WCU Faculty Forum

Biomedical Research

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Ken Clark, Ph.D.
Assistant Professor, Kinesiology Department
Personal Background

- NCAA D-III Running Back
- Consult for USA Track & Field
- S&C Coach: High School → Pro
- PhD & Research in SMU Performance Lab
- Assistant Sprints Coach for WCU Track Team
- Master's in Kinesiology from WCU in 2008
- Consult for USA Track & Field
Newton Rules… Force is **KING**

DETERMINES PERFORMANCE SPECTRUM

![Image of Newton with Burger King crown]

DYSFUNCTION

and everything in between

![Image of athlete in dysfunction]

FUNCTION
Faster Speed = Greater Force

$\text{Force} \quad \frac{\text{Mass}}{\text{Mass}}$

slow

slow

FAST!!
THE LONGITUDINAL EFFECTS OF RESISTED SPRINT TRAINING USING WEIGHTED SLEDS VS. WEIGHTED VESTS

KENNETH P. CLARK,1 DAVID J. STEARNE,1 CORY T. WALTZ,2 AND ANTHONY D. MILLER1

1Human Performance Laboratory, Department of Kinesiology, West Chester University of Pennsylvania, West Chester, Pennsylvania; and 2Athletic Department, Haverford College, Haverford, Pennsylvania
PhD Studies: mechanics separate **ELITE** from *average*

Leg Drive Powerful + **Stiff Contact** =

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**Are running speeds maximized with simple-spring stance mechanics?**

Kenneth P. Clark and Peter G. Weyand  
*Southern Methodist University, Locomotor Performance Laboratory, Department of Applied Physiology and Wellness, Dallas, Texas*
Determining **FORCE** from **MOTION**

\[ F_{z_{\text{average}}}(BW) = \frac{GCT(s) + FT(s)}{GCT(s)} \]
Determining **FORCE** from **MOTION**

**SHORT COMMUNICATION**

Foot speed, foot-strike and footwear: linking gait mechanics and running ground reaction forces

Kenneth P. Clark, Laurence J. Ryan and Peter G. Weyand*


**RESEARCH ARTICLE**

A general relationship links gait mechanics and running ground reaction forces

Kenneth P. Clark¹,², Laurence J. Ryan¹ and Peter G. Weyand¹,*

Current Issues in Sport Science 3 (2018)

Running impact forces: from half a leg to holistic understanding

Kenneth P. Clark¹, Andrew B. Udofo², Laurence J. Ryan² & Peter G. Weyand²,*

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Validating FORCE determined from MOTION

Video Measures of Running Ground Contact Times and Vertical Ground Reaction Forces
Sabrina M. Mangeri, Tyler D. Whitacre, David J. Steane, and Kenneth P. Clark
Department of Kinesiology, West Chester University, West Chester, PA

ABSTRACT

Purpose: Validate video-based measures of ground contact time (GCT) and vertical ground reaction force (VGRF) compared to a laboratory force plate.

Methods: 60 subjects (13 males, height = 1.74 ± 0.07m, mass = 76.0 ± 2.0kg; 7 females, height = 1.62 ± 0.09m, mass = 62.0 ± 2.0kg) volunteered and provided written consent. A high-speed camera (HSC, Phantom Vislo) filming at 240 Hz was placed at three locations designed to replicate a camera truck in a track setting. The camera filmed the ground contact on the force plate as subjects performed three running trials at different self-selected speeds (jog, run, sprint), with two minutes rest between each trial. Velocity was measured with an automatic timing system (Free Lap), and VGRF was directly measured using an invasive laboratory force plate (Kistler 9281A) collecting at 1000 Hz.

Results: Stat: are provided in Table 1. The HSC had excellent accuracy for GCT (R² = 0.97), but was less accurate for calculations of average VGRF (R² = 0.55).

Conclusions: A HSC filming at 240 Hz can accurately determine GCT during running, but demonstrates more error when calculating VGRF.

METHODS

Research Design: one testing session, within-subjects design
Subject:
- Healthy, recreationally-trained adults (N = 20 total)
- Males (N = 13, height: 1.74 ± 0.07m, mass: 76.0 ± 2.0kg, leg length: 0.90 ± 0.04 m)
- Females (N = 7, height: 1.62 ± 0.07m, mass: 62.0 ± 2.0kg, leg length: 0.87 ± 0.06 m)

Testing Procedures:
- Dynamic Warm-up before each test session.
- Three running trials at each self-selected speed (jog, run, sprint), with two minutes rest between trials
- Instructed to strike the force plate without altering gait instrumentation:
  - Apple iPad Pro 6.1 filming at 240 frames per second.
  - Kistler 9281A Force Plate collecting data at 1000 Hz
  - Free Lap Automatic Timing System

Calculations:

\[ \text{GCT}_{\text{average}} = \frac{\text{GCT}(t) + \text{FT}(t)}{\text{GCT}(t)} \]

RESULTS

Table 1. Mean Absolute Error and Mean Percentage Error

<table>
<thead>
<tr>
<th></th>
<th>iPd Error vs. Force Plate Contact Time</th>
<th>iPd Error vs. Force Plate Vertical Force</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Abs Error</td>
<td>0.007</td>
<td>0.17</td>
</tr>
<tr>
<td>Mean Abs Error (%)</td>
<td>1.2%</td>
<td>10.7%</td>
</tr>
</tbody>
</table>

Conclusion:
1. A commercially available high-speed camera filming at 240 Hz can accurately determine GCT during running.
2. Caution is warranted when calculating VGRF using a high speed camera at 240 Hz.

REFERENCES

Assessment of Between-Leg Asymmetry

**Vertical Force Application with Left and Right Leg**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Left Leg</th>
<th>Right Leg</th>
<th>Left-Right % Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Ground Contact Time (s)</td>
<td>0.134</td>
<td>0.129</td>
<td>3.4</td>
</tr>
<tr>
<td>Average Vertical Force (BW)</td>
<td>1.95</td>
<td>1.73</td>
<td>11.3</td>
</tr>
<tr>
<td>Average Vertical Impulse (BW*s)</td>
<td>0.26</td>
<td>0.22</td>
<td>14.3</td>
</tr>
<tr>
<td>Average Rate of Vertical Loading (BW/s)</td>
<td>32.3</td>
<td>30.7</td>
<td>5.1</td>
</tr>
</tbody>
</table>
Sprint Acceleration

#1) Enough vertical force to support & lift body

#2) rest of force directed horizontally
Sprint Acceleration

Block start on lab force plates with synchronized force-motion:

Train athlete to *optimize* vertical force and *maximize* horizontal force

Blue: Vertical Force
Red: Horizontal Force

*Sprinter 100m PR:*
*10.46 seconds*
New OptiTrack Motion Capture System
New OptiTrack Motion Capture System
Simultaneous **FORCE** and **MOTION**