The Influence of Rate of Force Development on Bone Mineral Density in Runners

Abby Hiller, Michele LeBlanc Ph.D., Steven Hawkins Ph.D.

INTRODUCTION

- Wolff's Law states: "Bone adapts to forces made on it"
- Bone strength and density are known to increase in response to both ground reaction forces (GRFs)and muscle forces.
- Rate of force development (RFD) is a measure of power and explosive muscle force.

PURPOSE

The purpose of this study was to determine if rate of force development abilities affects bone density by measuring numerous bone mineral density parameters and ground reaction forces.

METHODS

Subjects:

Data collected by Marcus McKinnon in conjunction with Dr. Steven Hawkins and Dr. Michele LeBlanc from Summer 2010 Research.

- 40 Male distance runners 21.4 ± 3.1 yrs, mass: 66.5 ± 6.7 kg, average distance per week: 52.0 ± 16.7 mi
- All participants completed a consent form approved by the institutional IRB

Each subject completed:

- Health & Training Questionnaire
- Bone density scan of the lumbar spine, hip, and whole body by DXA Hologic Discovery W
- GRF data: Subjects ran barefoot at a self-selected pace (3 trials)on a Kistler 9281CA force plate collecting at 1200Hz
- RFD data: Subjects performed squat jumps (3 trials) from a Kistler 9281CA force plate collecting at 1000 Hz
- Bioware software was used to calculate average RFD
- Two distinct groups of subjects were formed based on the average rate of force development: High RFD: Average RFD > 2000 N/s, Low RFD: Average RFD< 2000 N/s

Analysis:

- Statistics were performed using Excel
- Independent sample t-tests were performed to compare the high and low RFD groups on bone mineral density, GRF and RFD parameters.

Table 1: Group Variables (Mean ± Standard Deviation)

Height (m)	Mass (kg)	Age (yrs)	Distance (mi)
1.8 ± 0.01	66.5 ± 6.7	21.4 ±3.1	52.0 ± 16.7

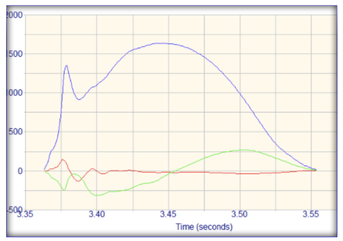


Figure 1: Ground reaction force data

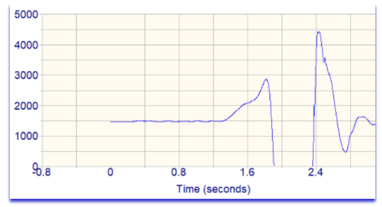
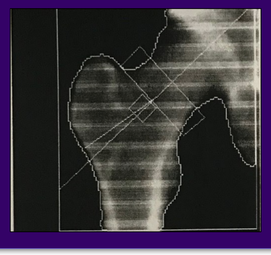


Figure 2: Rate of force development data



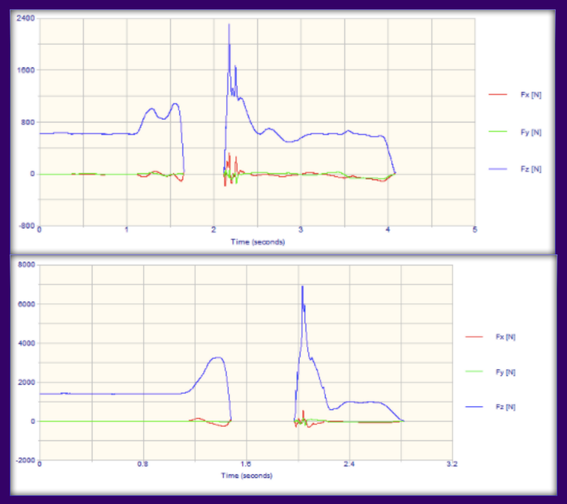


Figure 2. High RFD group > 2000 N/s, Low RFD group <2000 N/s

RESULTS AND DISCUSSION

- There was a significant difference in Peak vertical force between the two groups (1,238.8 ± 135.2 vs. 1,454.4 ± 133.7) (Table 2).
- There was a significant difference in average vertical force during the squat jump between the two groups (947.1 ± 84.1 vs. 1,025.829 ± 118.3) (Table 2).
- There was a significant difference in time to peak rate of force development between the two groups (0.262 ± 0.140 vs. 0.181 ± 0.086) (Table 3).
- There were no differences in any hip nor spine bone mineral density measures in the two groups (Table 2).
- There were no differences in any GRF measure between the two groups (Table 4)
- Differences in rate of force development ability in the squat jump was not a factor in bone mineral density.
- Ground reaction forces during running may be more of a factor.

	Mean ±SD	
Measure	*Low RFD Group*	*High RFD Group*
Femoral Neck BMD (g/cm^2)	0.951 ± 0.110	0.961 ±0.118
Greater Trochanter BMD (g/cm^2)	0.777 ± 0.086	0.761 ±0.069
Intertrochanteric Line BMD (g/cm^2)	1.239 ± 0.133	1.205 ± 0.110
Total Hip BMD (g/cm^2)	1.050 ± 0.104	1.034 ±0.092
Total Lumbar BMD (g/cm^2)	0.962 ± 0.098	0.989 ± 0.096

Table 2: Low RFD vs. High RFD in BMD

	Mean ±SD	
Measure	*Low RFD Group*	*High RFD Group*
SJ Peak Vertical Force (N)*	1,238.8 ± 135.2	1,454.4 ± 133.7
SJ Peak Vertical Force (BW)*	2.0 ± 0.120	2.3 ± 0.190
SJ Average Vertical Force (N)*	947.1 ± 84.1	1,025.829 ± 118.3
SJ Time to Takeoff (s)*	0.507 ± 0.045	0.401 ± 0.056
SJ Air Time (s)	0.486 ± 0.027	0.484 ± 0.037
SJ Peak RFD	4,352.837 ± 794.8	7,913.355 ± 3,137.9
SJ Time to Peak RFD*	0.262 ± 0.140	0.181 ± 0.086

Table 3: Low RFD vs. High RFD in Squat Jump

Measure		Mean ±SD	
Run GRF		*Low RFD Group*	*High RFD Group*
	Max Vertical Force at Fz2 (N)	1764.954 ± 209.2	1724.677 ± 179.9
	Max Vertical Force at Fz2 (BW)	2.703 ± 0.2	2.676 ± 0.1

Table 4: Low RFD vs. High RFD in GRFz from run

Research funded by Swenson Summer Research Fellowship

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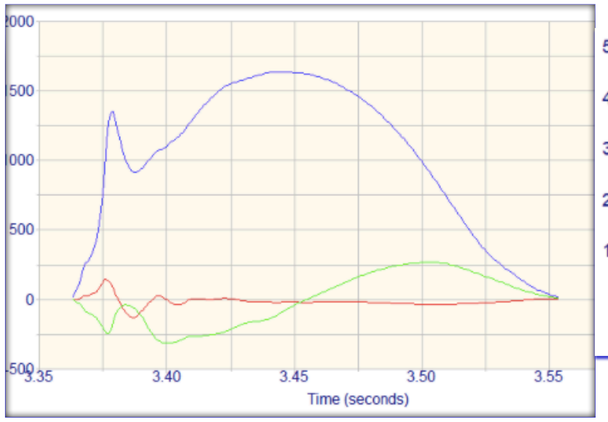

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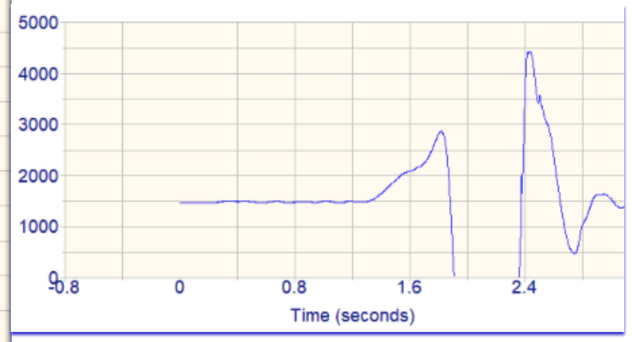

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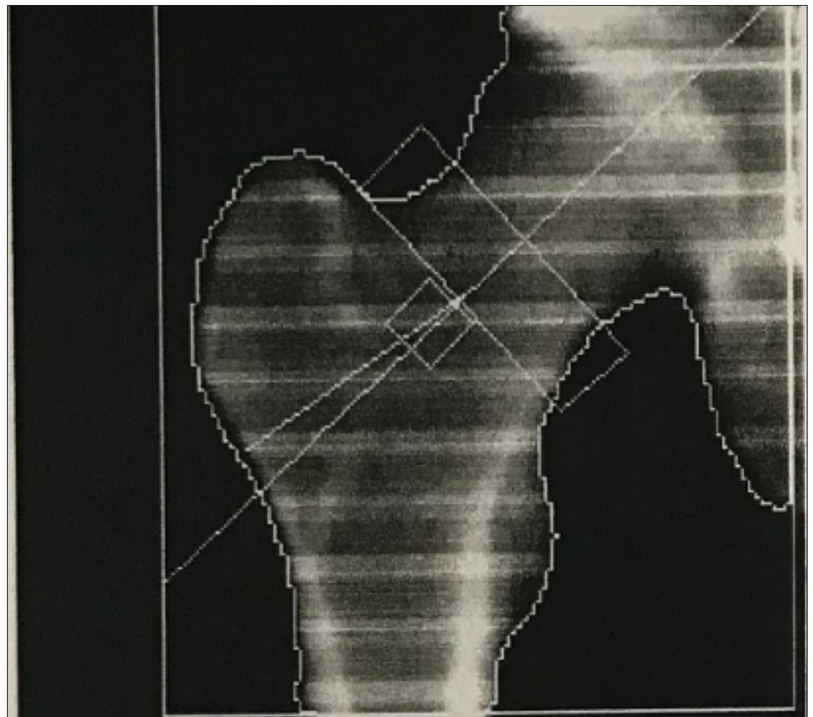

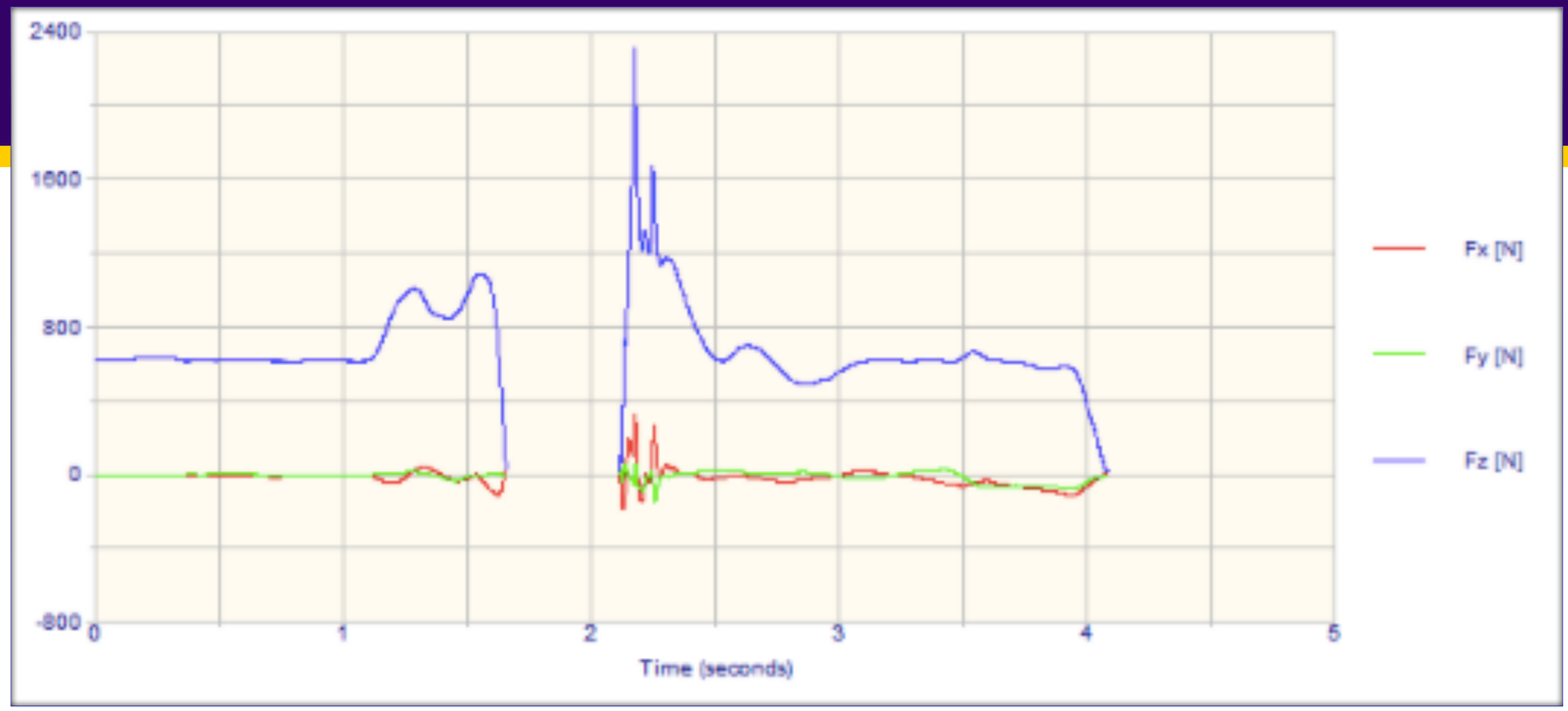

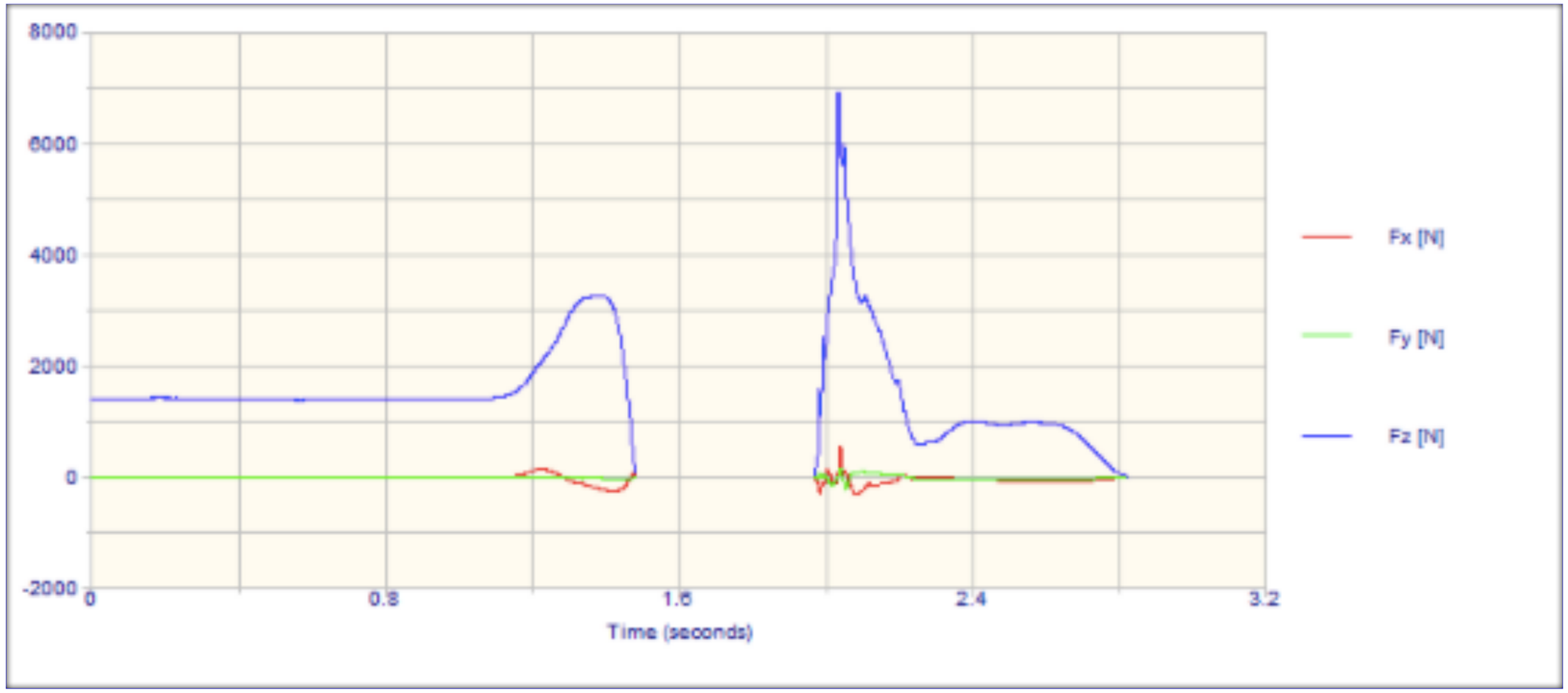

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