

THE EFFECTS OF VARYING STRIDE FREQUENCY ON GROUND REACTION FORCES IN RECREATIONAL RUNNERS

Yack HJ, Jobgen B, Kipp C, Rich P, Turner E, Rao S

Physical Therapy & Rehabilitation Science Graduate Program
The University of Iowa

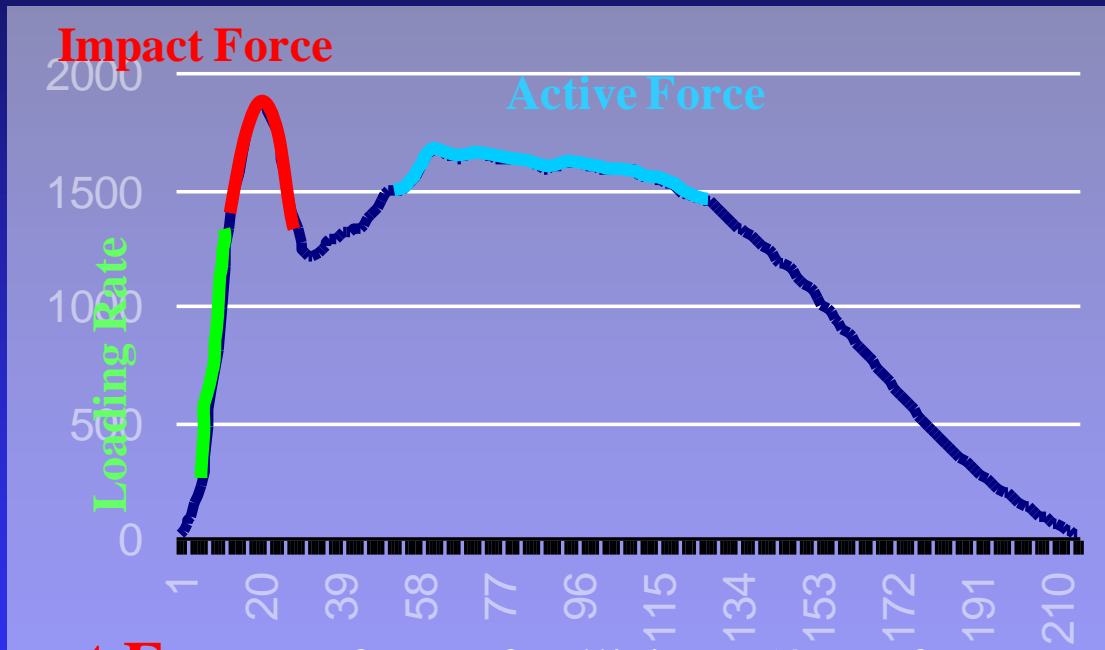
INJURIES IN RUNNING

- Annual incidence of running injuries 37-56%
 - ◆ Recurrence rate of 20-70% (Van Mechelen, 1992)
- Of all injuries 86% involve the lower limb
 - ◆ 70% attributed to stress and overuse (Marti, et al., 1988)
 - ◆ 50- 70% are attributed to overuse (Van Mechelen, 1992)

ROLE OF IMPACT FORCES ON RUNNING INJURIES

- Animal studies have shown a relationship between impact forces and the development of osteoarthritis (Radin et al., 1973)
- Impact forces resulting from the foot contacting the ground may play a role (McClay, 2000)
- May especially be affected by: Impact force, Loading rate, Active Force

GROUND REACTION FORCES (GRF)



Impact Force ≡ force of collision <50ms after contact

Loading Rate ≡ slope of the line from initial contact to Impact Force

Active Force ≡ forces generated by muscular activity

FACTORS THAT INFLUENCE THE GRF DURING RUNNING

- Running speed (Hamill et al., 1983)
- Running downhill (hamill et al., 1984)
- Stride Frequency (Clarke '83; Derrick '98; Farley '96; Hamill '95)
 - ◆ Results somewhat inconsistent
 - ◆ Collection of force data inconsistent
 - ◆ Limited number of subjects
 - ◆ Some cadence ranges are not practical
 - ◆ Using tibial acceleration problematic – ankle may be major component in adjusting lower limb stiffness (Farley '99)

PREVIOUS RESEARCH

| | Method | #Subj. | Speed m/s | Varied | Results Impact Force |
|----------------|---------------------------------|--------|--------------|--|---|
| Clarke '83 | Accel | 10 | 3.8 | Stride Freq. ±5 & 10% | +5 & +10% < Pref |
| Derrick '98 | Accel | 10 | 3.8 | Stride Len. ±10 & 20% | Linear trend +10 & +20% greatest effect |
| Hamill '95 | Accel | 10 | Pref. | Stride Freq. ±10 & 20% | -20% > +20% |
| Farley '95 | Treadmill Forceplate | 4 | 2.5 | Stride Freq. -18 & 26% +17 & 36% | NS |

PURPOSE

To determine if altering stride frequency would change the impact and active peak forces and loading rate of runners who were classified as rearfoot strikers.

Hypothesis

Increasing stride frequency would decrease active force, impact force, and increased loading rate

Subjects

- 19 (14 females, 5 males)
- Inclusion Criteria:
 - ◆ Running History
 - ◆ minimum of three times/week
 - ◆ minimum of 6miles/week
 - ◆ at least three months
 - ◆ no complaints of lower limb pain for 3 months
 - ◆ Willing to give Informed Consent

SUBJECT CHARACTERISTICS

| | Female | Male |
|---------------------|---------------|-------------|
| Age (years) | 23 ± 5 | 24 ± 4 |
| HEIGHT (in) | 171 ± 9 | 183 ± 7 |
| WEIGHT (lbs) | 141 ± 15 | 155 ± 9 |

INSTRUMENTATION

Gaitway[®] Instrumented Treadmill



- ◆ Measures Vertical Ground Reaction Forces
- ◆ Data Acquisition and Analysis via System CPU & Custom Software

– Sampling Rate:
200 Hz.

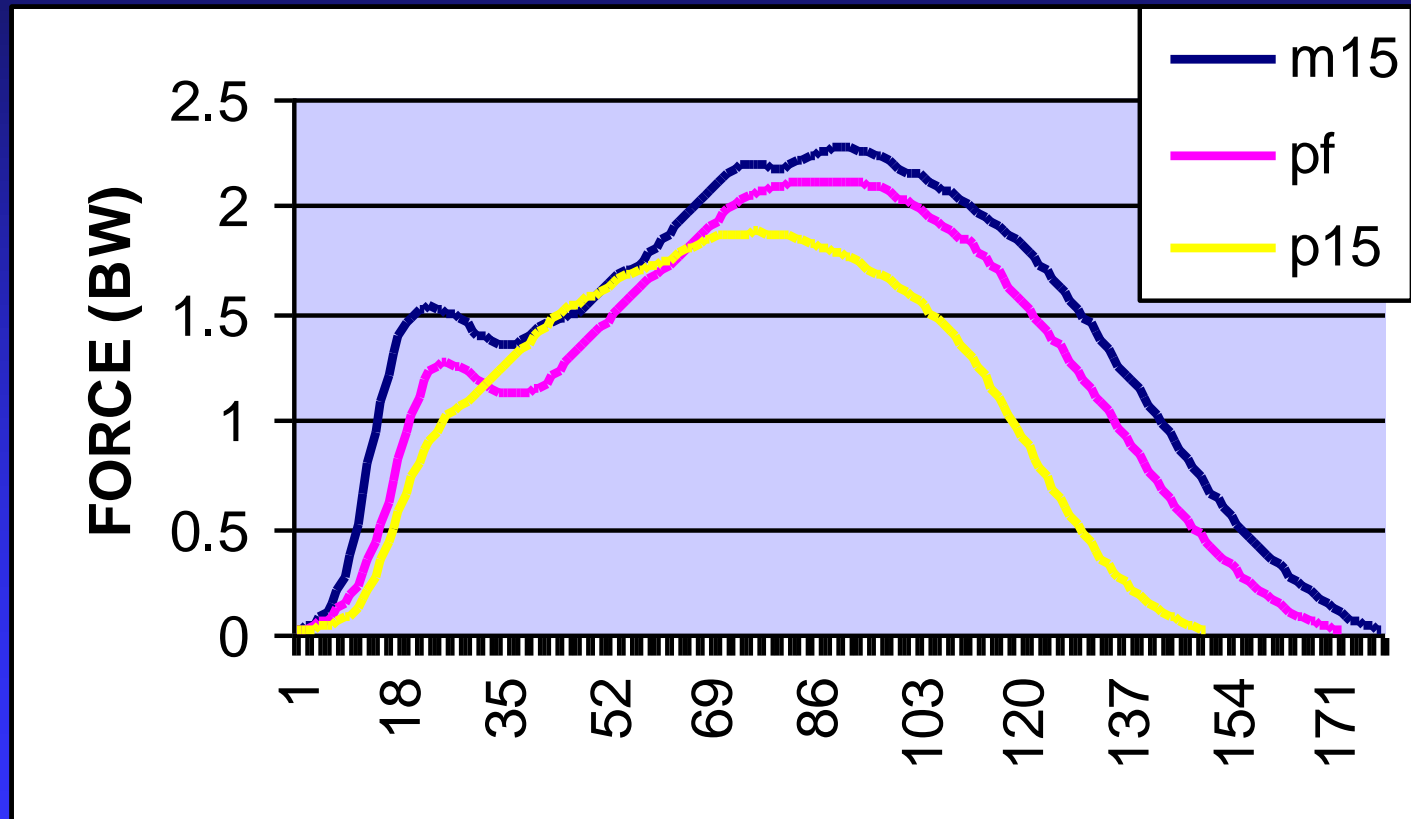
PROCEDURES

- Five Minute Warm-up @ 6.5 mph
 - ◆ Documented preferred cadence
 - ◆ Verified rear foot strike via video recording
- Ran @ Five Cadences: Preferred, +/- 8%, +/- 15%
 - ◆ Cadence maintained via a digital metronome
 - ◆ Cadence order randomly assigned
 - ◆ Protocol
 - ◆ Two-minute rest
 - ◆ One minute practice
 - ◆ Two-minute rest
 - ◆ Two minute run – data collection during final 15 seconds

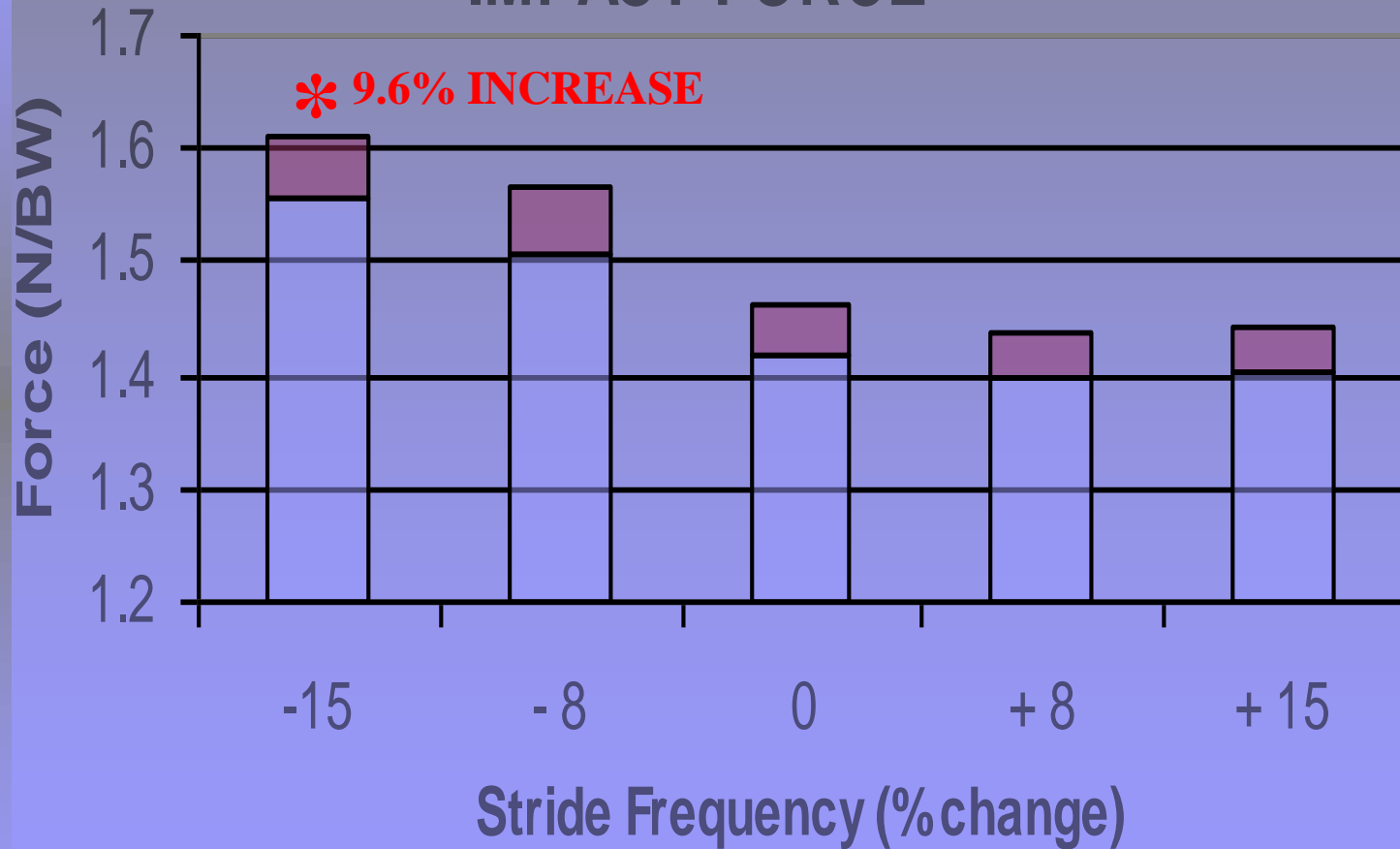
DATA ANALYSIS

- 13 Strides Analyzed
 - ◆ No significant difference between left and right
- Impact Peaks, Active Peaks, and Loading Rates
 - ◆ Loading rate was defined as the slope of the curve from the time of initial contact to the time of the impact peak
- A 2-way ANOVA was used for statistical analysis
 - ◆ Differences from preferred cadence characterized

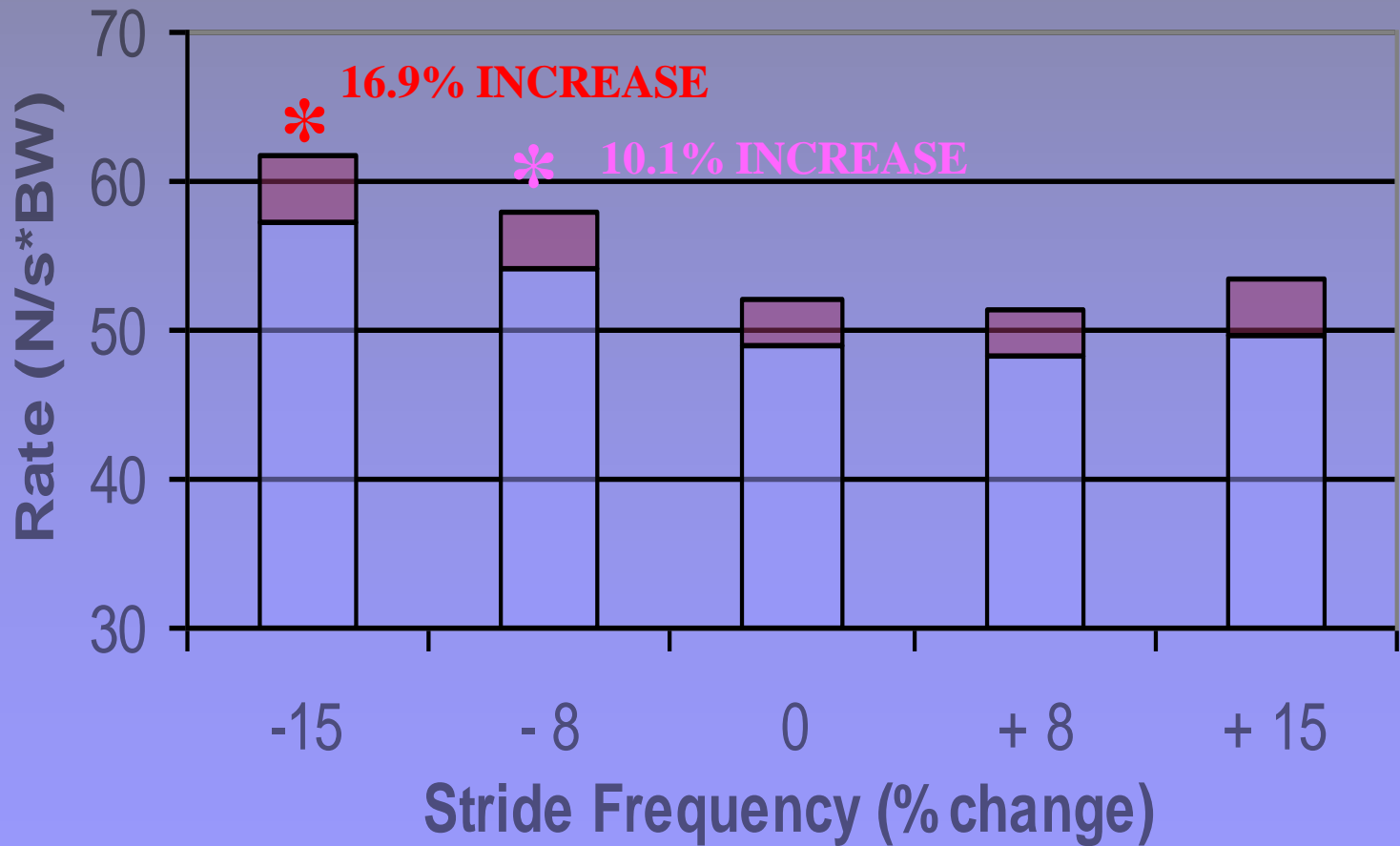
SAMPLE GRFs FOR THREE CADENCES



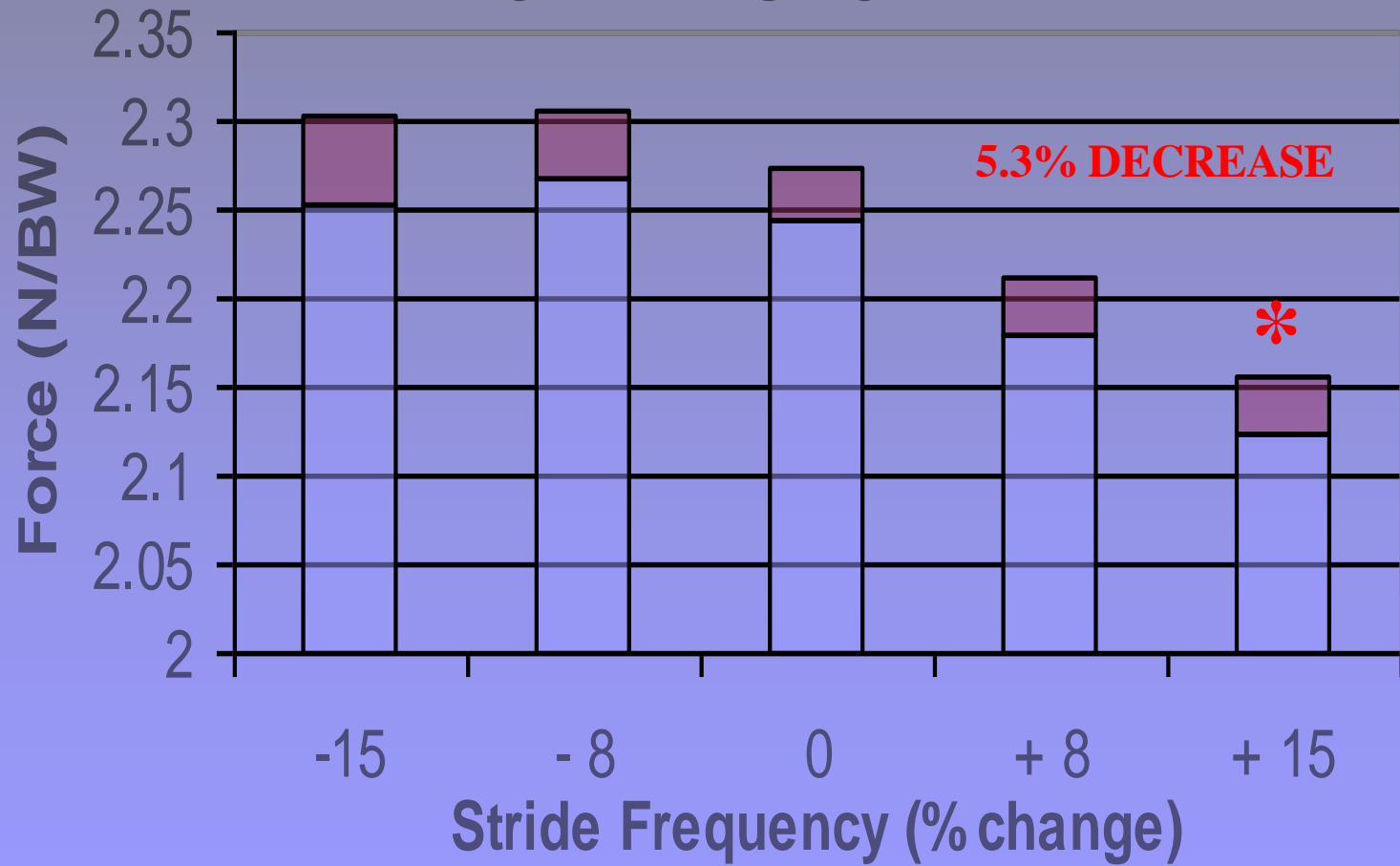
IMPACT FORCE



LOADING RATE



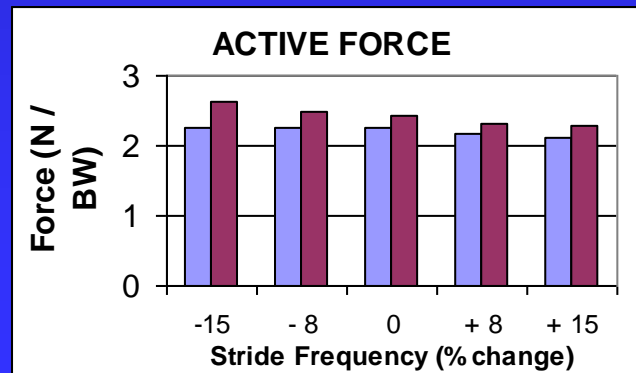
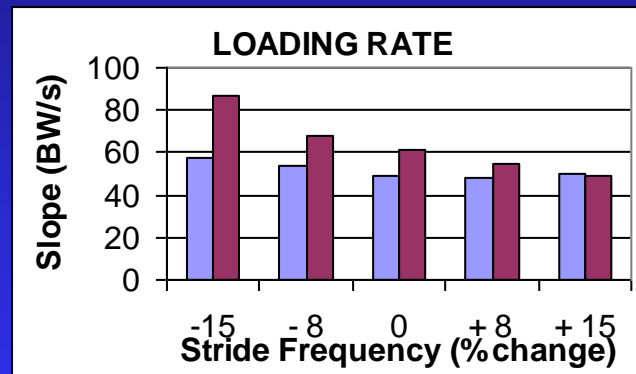
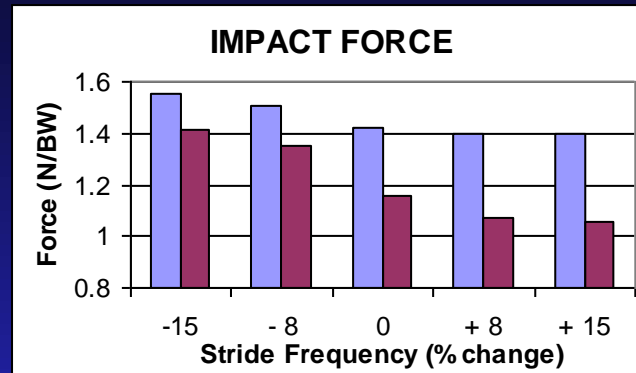
ACTIVE FORCE



SUMMARY & CONCLUSIONS

- It is possible to manipulate GRF by varying cadence by +/- 15%
 - Decreasing the cadence 15% had the undesirable effect of increasing both the Impact Force and Force Rate – requires regulating LE stiffness
 - Increasing the cadence 15% had the potentially beneficial effect of decreasing the Active Force
- (Manipulating the cadence will effect the metabolic cost of running)*

REARFOOT (16) vs FOREFOOT (3) STRIKERS



Questions?