KINEMATIC ANALYSIS OF FIVE CARDIOVASCULAR EXERCISES

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Introduction

Cardiovascular (CV) exercise is key to national health efforts aimed at preventing chronic and secondary medical complications in people of all abilities. While there are several equipment options available, a variety of individual factors (e.g., fitness goals, physical impairments) complicate selection of appropriate training devices. While our earlier work[1-3] documented significant differences in muscle demands across exercises, a clearer understanding of kinematic demands is needed to guide device selection.

Purpose

The purpose of this study was to explore lower extremity kinematic demands during five common CV exercises.

Methods

Participants

Ten adults (6 males, 4 females) without musculoskeletal or neurological disorders participated.

Participant Characteristics, Mean (SD)

Age (y)	Height (m)	Mass (kg)
25 (5)	1.73 (1.12)	75 (16)

Instrumentation

Five cardiovascular exercises performed using Life Fitness™ Exercise Equipment: A) Recumbent Biking (95Ri); B) Stair Stepping (95Si); C) Elliptical Training (95Xi); D) Treadmill Walking (97Ti); and E) Treadmill Jogging (97Ti)

- Kinematics
  - 8 Camera Motion Analysis System (Motion Analysis; 60 Hz)
- Foot-to-surface contact patterns
  - Compression closing footswitch insoles (B&L Engineering; 1,200 Hz)

Procedures

Sessions 1-3: Familiarization

- Participants walked and jogged on treadmill (TW and JG), trained on elliptical trainer (EL), recumbent bicycle (RB), and stair stepper (SS) for 3 minutes at a self-selected speed.

Session 4: Data Collection

- Dominant limb lower extremity kinematics recorded during final minute

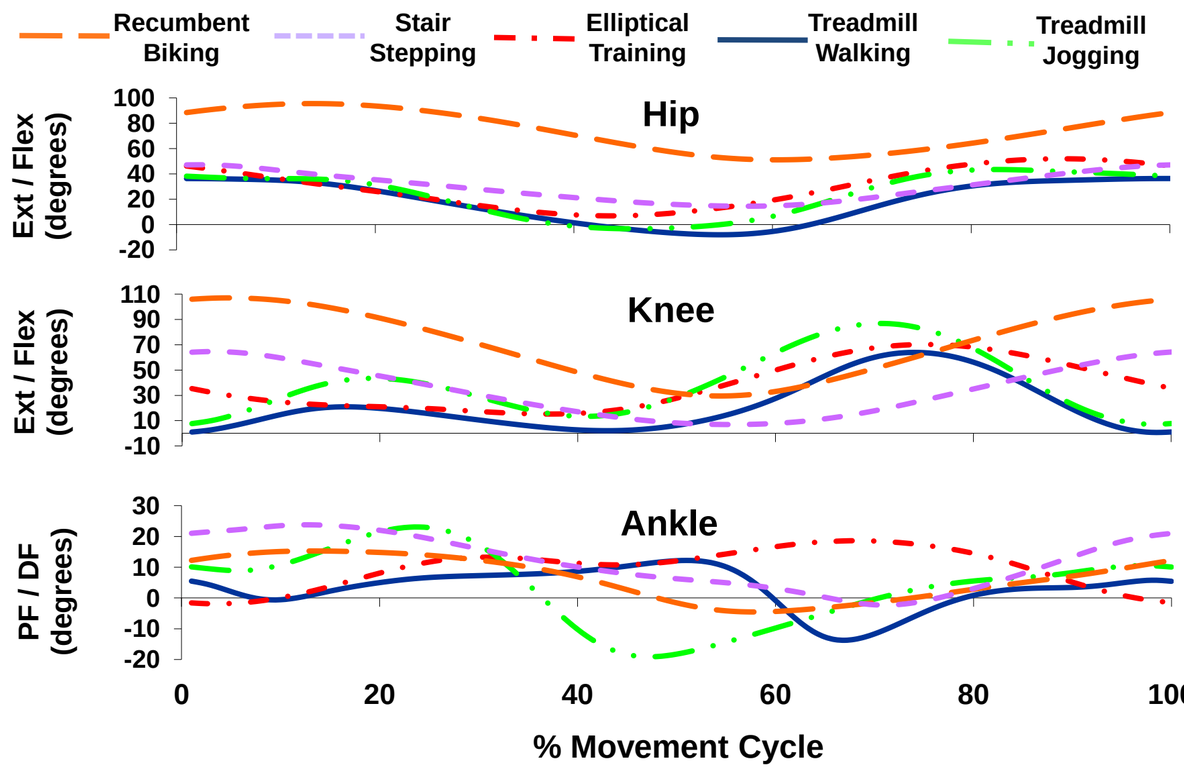
Data Analysis

- 10 strides from final 30 seconds analyzed
- Cycles defined using footswitches (TW, TJ) or pedal kinematics (RB, SS, EL)
- Peak flexion and extension angles identified at hip, knee and ankle.

Statistical Analysis

Separate one-way analyses of variance (5 x 1 ANOVAs) with repeated measures determined if peak angles varied significantly across the five exercises at the hip, knee, and ankle.

Results



Ensemble averaged (mean) kinematic plots of sagittal plane hip, knee, and ankle motion while performing five cardiovascular exercises (n=10 participants).

Peak Flexion and Extension Angles, Mean (SD)

	Peak Position	RB	EL	SS	TJ	TW	Significant Main Effect
HIP	Flexion	96 (13)	54 (5)	48 (8)	44 (3)	38 (4)	RB > TJ, TW; EL > TW
	Extension	51 (10)	5 (4)	14 (6)	-4 (6)	-9 (5)	TW, TJ, EL > RB; TW > SS
KNEE	Flexion	107 (5)	71 (3)	66 (10)	87 (9)	65 (4)	RB > TJ > EL, SS, TW
	Extension	29 (9)	12 (4)	6 (8)	6 (4)	-2 (4)	TW > SS, TJ, EL > RB
ANKLE	Dorsiflexion	17 (10)	25 (6)	25 (7)	24 (3)	13 (3)	EL, SS > TW
	Plantar Flexion	-5 (6)	-4 (4)	-4 (7)	-20 (7)	-15 (5)	TJ, TW > RB, EL, SS

Key: ⊕ = flexion / dorsiflexion; ⊖ = extension / plantarflexion

Discussion & Conclusions

Significant variations in motion demands documented across cardiovascular exercises provide empirical data to guide selection of exercise interventions to promote therapeutic goals. For example, if full hip extension induces pain, then RB and SS may provide opportunities to achieve cardiovascular goals while minimizing pain. Alternatively, the gentle repetitive stretch on anterior capsule structures during EL may offer a means for progressively elongating a flexible hip flexion contracture. Further research exploring the application of select CV exercises on reducing range of motion impairments is warranted.

References

1. Takahashi S et al. *Supp to MSSE,* 39(5): S255.
2. Burnfield JM et al. *Supp to MSSE,* 41(5): S568-569.
3. Buster TW et al. *Supp to MSSE,* 41(5): S569.

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