Running Form Modification: When Self-selected is Not Preferred

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Where is the Knee Pain?

9.4 min/mile pace

172 steps/min 180 steps/min
Outline

- Determinants of step frequency/length
- Biomechanical effects of forced change in step frequency
- Evidence for application of step frequency change in treating runners with anterior knee pain
Step Frequency Determinants

- Optimized for metabolic cost
  - minimize muscle activity

External factors:
- Velocity
- Grade
- Footwear
- Surface properties

Internal factors:
- Anthropometry
- Developmental status
- Muscle fiber composition
- Fatigue
- Injury history

Stride Frequency and $O_2$ Uptake

- Most runners naturally choose a stride length–frequency combination that minimizes metabolic cost

- Accomplished through adjustment of leg stiffness so that optimal muscle activation is achieved

COM Vertical Displacement and Step Frequency

- Increased step frequency:
  - Decreased contact time
  - Decreased COM vertical displacement
  - Slight decrease in vertical GRF

Morin et al. (2007) *J Biomechanics*
COM Vertical Displacement and Step Frequency

- Increased step frequency reduces vertical displacement of COM
  - $r = -0.81$

- Step frequency appears to increase with training experience
  - Similar running speed across subjects

Step Frequency and Leg Stiffness

- Leg stiffness increases with step frequency
- Minimal change if ±10% PSF

Morin et al. (2007) *J Biomechanics*
Farley and Gonzalez (1996) *J Biomechanics*
Metabolic Cost vs Tissue Stress

- Forcing a shift away from preferred may be necessary under some circumstances

  Cavanagh (1987) *Foot Ankle*

- **Metabolic cost**

- **Local tissue stress/strain**

- **Injury Recovery and Prevention**
  - Tissue protection
  - Load distribution
Stride Frequency and Tibial Accelerations

- Decreased tibial accelerations with increased stride frequency
  - Constant speed

- More vertical leg posture at initial contact
  Farley and Gonzalez (1996) J Biomechanics
Location of Injury

5 most common injuries

- Patellofemoral pain syndrome
- Iliotibial band friction syndrome
- Plantar fasciitis
- Tibial stress fracture
- Knee meniscal injuries

Running-related Injuries

Potential benefits of increased step frequency:

1. Decrease horizontal distance of foot-ground contact from COM
   - Reduce braking impulse
   - Reduce knee extensor moment

2. Increase lower extremity stiffness
   - Reduce vertical excursion of COM
   - Increase muscle pre-activation
Step Frequency and Joint Mechanics

- 50 healthy runners
  - > 15 miles/week

- Run at self-selected speed
  - constant across conditions

- 5 step frequencies:
  - Preferred (PSF)
  - PSF ± 5%
  - PSF ± 10%

- Paced by metronome
Step Frequency Manipulation

- Preferred (160 steps/min)
- Preferred + 5% (168 steps/min)
- Preferred + 10% (176 steps/min)
COM and Forces

- COM vertical displacement
- COM-heel distance
- GRF - braking impulse
- GRF - peak vertical

Step Frequency (% PSF)
Knee Angle and Moment

Knee Flexion Angle (deg) vs. Knee Ext Moment (% PSF)

-10 -5 PSF +5 +10

Step Frequency (% PSF)

- Knee Flexion - IC
- Knee Flexion - Peak
- Knee Extension Moment

mid-stance
initial contact

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Clinical Application

- Runners with anterior knee pain
  - Trial treatment of cadence manipulation
    - 5-10% increase in step frequency using metronome on treadmill
    - 1-2 min period of adjustment
    - 50+% decrease reported in symptoms during session
    - Follow-up indicates immediate symptom improvement/resolution

PSF (162) with knee pain

172 without knee pain
Utilization of Step Frequency Manipulation

- Temporary form change to maintain mileage
  - Reduce load to knee joint

- Strategy to promote muscle activation prior to loading
  - Mechanism to facilitate carryover of strength gains into running

- Consider as more permanent change to running form
  - “better to understride [length] than overstride”...especially in beginning runners

Elliott and Blanksby (1979) Br J Sports Med
Step Frequency and Anthropometrics

- Anthropometrics should not be used to determine the appropriateness of a person’s step length/frequency
  - Anthropometrics are not strongly associated with step length
    - tall or long legged runners do not necessarily have a longer stride length
    - runners with thinner legs do not have a longer stride length

- 180 steps/min suggested as optimum for performance
  - 145-160 steps/min is common in recreational runners

- Requires trial-and-error approach
  - Fast and simple

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Evidence for Training Carryover

- Reduce impacts by using impact as feedback
- 8 training sessions over 2wks
- New running form maintained at 4wk follow-up with no intermediate training

Metabolic Cost of Step Frequency Change

- 8% shift from preferred stride frequency (PSF) increased $O_2$ uptake by 3 ml/kg/min
  Hunter et al. (2007) *Eur J Appl Physiol*

- Moderate deviations in stride length had minimal effects on $O_2$ uptake
Other Potential Applications

Increase step frequency:

- Iliotibial band syndrome
  - Reduce knee flexion excursion

- Plantar heel pain
  - Reduce foot-ground angle at initial contact

- Anterior compartment
  - Reduce eccentric demand on tibialis anterior
Comprehensive Treatment

- Step frequency change part of treatment plan

- Additional interventions included as needed to target impairments
  - strengthening and stretching
Summary

- Increasing step frequency reduces knee joint loading during running
- Preliminary evidence of symptom reduction by increasing step frequency in runners with anterior knee pain
- Running form modification should be considered as an adjunct to current interventions
  - injury prevention or recovery
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References


