Using Force Sensitive Resistors to Monitor Foot Contact Events in Sprint Running

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Context

• Sensors are getting smaller, lighter, cheaper, wireless

• Analysis can be undertaken in training

• Allows quantitative assessment of training and sharing of data
Sprint Biomechanics

• Ground contact time (CT) is an important measure in sprinting

• CT is a variable that elite coaches are interested in monitoring

• CT is linked to force production
  – Force production allows CT to be minimised  
    (Mann, 1985)
  – Negative relationship between CT and velocity  
    (Weyand et al., 2000)
Ecological Validity
Ecological Validity

– Use sensors with athletes in ‘normal’ training
  • *sprinters don’t want to wear anything extra*
– Disturb the environment as little as possible
– Capture and store data automatically
– Provide feedback as soon as possible
Unobtrusiveness?!
Considerations

• Measurement of CT requires a high sampling rate
  – Ideally ~ 1000 Hz

• A simple method of detecting touchdown and take-off is necessary
  – CODA marker vertical acceleration

  (Bezodis et al., 2007)

• Data capture volume is constrained with automatic motion analysis
Why Use In-Shoe Measures?

• Facilitates collection of data for all steps of a sprint run
  – Combines high-resolution quantitative measurement with large capture volume

• Can be engineered so system is comfortable and unobtrusive
Aims

• To develop and evaluate an in-shoe method of obtaining contact times during a sprint run

• To use data for research and feedback purposes

• To integrate this system into an on-athlete wireless network of data collection devices
System Specifications

- Tiny sensing node
- Weighs 8 g (with battery)
- Multiple nodes sync
- Tens of pounds
Force Sensitive Resistors (FSR)
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Shoe to shoe wireless synchronisation errors:
mean = 0.1 ms
max   = 1.0 ms
capture duration (3 mins)

Twin Force Plate criterion

ION board
Small, lightweight sensing node, on-board storage
wire-less communications, sampling rate = 1kHz.
[Atmel AT91SAM7S256 processor
Nordic nRF24L01+ 2 Mbps radio, 16 MBytes of flash,
12 bit external ADC and a 16 g 3D accelerometer].
SMD radio antenna edge of ION board, all outside shoe
System Validation

- Validate CT against criterion measures
  - CODA motion analysis
  - Kistler force plate
- Contact time (FSR)
  - Automated algorithm
  - First derivates of FSR signal
Validity (FSR v CODA)

CODA CT
FSR CT
Validity (FSR v FP)
System Validation

• Comparison to criterion motion analysis and force plate data

• Motion Analysis (CODA): 0.0033 s, 1.2%

• Force plate: 0.0025 s, 1.4%
Heel does little on the medial then roll... onto the lateral... final push from the toe.
Can sync to video...
Compute the stride/step times, flight/swing times, contact times

Stride time

Swing time

Step time

CT

FT*

*FT = flight time
Speed vs. Contact Time

Linear CSA: 1.36341464317

Exp CSA: 0.876881399886
System Application: Hurdling

![Graph showing time (ms) vs. step count for left and right steps. The graph highlights pre-hurdle and post-hurdle counts, with distinct markers for each phase.]
Contact & Flight Times

- Hurdle flight time
- Pre-hurdle step
- Post-hurdle step

Step Count: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35

Time (ms): 0 50 100 150 200 250 300 350 400
Athlete & Coach Feedback

• Worn in both training and competition

• “Forget it’s there”

• Useful data to facilitate and support the coaching process
Future Work

• Establish link between contact time and performance

• Integrate system with other wireless monitoring devices
Summary

- On-body sensor system for foot/ground interaction in elite sprinting and sprint hurdling
- Domain specific demands, coach information, scientific tool
Thank you for your attention