OPTIMIZING BONE LOADING: PRESCRIBING EXERCISE FOR MAXIMUM IMPACT

SANDRA WEBBER, NIRMAL DAVE, DEAN KRIELLAARS

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UNIVERSITY OF MANITOBA | Rady Faculty of Health Sciences

IMPORTANCE OF PHYSICAL ACTIVITY FOR BONE

- Osteoporosis is a common disorder, but public awareness and engagement in exercises to reduce the likelihood of developing osteoporosis is low
- Dynamic loading positively influences bone mass
- Recommended exercises include: jogging, running, climbing stairs, hiking, jumping activities (ACSM Position Stand Bone Health 2004; NIH Exercise for Your Bone Health 2015)

IMPORTANCE OF PHYSICAL ACTIVITY FOR BONE

- Strain and strain rate are important cues for bone adaptation (Turner, Owan, Takano 1995; Mosley & Lanyon 1998)
- In vivo, acceleration and jerk are analogous to strain and strain rate and are strongly correlated with external loads (ground reaction forces) (Rowlands & Stiles 2012; Stiles, Griew, Rowlands 2012; Vainionpaa et al 2006)
- Exercise intervention studies: positive effects >4.9g or > 100g/s (Vainionpaa et al 2006 and 2007; Jamsa et al 2006; Ahola et al 2009, Heikkinen et al 2007)

IMPORTANCE OF PHYSICAL ACTIVITY FOR BONE

- Studies to date have not reported both acceleration and jerk (the 2 measures have not been rationalized), and individual repetition loading values attained during activities have not been examined (mean values have been reported)
- Purpose: to characterize and compare acceleration and jerk measures for activities and exercises recommended to positively influence bone

METHODS:

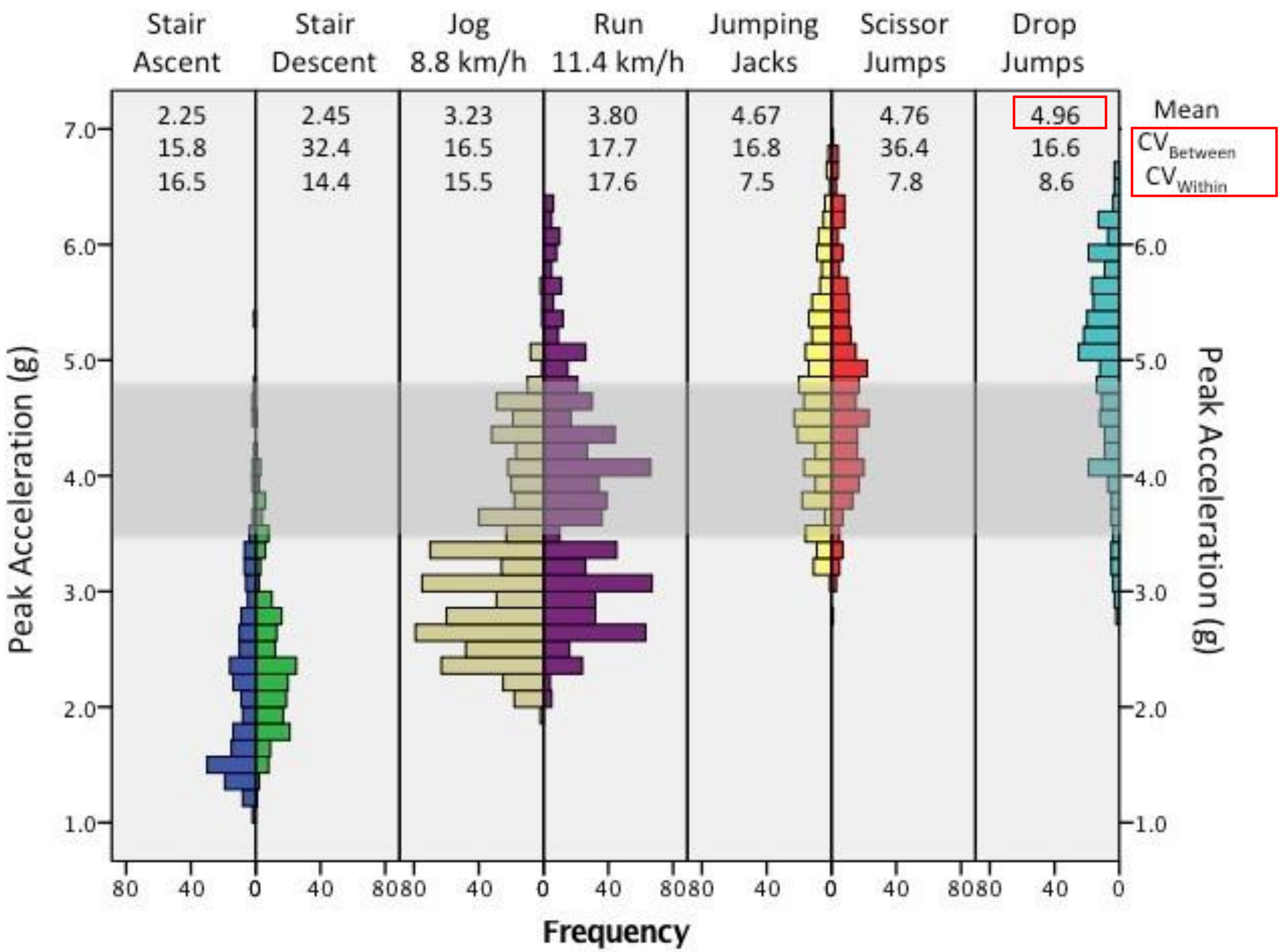
- 30 healthy premenopausal women (39.6 ± 5.5 years) wore GT3X+ monitors on right hip (100 Hz) during standardized exercises
    - Treadmill jog (8.8 km/h, 45s) and run (11.4 km/h, 45s)
    - Ascend/descend 3 X 7 stairs (usual pace)
    - 10 jumping jacks, 10 scissor jumps, 10 drop jumps (box height 20cm)

- Rep by rep analyses were conducted
    - Descriptive statistics
    - Between and within participant coefficients of variation
    - One-way ANOVAs to compare acceleration and jerk between activities
    - Curve fitting and Pearson correlations

RESULTS:

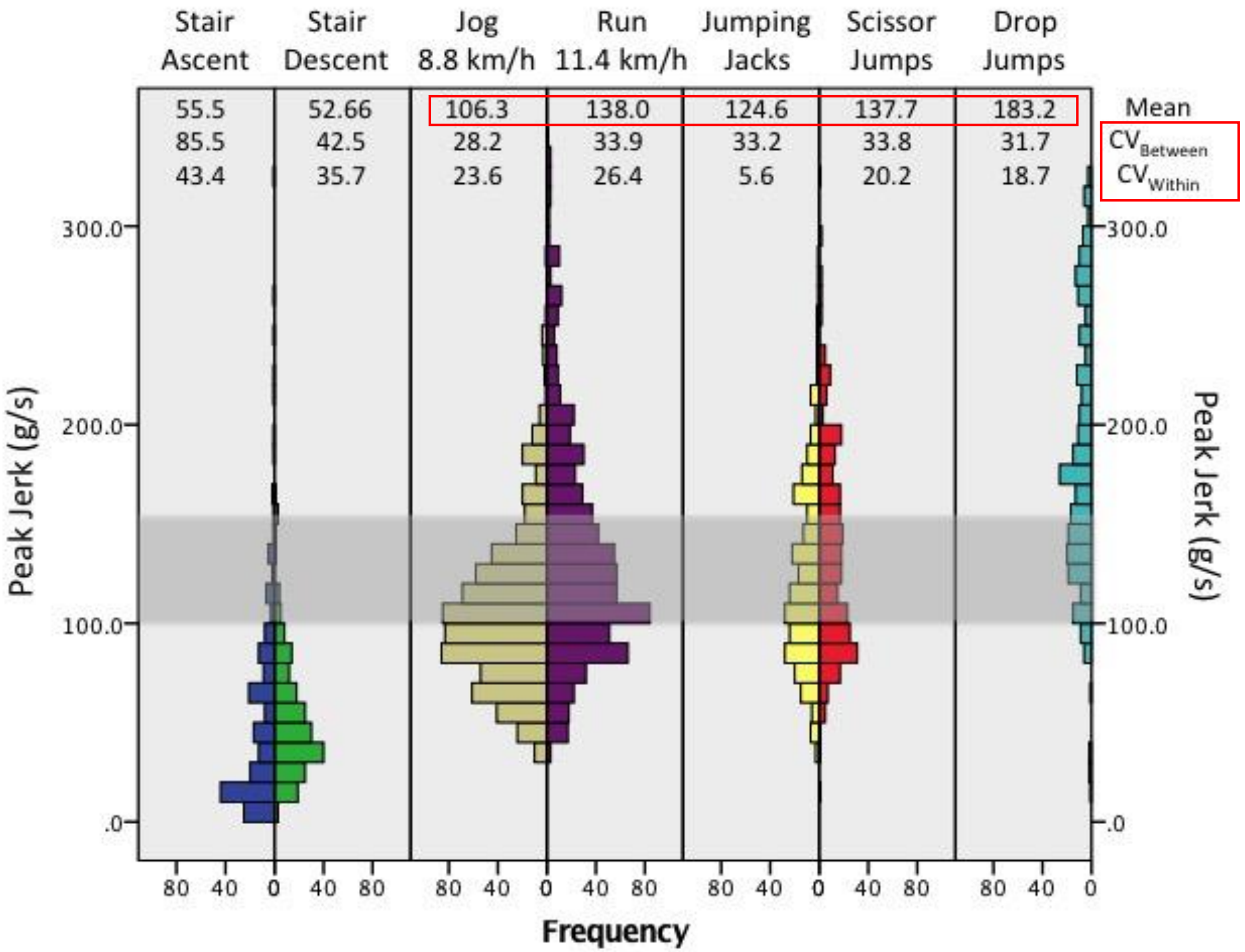
Characteristic	Mean ± SD
Body mass index (kg/m^2)	24.7 ± 4.0
Steps/day	8303 ± 3368
Light activity (min/day)	284.4 ± 61.6
MVPA (min/day)	36.2 ± 22.4
MVPA in bouts (min/day)	18.3 ± 17.9
Number of MVPA bouts/day	0.8 ± 0.7

RESULTS:



JUMPING > RUN/JOG > STAIRS (P<0.001)

RESULTS:

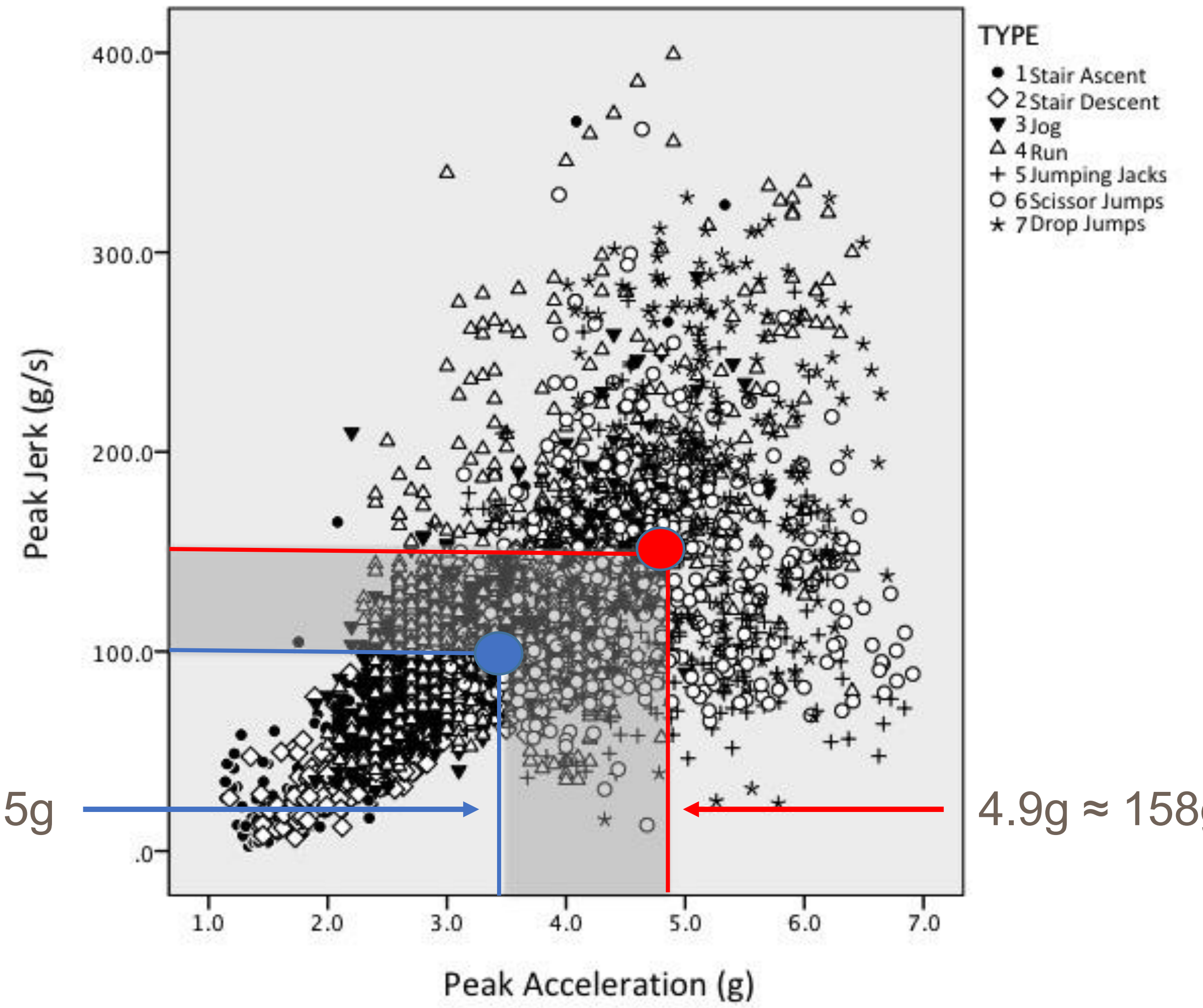


DROP JUMPS > JACKS/SCISSORS/RUN/JOG > STAIRS (P<0.001)

RESULTS:

Best Fit Equation
4.9g ≈ 158g/s
100g/s ≈ 3.5g

100g/s ≈ 3.5g



4.9g ≈ 158g/s

RESULTS:

Activity	Accel/Jerk Correlations
Stairs Up	0.85 (P<0.001)
Stairs Down	0.80 (P<0.001)
Jog	0.76 (P<0.001)
Run	0.52 (P<0.001)
Jumping Jacks	-0.11 (NS)
Scissor Jumps	-0.02 (NS)
Box Jumps	0.23 (P<0.001)

Percentage Participants Meeting Thresholds

Activity	Acceleration ≥ 4.9 g		Jerk ≥ 100 g/s	
	mean peak	any peak	mean peak	any peak
Stairs Up	0	3.4	13.8	31.0
Stairs Down	0	0	3.4	24.1
Jog (n=28)	0	17.9	50.0	75.0
Run (n=27)	7.4	40.7	77.8	85.2
Jumping Jacks	44.8	62.1	65.5	86.2
Scissor Jumps	41.4	72.4	69.0	93.1
Drop Jumps	65.5	75.9	96.6	100

RESULTS & CONCLUSIONS:

- Jumping > Running/Jogging > Ascend/Descend Stairs
- Peak acceleration and jerk demonstrated substantial between-participant (16-86%) and within-participant variability (6-43%)
- Peak acceleration and peak jerk were not correlated with body mass (P=0.70 and P=0.20 respectively)
- First comparison of acceleration and jerk measures
- Threshold recommendation for acceleration (4.9g) not equivalent to threshold recommendation for jerk (100g/s): 4.9g ~ 158g/s and 100g/s ~ 3.5g
- Acceleration and jerk are correlated for some activities but not significantly or substantially correlated for jumping activities

RESULTS & CONCLUSIONS:

- Cannot assume that thresholds based on average loading (4.9g:100g/s) are appropriate for all individuals (high variability in individual repetition response)
- Need further research to determine how acceleration and jerk provide differential stimuli to bone (relative importance of each measure)
- Also need to remember that osteogenic thresholds are individual, bone and bone site specific and depend on the differential between the "training" loading stimulus and the usual stimulus
- However, for premenopausal women who do not run or participate in high impact physical activities (aerobics, court sports etc), we can make some recommendations...

RESULTS & CONCLUSIONS:

4 X 10 jumping jacks

4 X 10 scissor jumps

4 X 10 drop jumps

= 56 reps > 4.9g or 92 reps > 100g/s

approximately 60-100 reps at osteogenic levels

(Vainionpaa 2006, Ahola 2009)

5-6 minutes running (≥ 11.4 km/h)

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