Response to Eccentric Exercise Following Four Weeks of Flexibility Training

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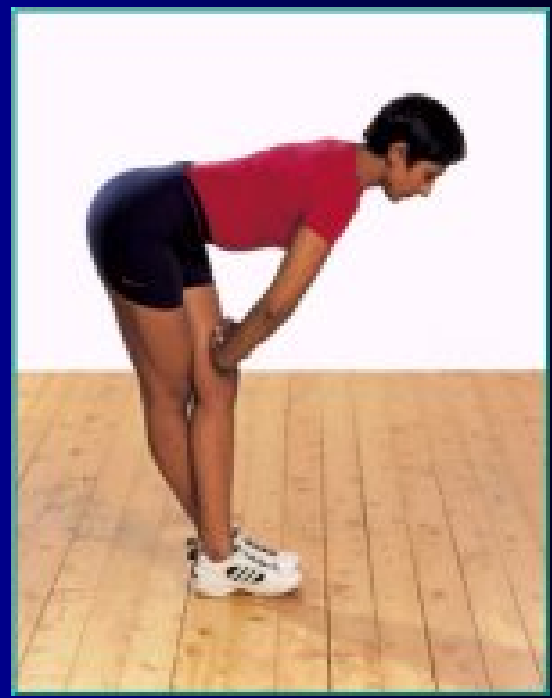
Introduction

- Stretching:
  - flexibility, injury, and performance
  - reduce stiffness
  - delayed onset muscle soreness



- Criterion Measures:
  - range of motion (ROM)
  - material properties
  - passive resistance to stretch

(Chan, 2001; Magnusson, 1996; McHugh, 1999)

Purpose

To test the hypothesis that chronic stretching can reduce muscle impairment following unaccustomed eccentric exercise

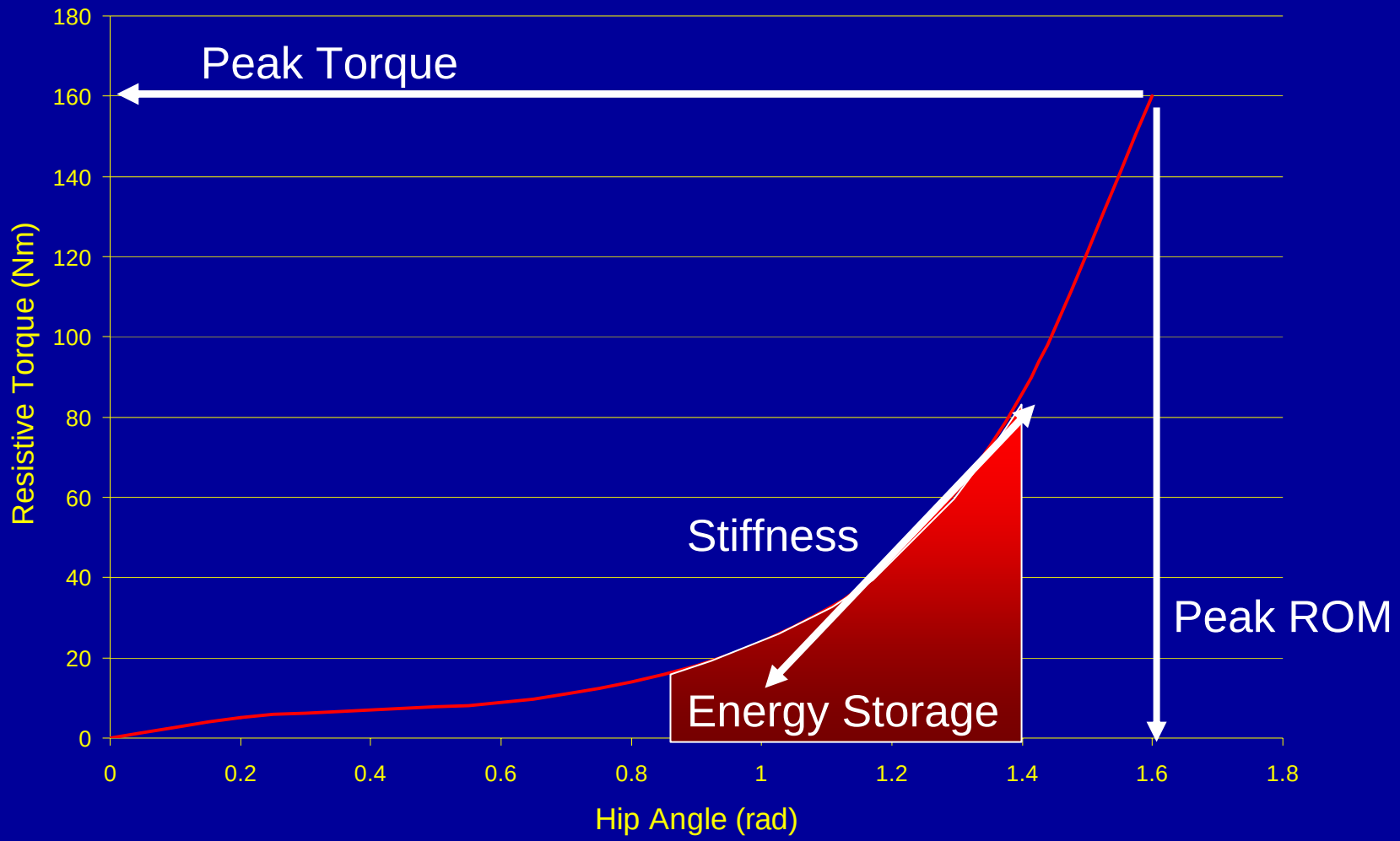
Subjects:

- Thirty-one, male, able-bodied, recreationally active, age 18-60 years
- Static stretching, ballistic stretching, control groups

	Control n = 11	Static n = 10	Ballistic n = 10	p
Age (years)	35.1 ± 17.4	31.0 ± 16.4	28.2 ± 11.9	0.62
Mass (kg)	80.1 ± 10.1	77.0 ± 9.2	86.3 ± 22.5	0.42
Height (m)	1.76 ± .07	1.78 ± .18	1.77 ± .08	0.86
Minutes of flexibility training · week^{-1}	17.7 ± 26.5	16.3 ± 15.7	18.5 ± 29.4	0.96
Initial Range of Motion (rad)	1.77 ±.22	1.69 ± .16	1.66 ± .17	0.36
Initial Peak Torque (Nm)	131.1 ± 41.9	113.1 ± 30.3	105.3 ± 34.3	0.26
Initial Stiffness (Nm·rad^{-1})	84.4 ± 30.0	97.2 ± 23.1	101.6 ± 29.5	0.46

Methods

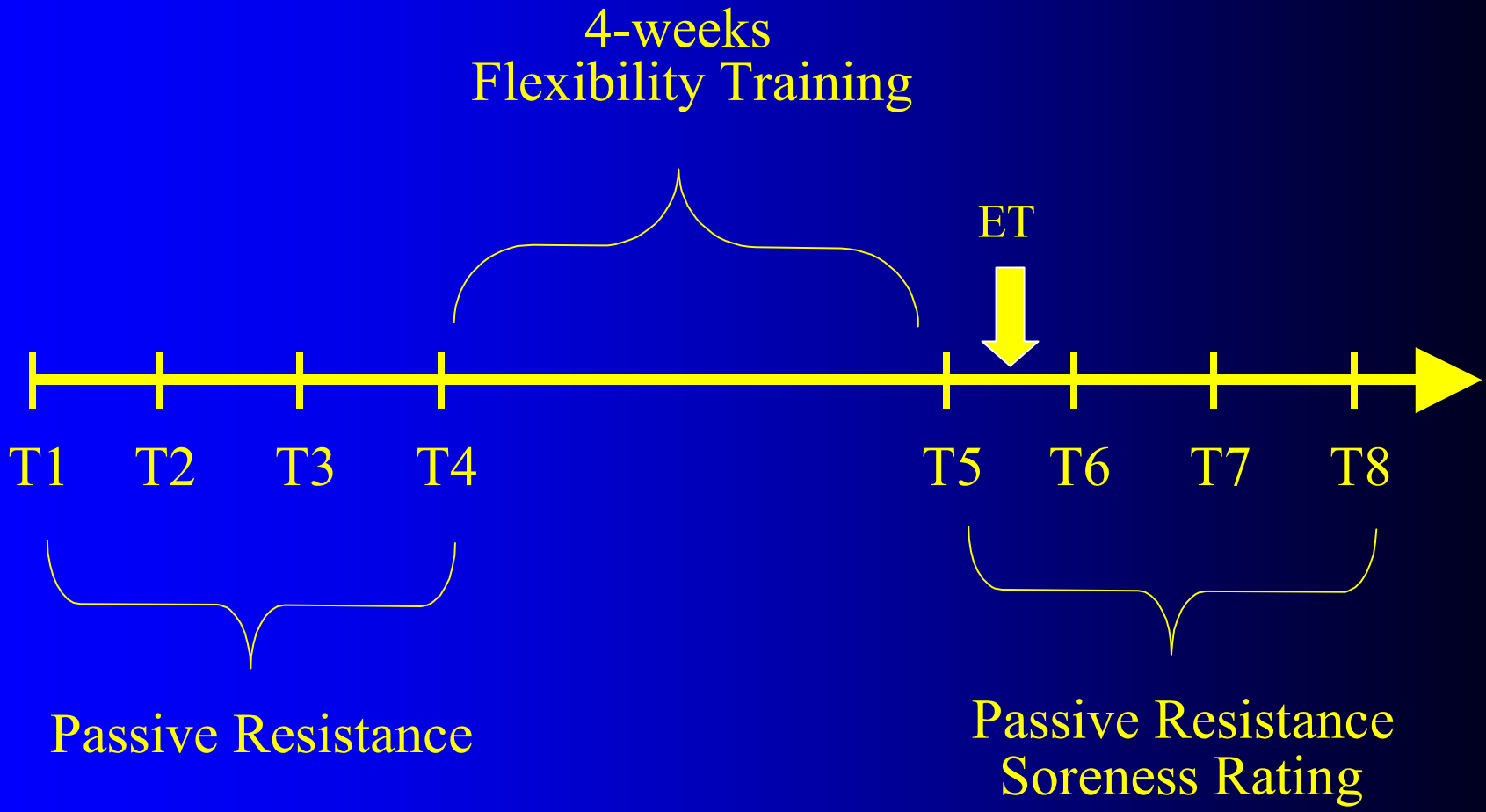
Passive Muscle Resistance



Measures

- Range of Motion (rad)
  - highest angle of hip flexion from table level
- Peak Passive Torque (Nm)
  - highest passive torque
- Stiffness ($Nm \cdot rad^{-1}$)
  - slope of torque vs. angle curve
- Energy ($Nm \cdot rad$)
  - area under the torque curve
- Soreness (mm)
  - visual analog scale
  - 0 mm (no soreness) $\leftrightarrow$ 100 mm (worst possible soreness)

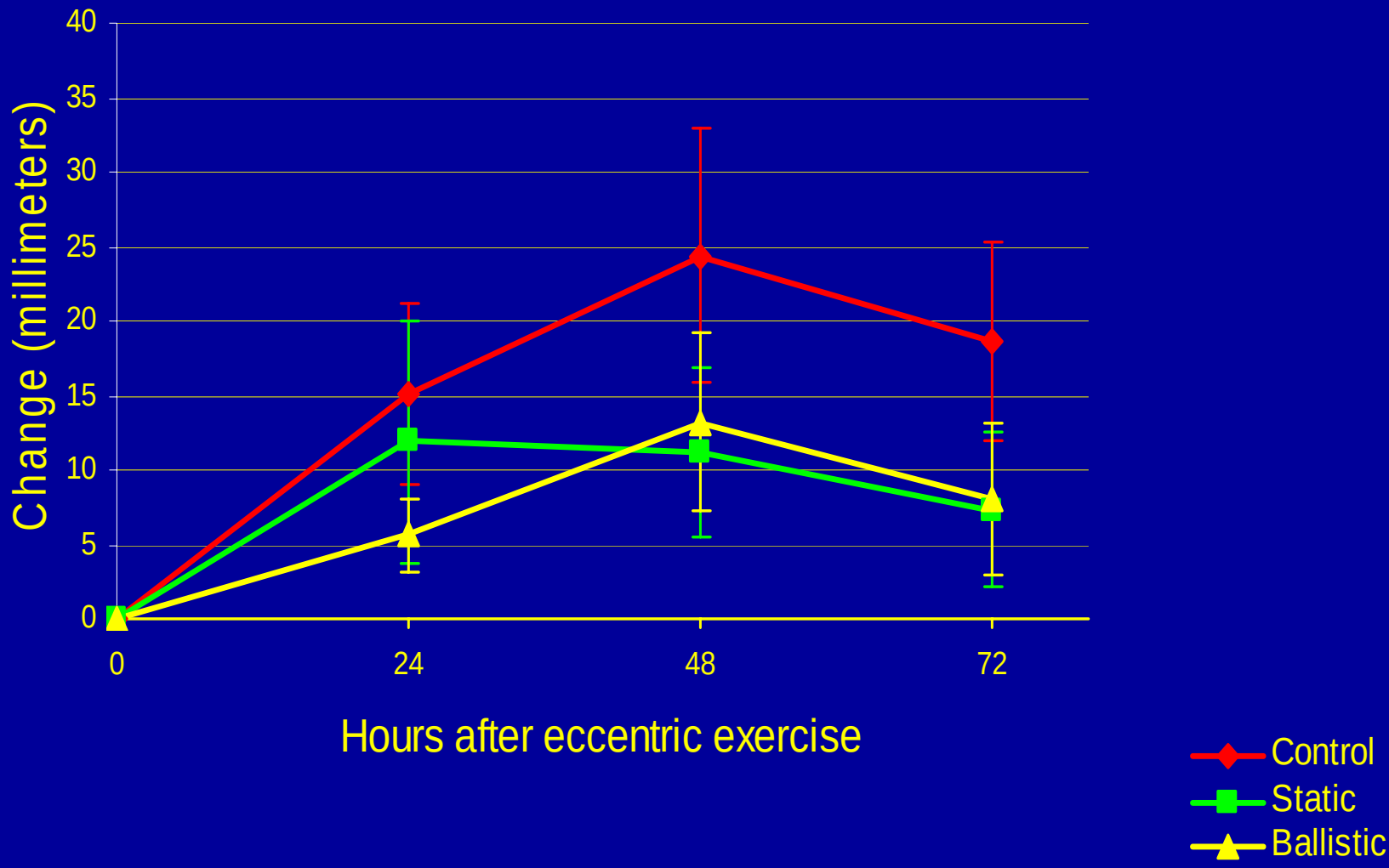
Experimental Timeline



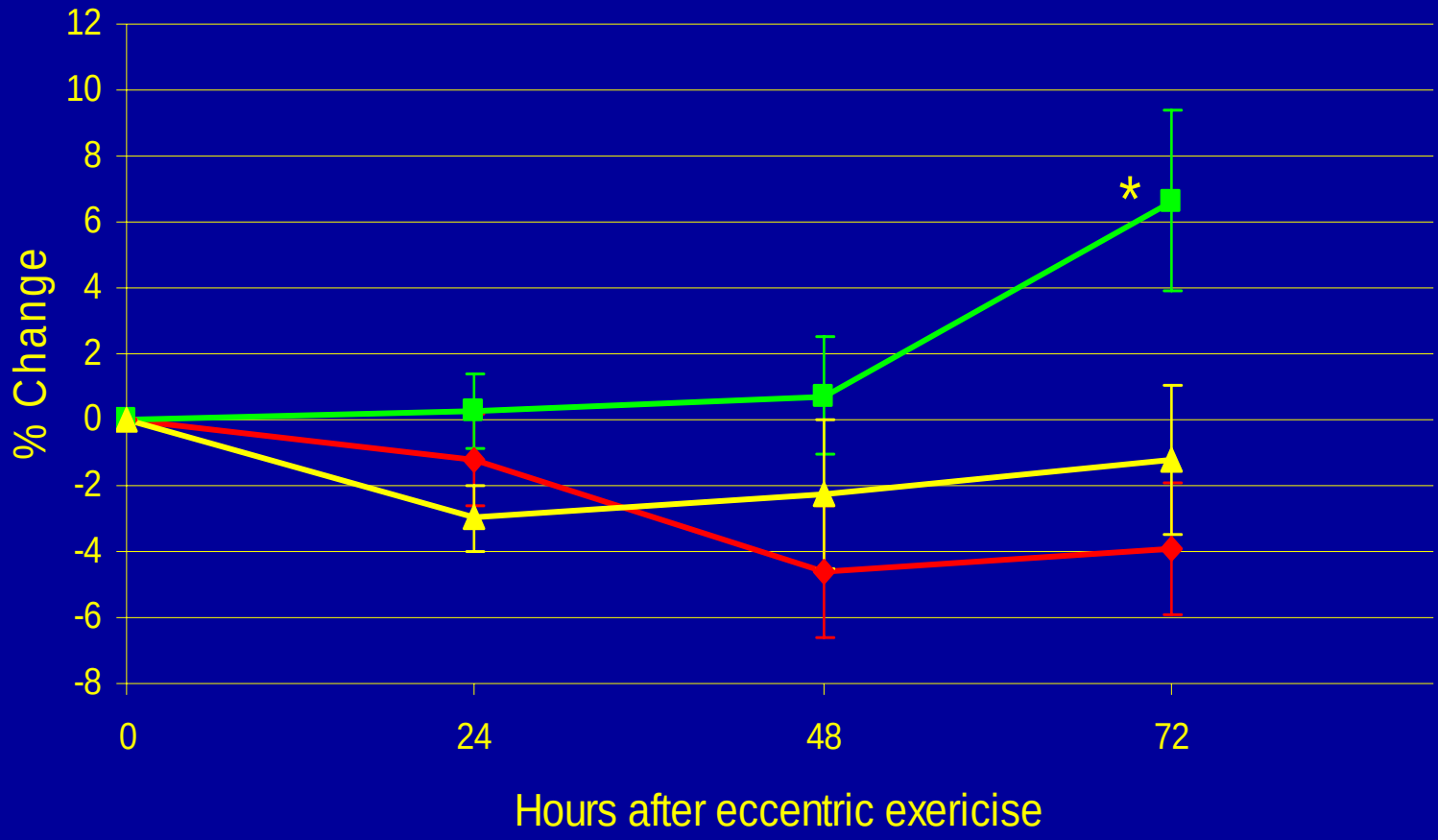
Treatments:

- Flexibility Training
  - 4 weeks
  - 10 × 30 s, 3 × week^{-1}
    - Static stretching
    - Ballistic stretching
- Eccentric Task
  - hamstring curl exercise
  - 3 × 15 reps (70% MVC)

Perceived Soreness Following Novel Eccentric Exercise

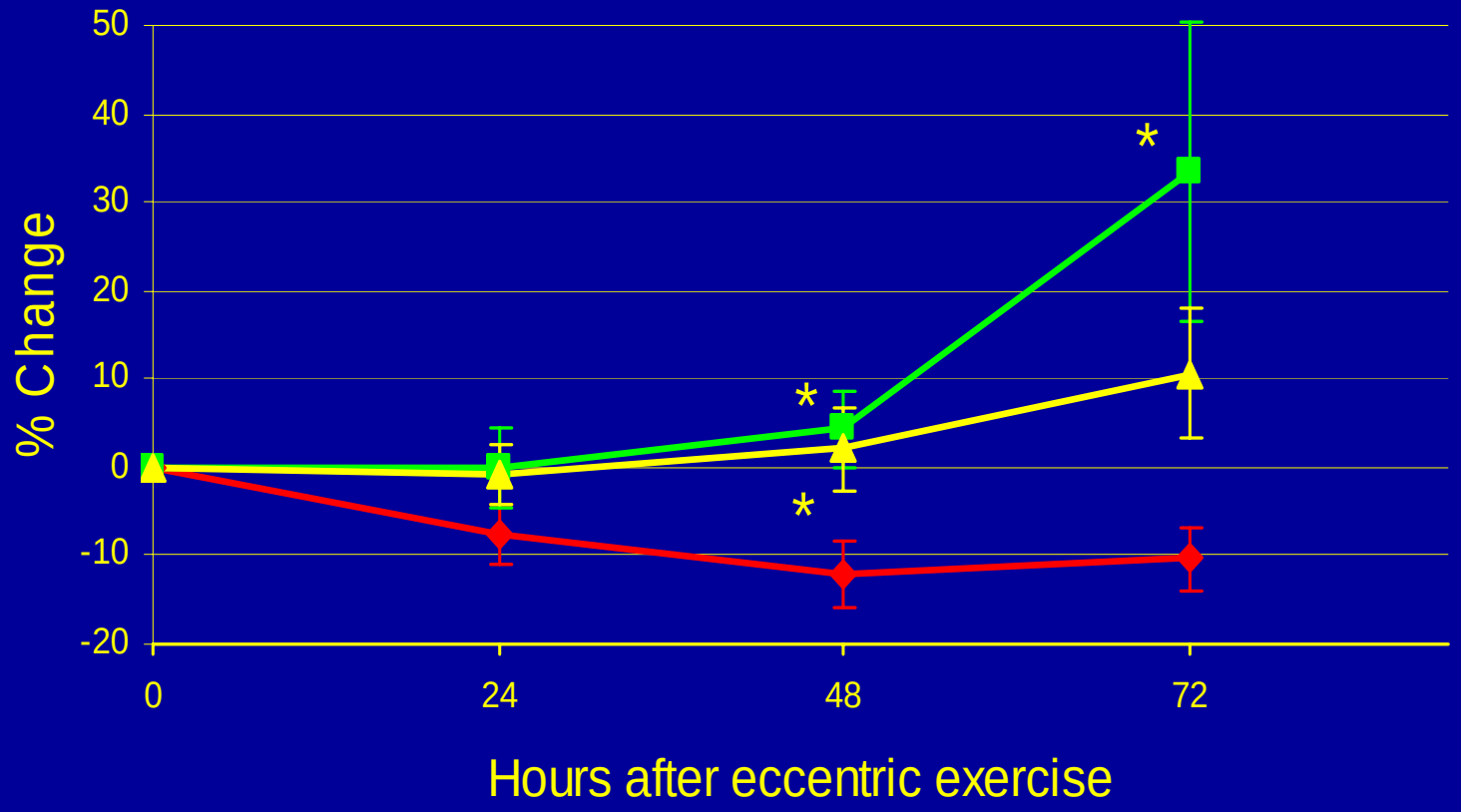


Range of Motion



* = different from control ($p < .05$)

Peak Passive Torque



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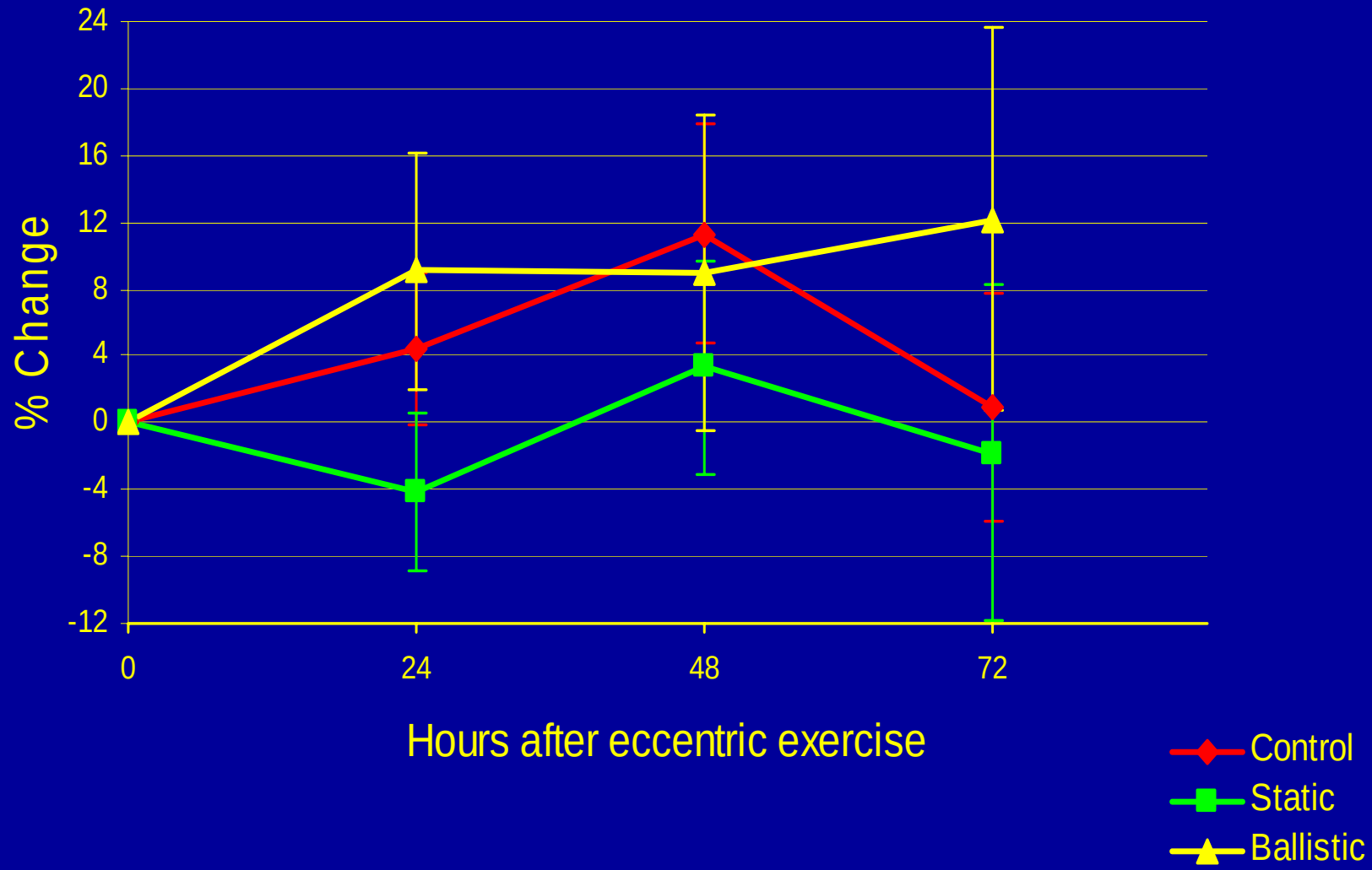
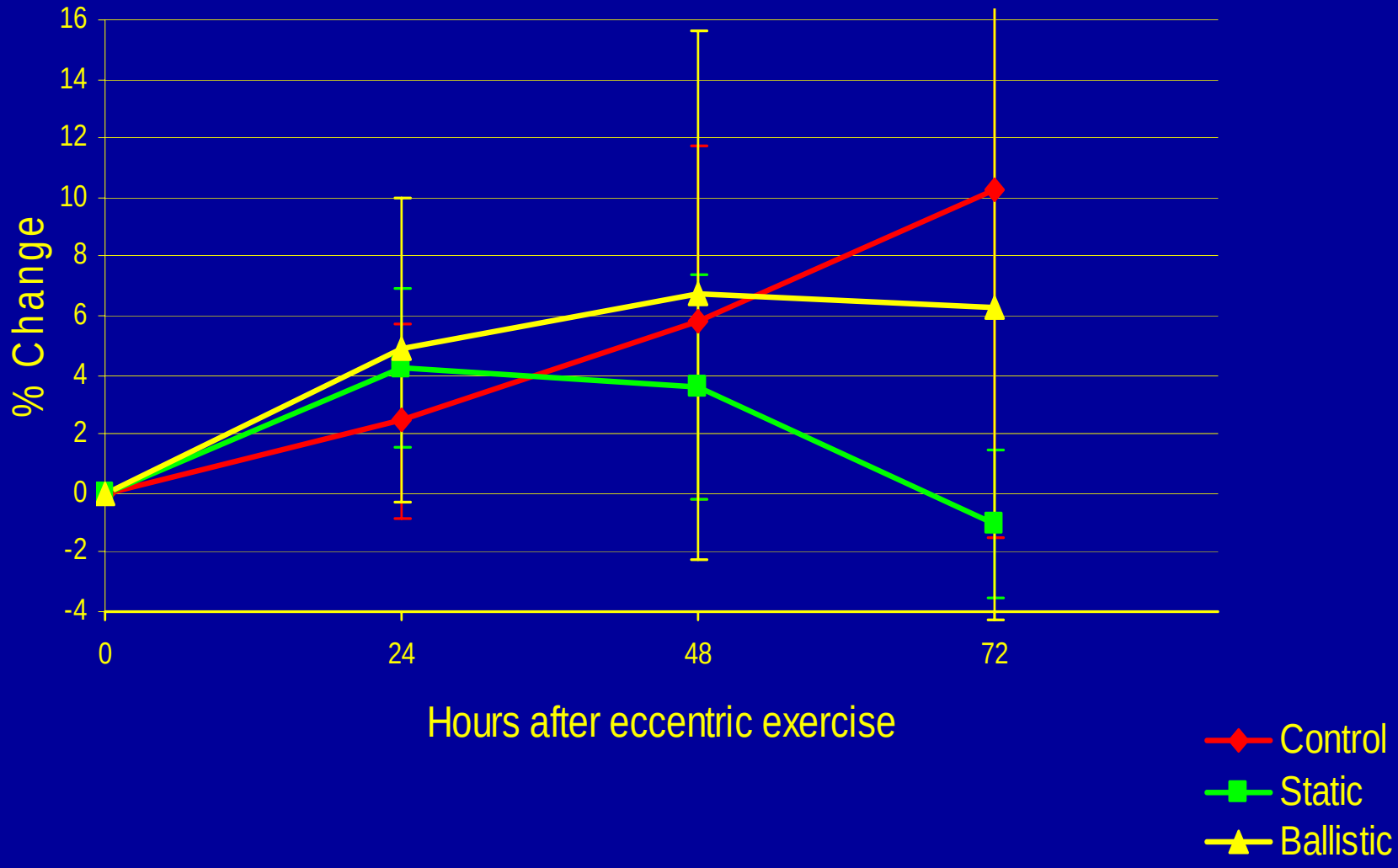
Stiffness

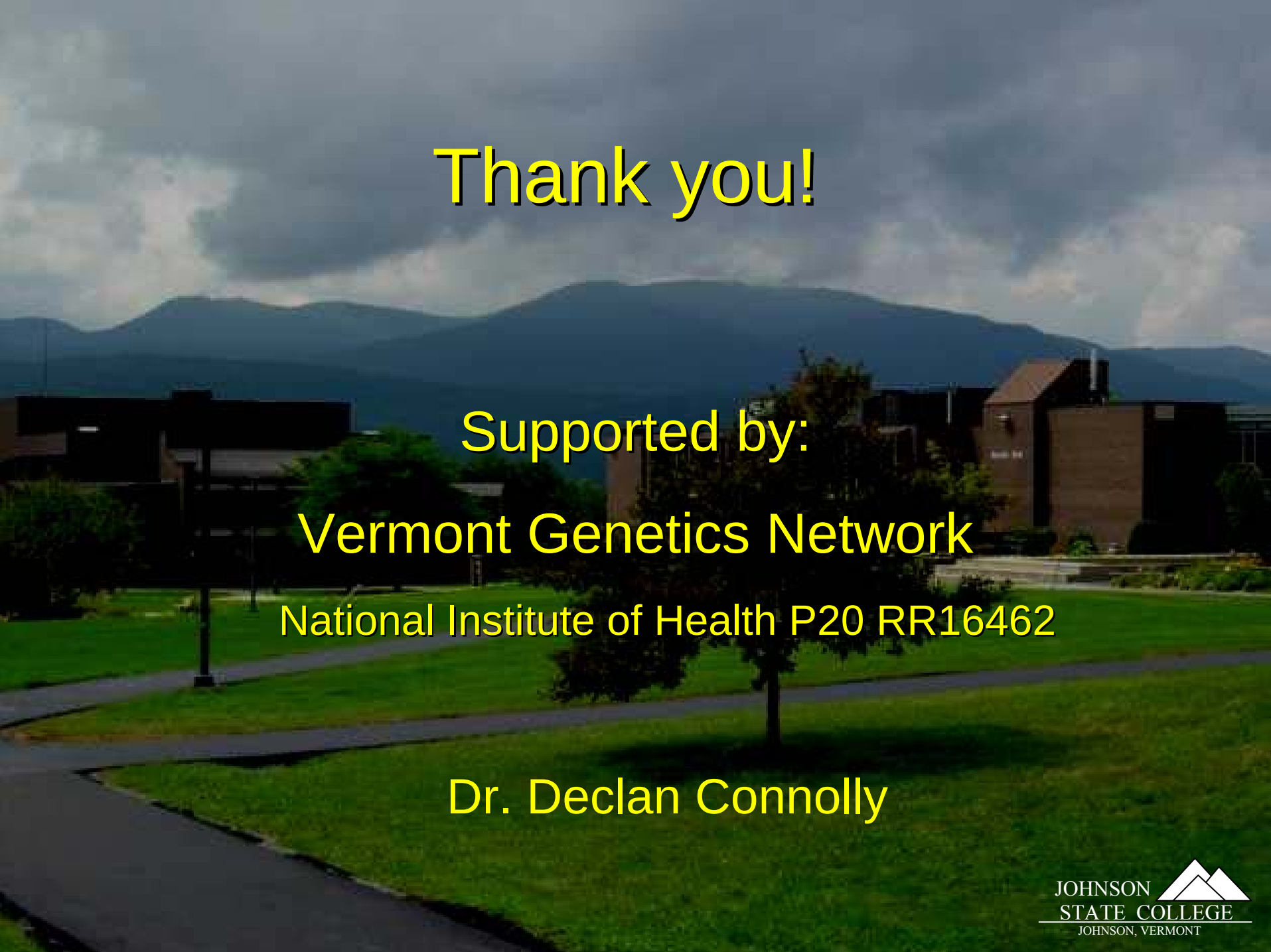

24
20
16
12
8
4
0
-4
-8
-12
% Change
0
24
48
72
Hours after eccentric exercise
Control
Static
Ballistic

Stored Energy



Conclusions

- No effect on soreness after eccentric exercise
- Attenuation of loss of ROM and force tolerance
- No differences in stiffness or energy storage that could account for enhanced ROM
  - Central Nervous System sensitivity to afferent input
- Increased stiffness and energy storage parallel soreness
- Stretching may provide some protective effects against unaccustomed eccentric exercise


Thank you!
Supported by:
Vermont Genetics Network
National Institute of Health P20 RR16462
Dr. Declan Connolly
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Change in Passive Resistance to Stretch following 4-weeks of Stretching

Group	ROM (rad)	Peak Torque (Nm)	Stiffness ($Nm \bullet rad^{-1}$)	Energy ($N \bullet s$)
Control %Δ	**1.2 ± 4.4**	**.04 ± 26.4**	**-2.0 ± 27.8**	**-14.0 ± 11.7**
Static %Δ	**9.5 ± 6.7[a]**	**30.1 ± 38.7[a]**	**-10.3 ± 9.5**	**-8.0 ± 11.8**
Ballistic %Δ	**9.3 ± 9.3[a]**	**25.4 ± 25.3**	**-10.0 ± 19.5**	**.06 ± 21.7**

[a] different from control ($p<0.05$)