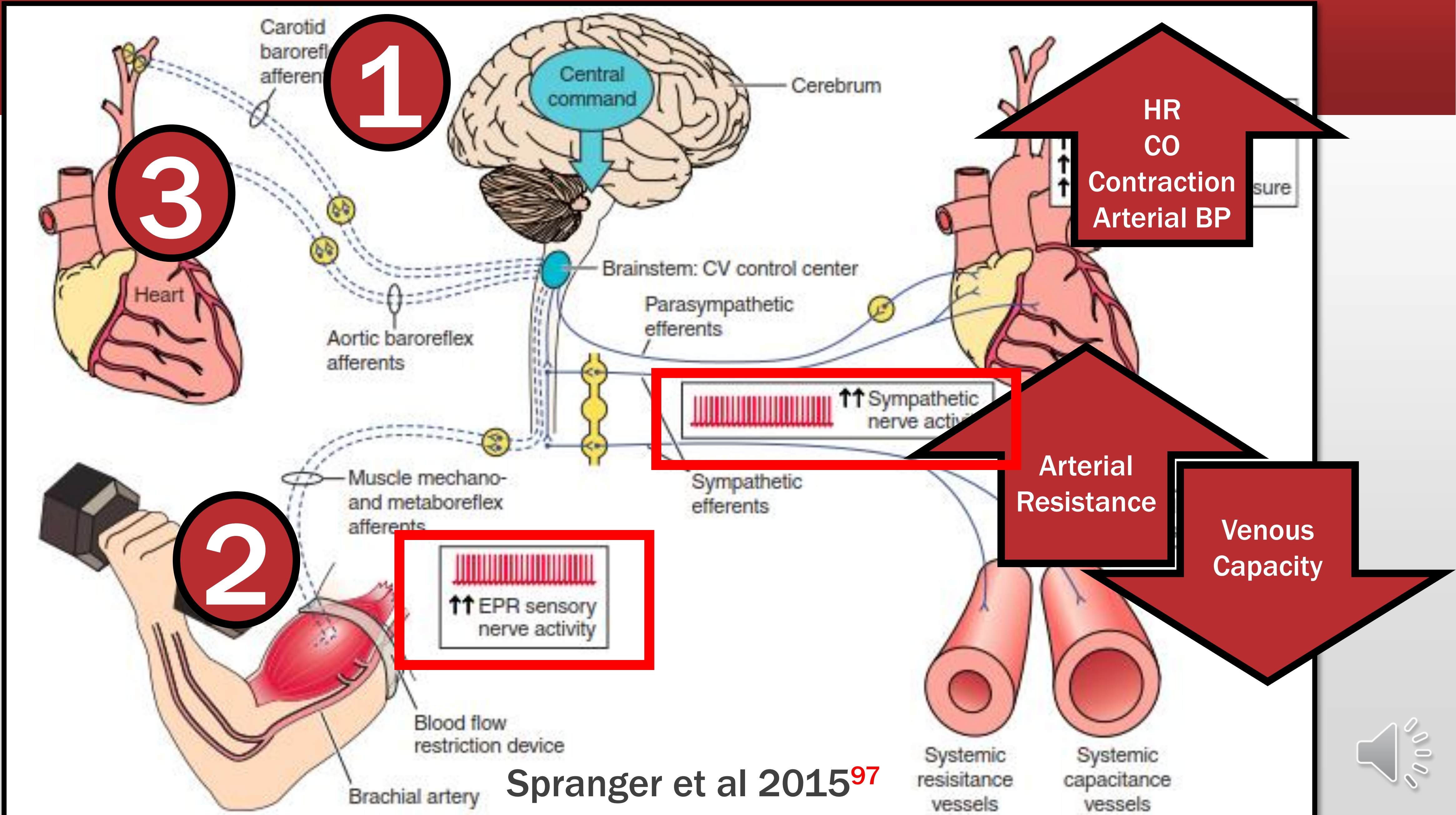
Safety & Side Effects – Exercise Pressor Reflex



Spranger et al 2015[97]
Cristina-Oliveira 2019[136]



Safety & Side Effects – Exercise Pressor Reflex



Sprangér et al 2015[97]

Safety & Side Effects – Exercises Pressor Reflex

- Individuals with CVD (HTN, HF, PAD) are especially at risk of deleterious CV events when performing BFR
- Healthy Individuals Resistance Training
  - Systolic AND Diastolic: >300 mmHg[99]
  - Young Healthy Bodybuilders on Leg Press: 320/240 mmHg (max 480/350 mmHg)[99]
- ↑ Venous Compression ➔ ↑ Venous Pressure ➔ Valve Damage ➔ Chronic Venous Insufficiency
- Spikes in Arterial Pressure (+BFR) = ↑(↑) Risk of CV event
- ↑ Pain response w/ BFR ➔ (may) ↑ Central Command & EPR funx ➔

↑SNA, ↑MAP in healthy individuals

Spranger et al 2015[97]

Safety & Side Effects – Exercises Pressor Reflex

- Arterial waveforms show that vascular changes appear to be localized within the involved musculature
- NO negative effects on:
  - Large Vessel Stiffness
  - Augmentation Index
  - Central Aortic Blood Pressure
- Correlations between BFR-induced Spikes in arterial pressure & risk of Cardiovascular events is unknown
- Further research is needed before BFR can be fully endorsed

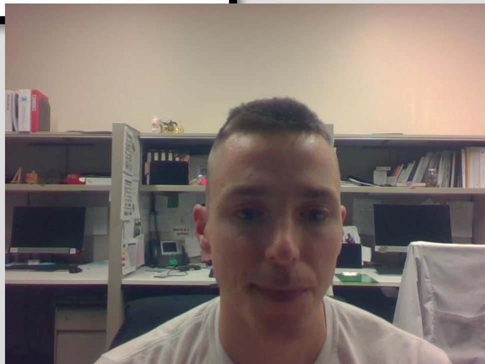
Spranger et al 2015

Safety & Side Effects – Adverse Events

COLIN W. BOND, MS[1-4] • KYLE J. HACKNEY, PhD[4]
SCOTT L. BROWN, DPT, OCS, SCS[3] • BENJAMIN C. NOONAN, MD, MS[1-3]

Blood Flow Restriction Resistance Exercise as a Rehabilitation Modality Following Orthopaedic Surgery: A Review of Venous Thromboembolism Risk

Bond et al. 2019[132]



Safety & Side Effects – Adverse Events

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Bond et al. 2019[132]

- *"studies have demonstrated that intermittent pneumatic compression (IPC) REDUCES COAGULATION and ENCHANCE FIBRINOLYSIS.[2,10,12,16,40,41,45,49,81,82,89,108,113,116,123]"*
- *"several studies have investigated IPC as an alternative or adjunct to prophylaxis and demonstrated SUCCESS*
results for a number of postsurgical orthopaedic pa
including those withtotal joint replacements.[26,47,95

Safety & Side Effects – Adverse Events

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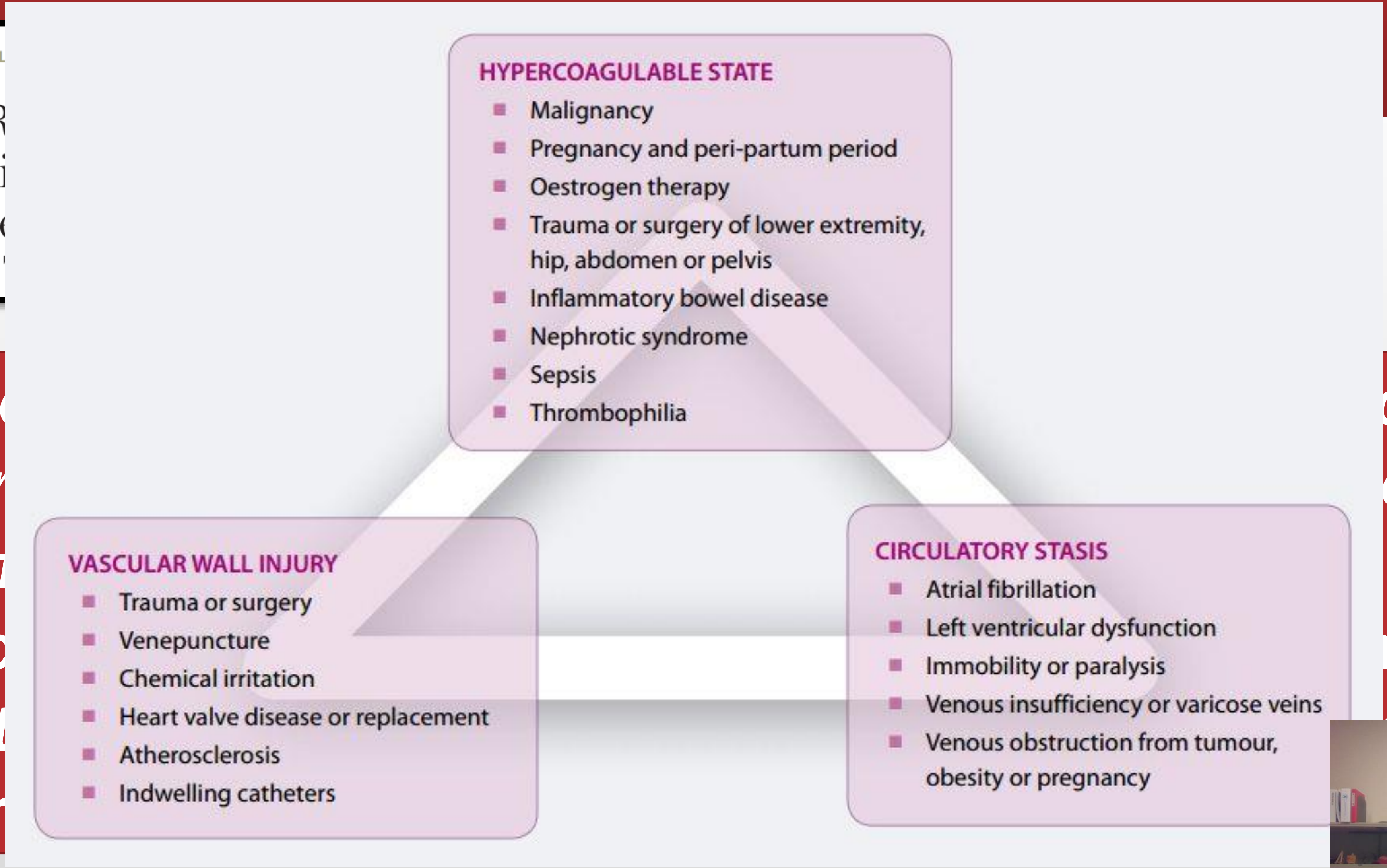
- "clinic ... s and sympt ... factor



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Safety & Side Effects – Venous Compliance

- Not yet included: Iida, H., Nakajima, T., Kurano, M., Yasuda, T., Sakamaki, M., Sato, Y., ... & Abe, T. (2011). Effects of walking with blood flow restriction on limb venous compliance in elderly subjects. *Clinical physiology and functional imaging*, *31*(6), 472-476. (https://www.ncbi.nlm.nih.gov/pubmed/21981459)

Safety & Side Effects – Summary

In conclusion, the current research on blood flow restriction training **with respect to safety outcomes** confirms earlier reports that blood flow restriction exercise, when used in a **controlled environment** by **trained and experienced personnel**, provides a **safe training alternative** for most individuals regardless of age and training status.

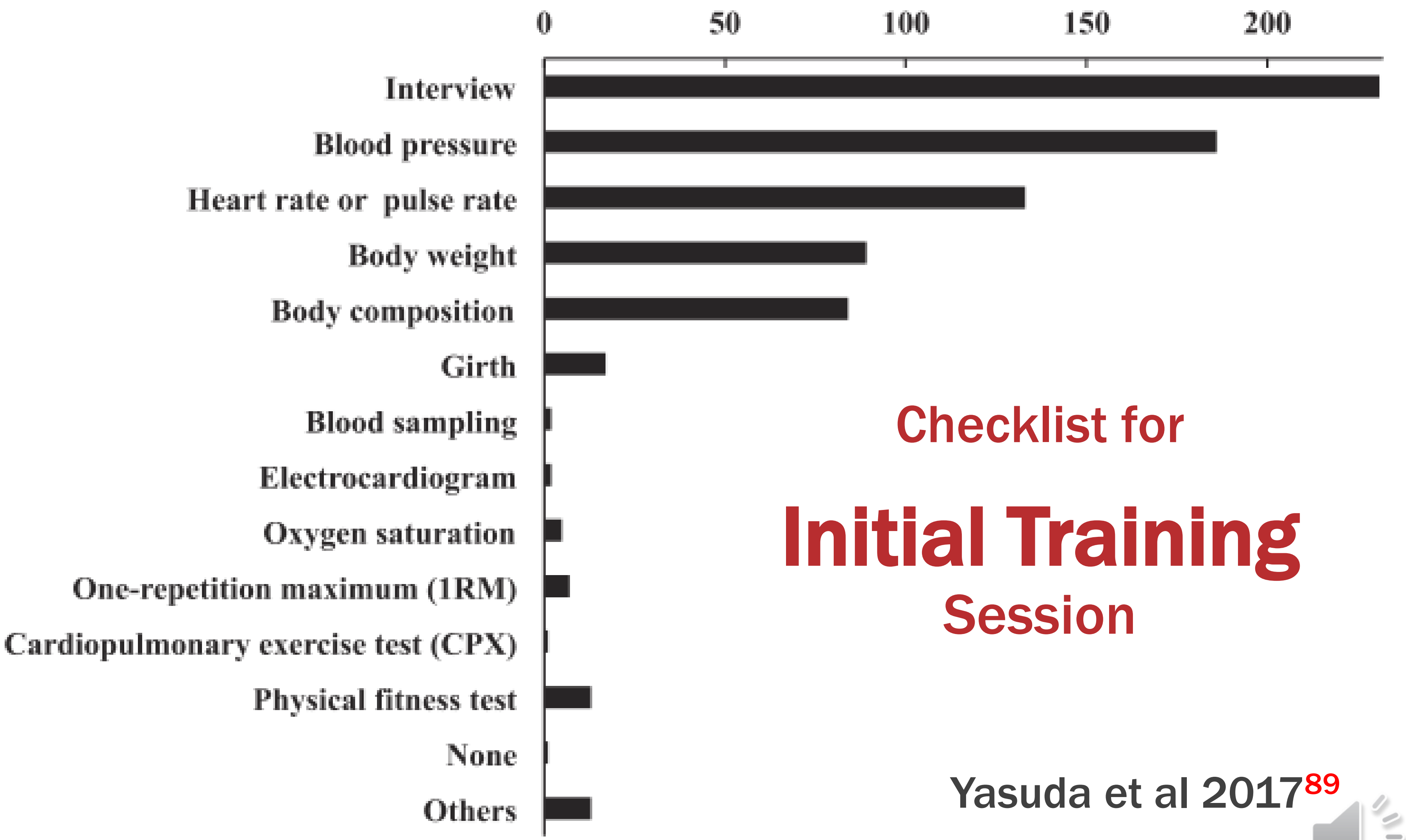
Loenneke et al 2011[100]

Safety & Side Effects

1. *Systematic Reviews*
2. *Proposed Screening Processes*
3. *Study Example*

Safety & Side Effects – Screening / Intake

- Adherence to proper screening & testing
- 232 Facilities in Japan
- 12,827 Subjects
- Nov – Dec 2016



Checklist for

Initial Training

Session

Yasuda et al 2017[89]

Safety & Side Effects – Screening / Intake

- Adherence to proper screening & testing
- 232 Facilities in Japan
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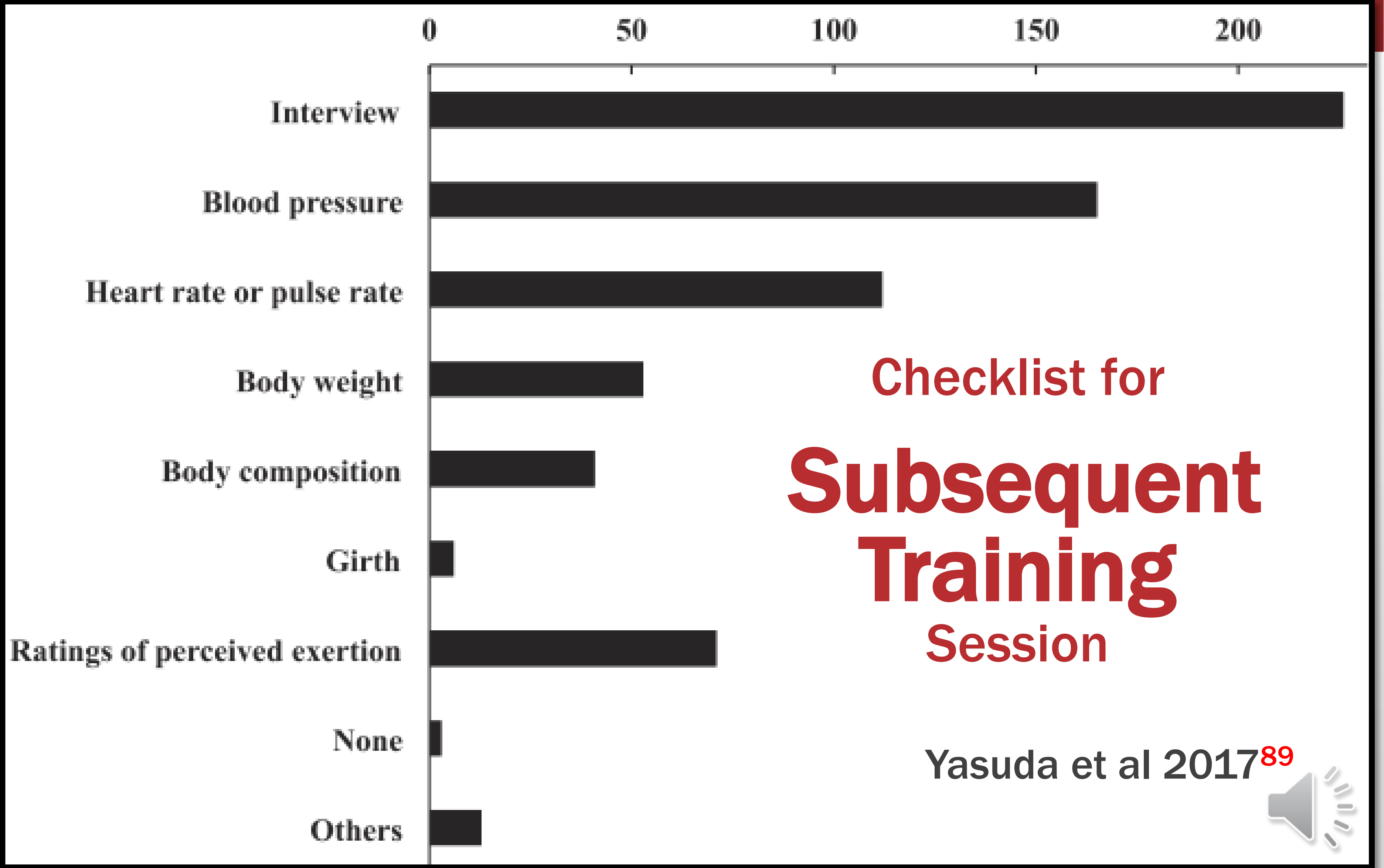


Checklist for

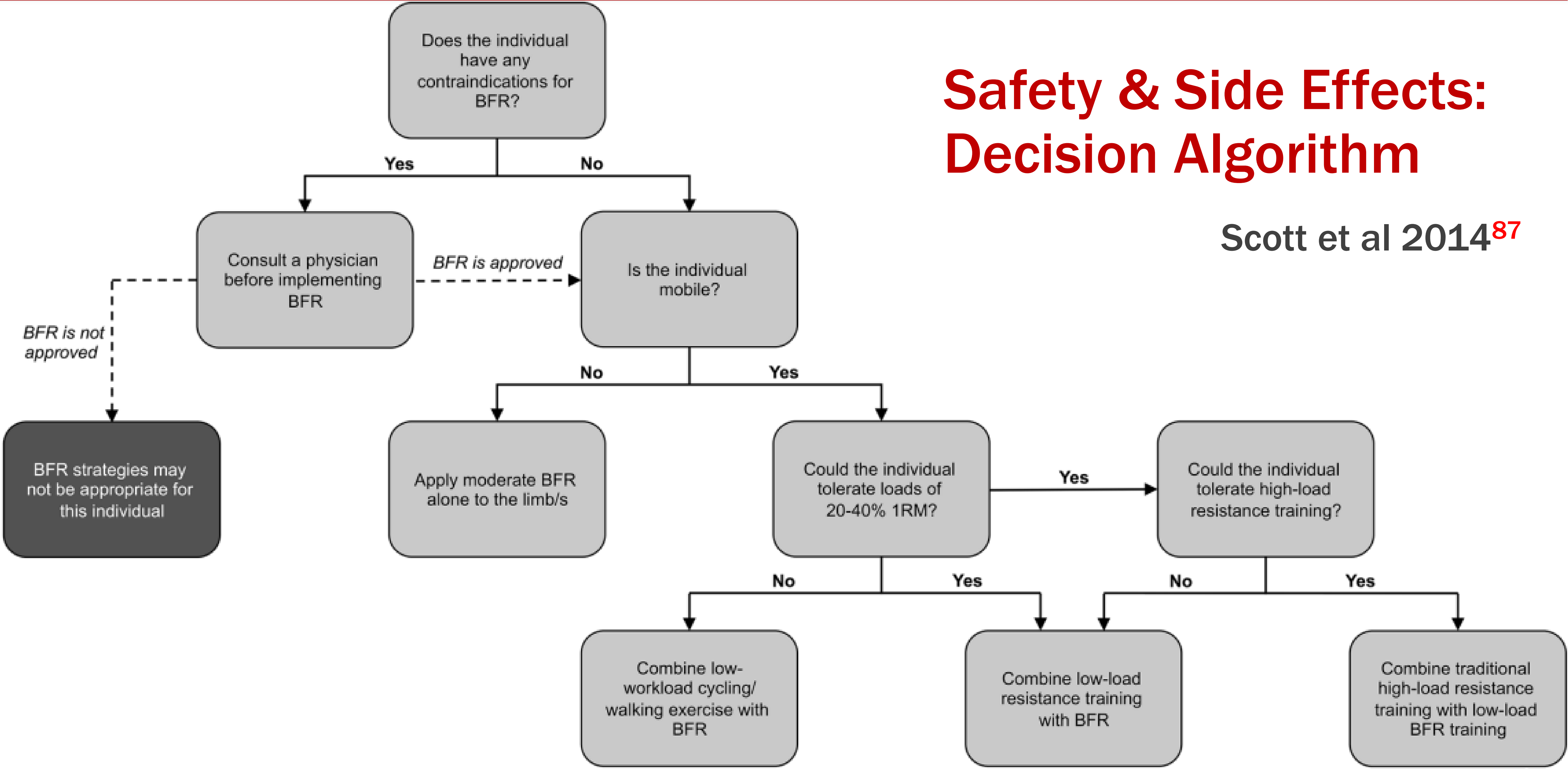
Subsequent Training

Session

Yasuda et al 2017[89]

Safety & Side Effects: Decision Algorithm

Scott et al 2014[87]



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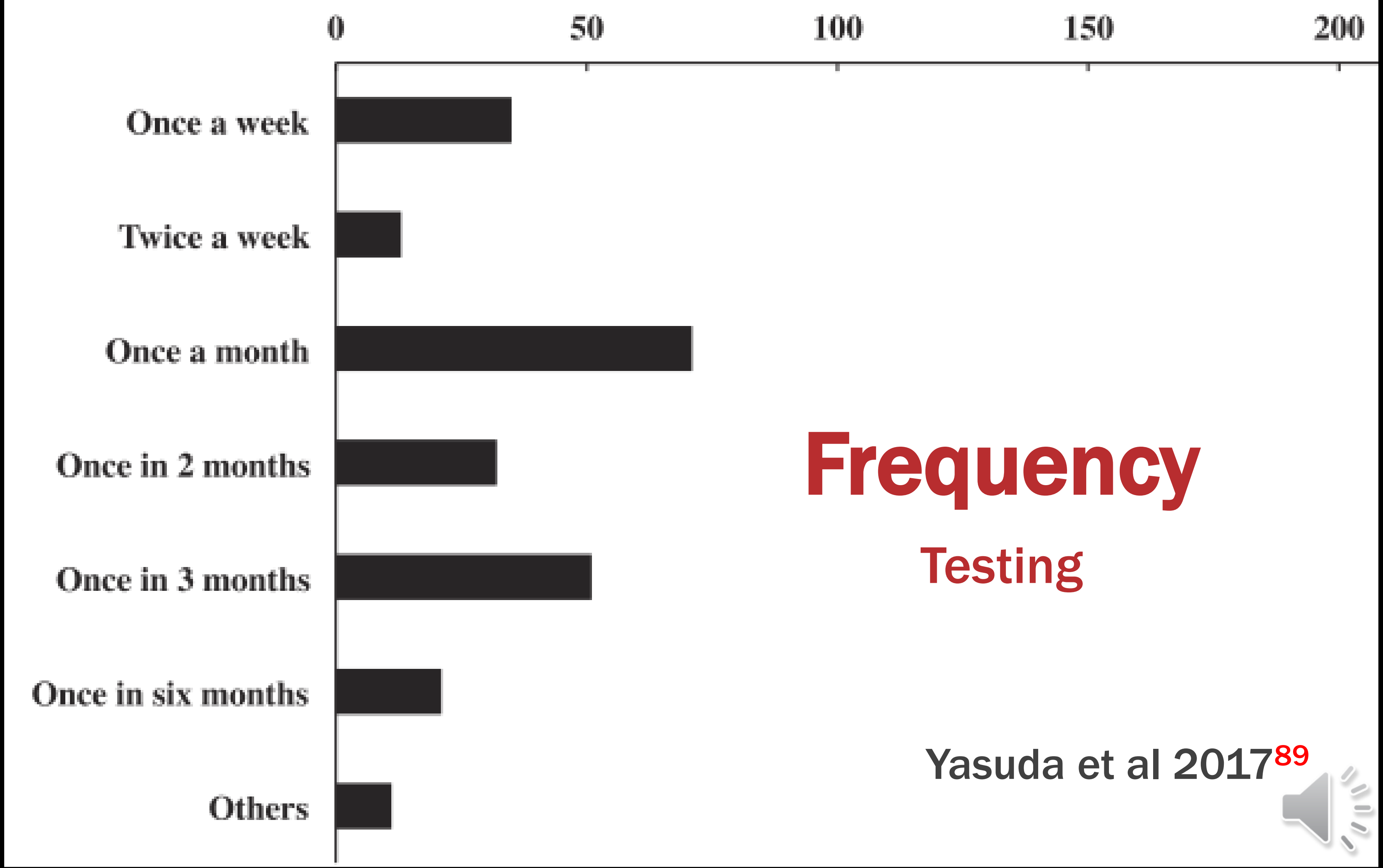


Frequency

Testing

Yasuda et al 2017[89]

Safety & Side Effects – Screening / Intake

Intake Information	Criteria	If indicated, action(s) to be taken
Symptoms	☐ Chest Pain/Discomfort ☐ Palpitations ☐ Shortness of Breath ☐ Dizziness ☐ Fainting ☐ Intermit. Claudication	☐ Exercise Tolerance Test
History of Disorder	☐ Cardiovascular Disease ☐ Orthopedic or Joint Disorder	☐ Exercise Tolerance Test ☐ Orthopedic Examination
Lifestyle Disorders	☐ High Blood Pressure ☐ Diabetes ☐ Hyperlipidemia ☐ Obesity	☐ Assess Severity of selected criteria
Family History	☐ Myocardial Infarction (Heart Attack) & sudden death of 1st degree relatives	☐ Exercise Tolerance Test
Lifestyle Habits	☐ Sedentary Lifestyle (workout <3 days/week) ☐ Smoking ☐ Alcohol	☐ Lifestyle Guidance
Resting EKG	☐ Myocardial Infarction ☐ ST-T segment abnormality ☐ Ventricular arrhythmia ☐ Important Observations	☐ Exercise Tolerance Test

Nakajima 2011

Safety & Side Effects – Indications, Precautions, Contraindications

Disease	Indications	Precautions	Contraindications
High Blood Pressure	- 140-159/90-94 mmHg	- 160-179/95-99 mmHg*	- >180/>100mmHg - CTR >55% - Life threatening Arhythmia - Uric protein: 100 mg/dl - Hypertension in fundus oculi
Diabetes	- Fasting BG: 110-139 mg/dl	- Fasting BG: 140-249 mg/dl*	- Fasting BG: ≥250 mg/dl - Urinary ketone body (+) - Diabetic Retinopathy (+)
Hyperlipidemia	- TC: 220-249 mg/dl - TG: 150-299 mg/dl	- TC: 250 mg/dl* - TG: 300 mg/dl*	
Obesity	- BMI: 24.0 – 29.9	- BMI: 24.0 – 29.9 & LE joint damage (ortho exam)	- BMI: >30

TC: Total Cholesterol; TG: total triglycerides; *: M:>40 y/o or F:>50 y/o require 'Exercise Tolerance Test'

Nakajima 2011

Safety & Side Effects – BFR Risk Stratification

Points	1	2	3	4	5
Criteria	☐ Age 40-58	☐ Age > 60	☐ Varicose Veins LE	☐ Pregnancy	☐ Hx of DVT
	☐ Female	☐ Malignancy	☐ Immobility¥		☐ Antiphospholipid Antibody Syndrome
	☐ BMI 25-30	☐ BMI >30	☐ A-Fib or Heart Failure		
		☐ Hyperlipidemia			
		☐ Leg Tourniquet			☐ Hx of PE
		☐ Oral Contraceptive			
		☐ Corticosteroid Use			
		☐ Quadriplegia			
		☐ HMG >20g/dL			
Column Score					
Total Score		● ≤ 1 Low Risk | ● 2 Mild Risk | ● 3 Moderate Risk | ● ≥ 4 High Risk			

HMG: hemoglobin; ¥: incapable of 8 hours thromboprophylaxis rehabilitation

Nakajima 2011

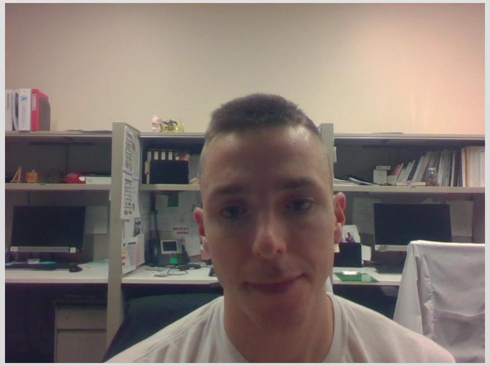
Safety & Side Effects

1. *Systematic Reviews*
2. *Proposed Screening Processes*
3. *Study Example*

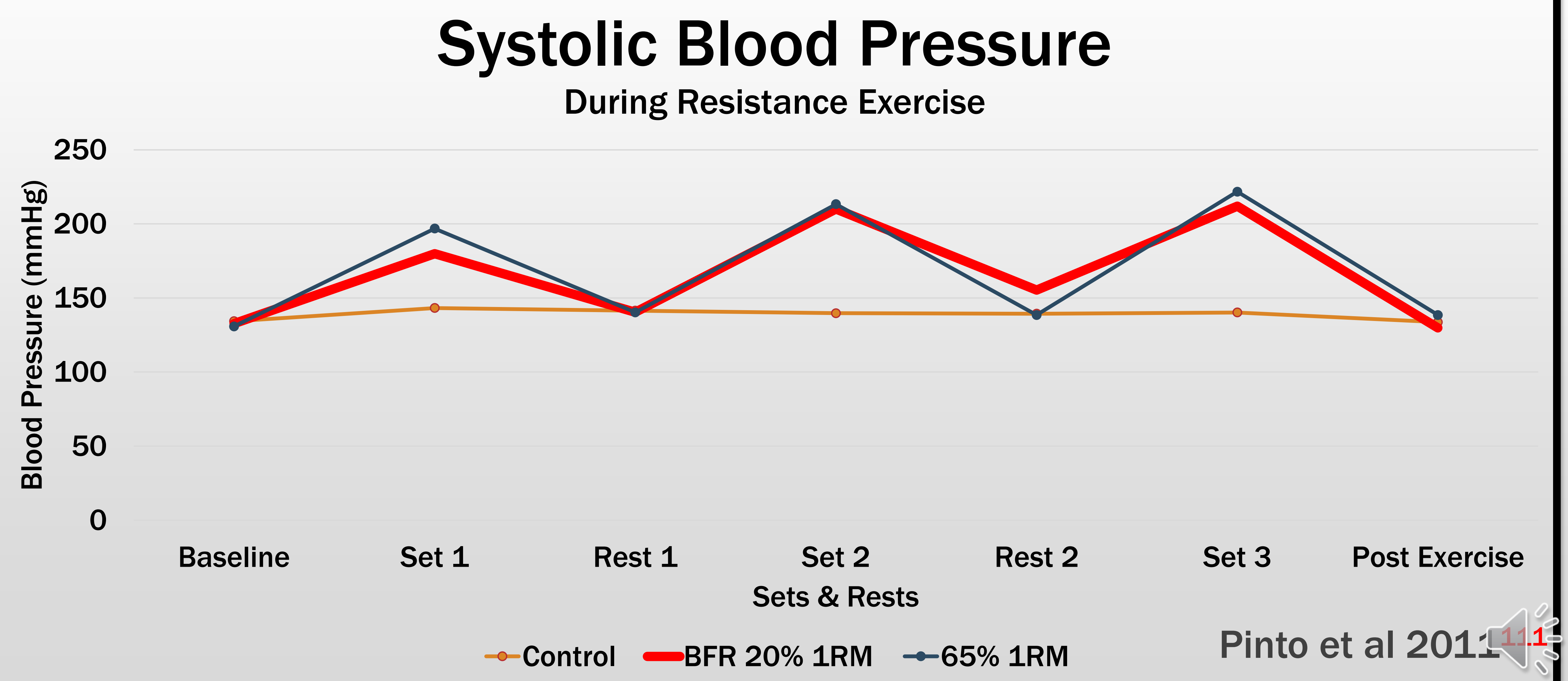
Safety & Side Effects – BFR in HTN Women

Method Variable	Value
Study Design	Randomized Cross Over
Subjects	N = 18, > 60 y/o
Duration	3 sessions Each Session Randomized: 1. Control: No Exercise 2. BFR: 20% 1 RM 3. Strength: 65% 1 RM
Cuff	Width: 90 mm
Type	Knee Extension
Volume/Intensity	3x10 (1 min rest) Control: N/A BFR: 20% 1RM Strength: 65% 1 RM
Tempo	2 sec CON / 2 sec ECC 40 sec/set 4 min/session

Pinto et al 2011[111]

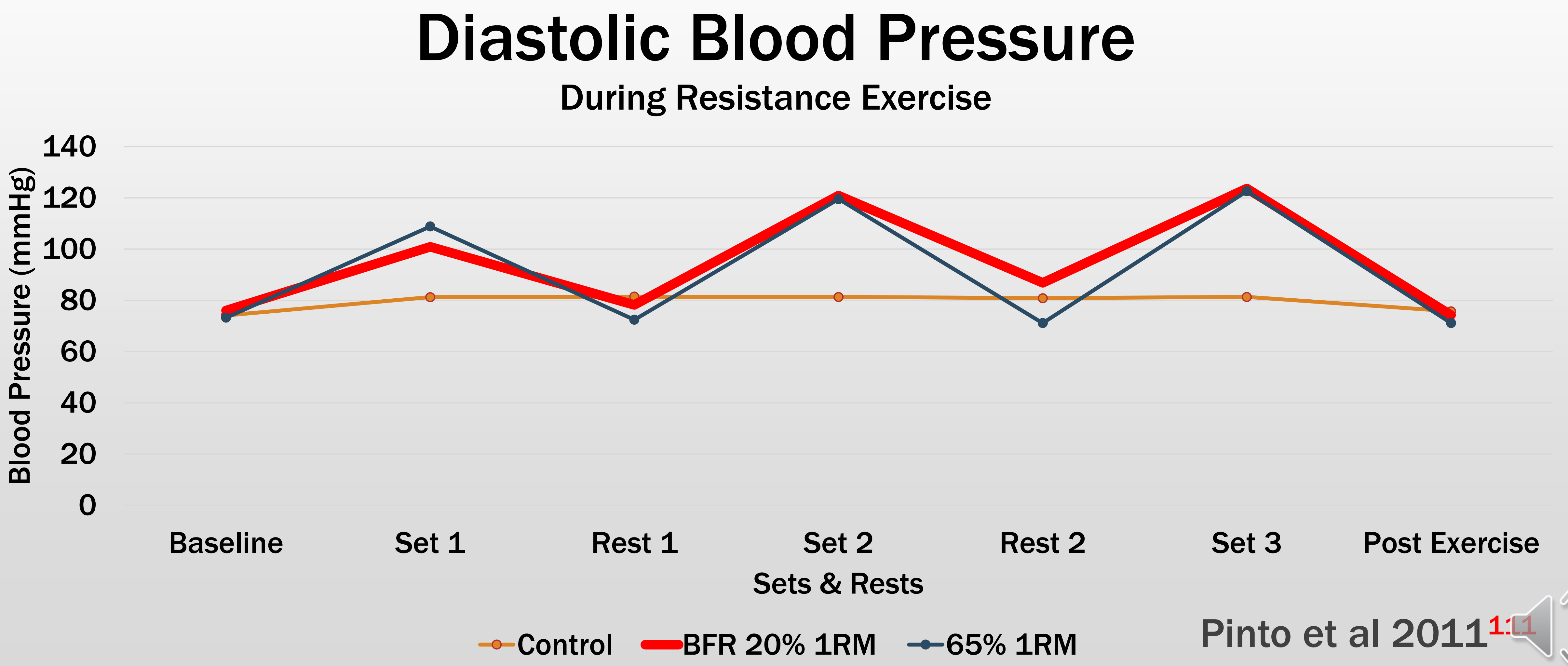


Safety & Side Effects – BFR in HTN Women



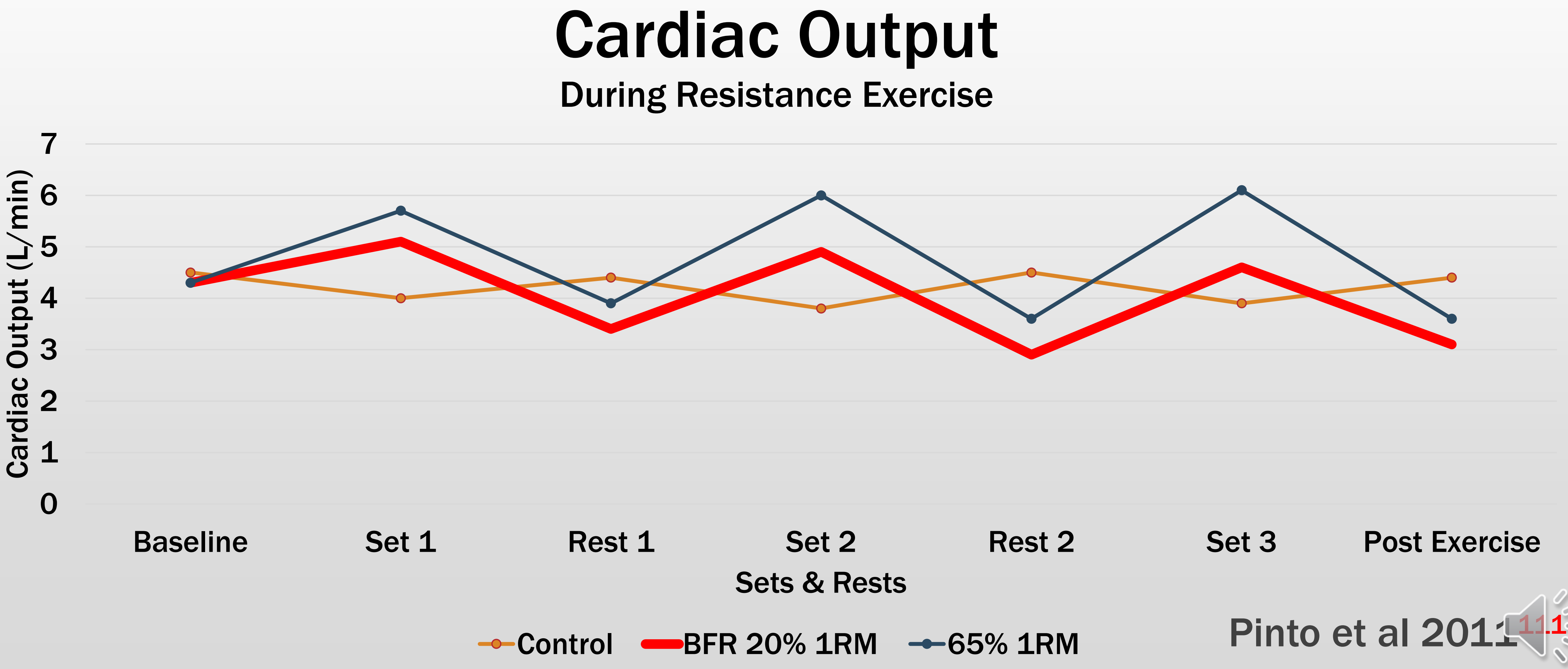
Pinto et al 2011

Safety & Side Effects – BFR in HTN Women



Pinto et al 2011[11]

Safety & Side Effects – BFR in HTN Women



Pinto et al 2011

Conclusion & Summary

Safety & Side Effects – Follow Basic Principles

1. **Confirm No Contraindications**
2. **Hemodynamically Unstable Patients** should NOT partake
3. **Thrombotic Diseased Patients** are Contraindicated
4. Explain **Petechial Hemorrhage Risk**
5. Individualize training
6. **Build Relationship & Trust** with Patient
7. **Pay Attention to** faintness, dizziness, or light-headedness
8. **Caution:** Older (>65), Bedridden, Postoperative Patients (DVT risk)
9. **AED Available**
10. **SHORT Term and LOW intensity Loads**
11. **CONTRAINDICATION:** Patient is sick
12. **If unsure about medical condition seek specialist consult**

Nakajima 2011

Questions, Comments, Feedback, Discussion…

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