WCU Faculty Forum

Biomedical Research

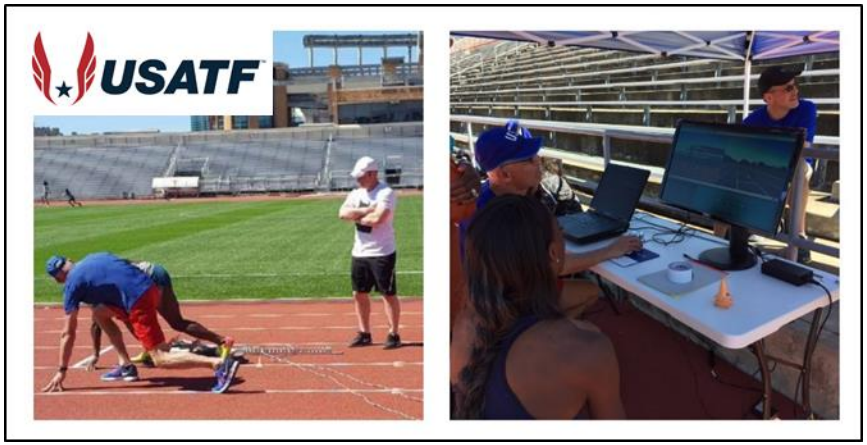
February 6th, 2020

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

Newton Rules… Force is *KING*

DETERMINES PERFORMANCE SPECTRUM

DYSFUNCTION

FUNCTION

and everything in between

Faster Speed = Greater Force

Force
Mass

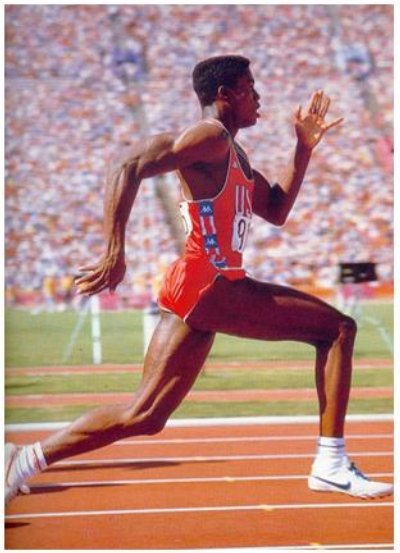
slow

Force
Mass

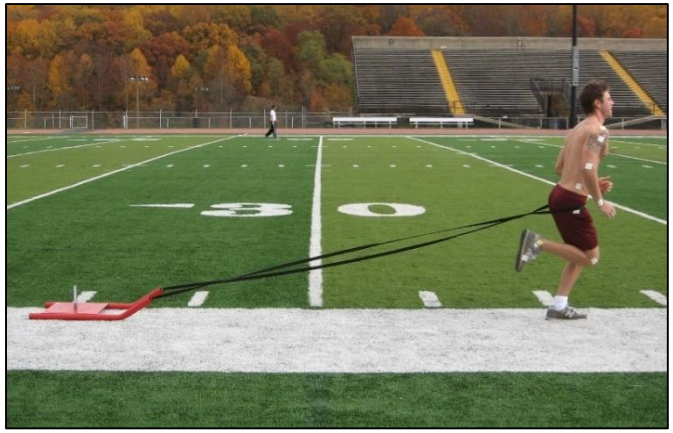
slow

Force
Mass

FAST!!



WCU Master's Thesis: Sprint Training Study



HAVERFORD

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

KENNETH P. CLARK,[1] DAVID J. STEARNE,[1] CORY T. WALTS,[2] AND ANTHONY D. MILLER[1]

[1]Human Performance Laboratory, Department of Kinesiology, West Chester University of Pennsylvania, West Chester, Pennsylvania; and [2]Athletic Department, Haverford College, Haverford, Pennsylvania

the Journal of Strength and Conditioning Research™

NSCA National Strength and Conditioning Association

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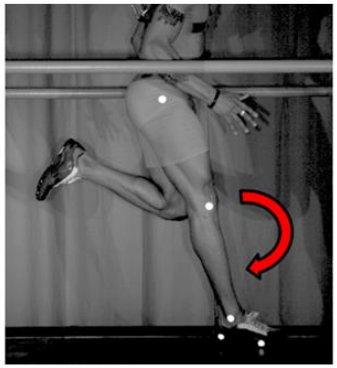
PhD Studies: mechanics separate **ELITE** from *average*

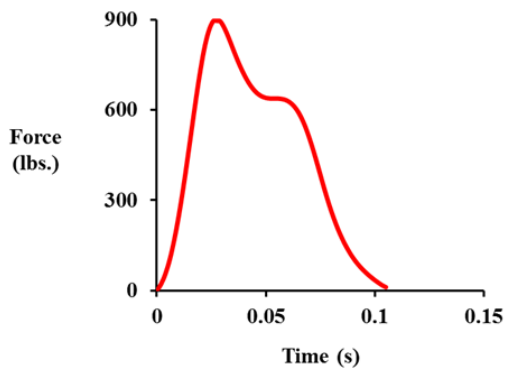
Leg Drive Powerful



+

Stiff Contact

=



J Appl Physiol 117: 604–615, 2014.
First published July 31, 2014; doi:10.1152/japplphysiol.00174.2014.

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

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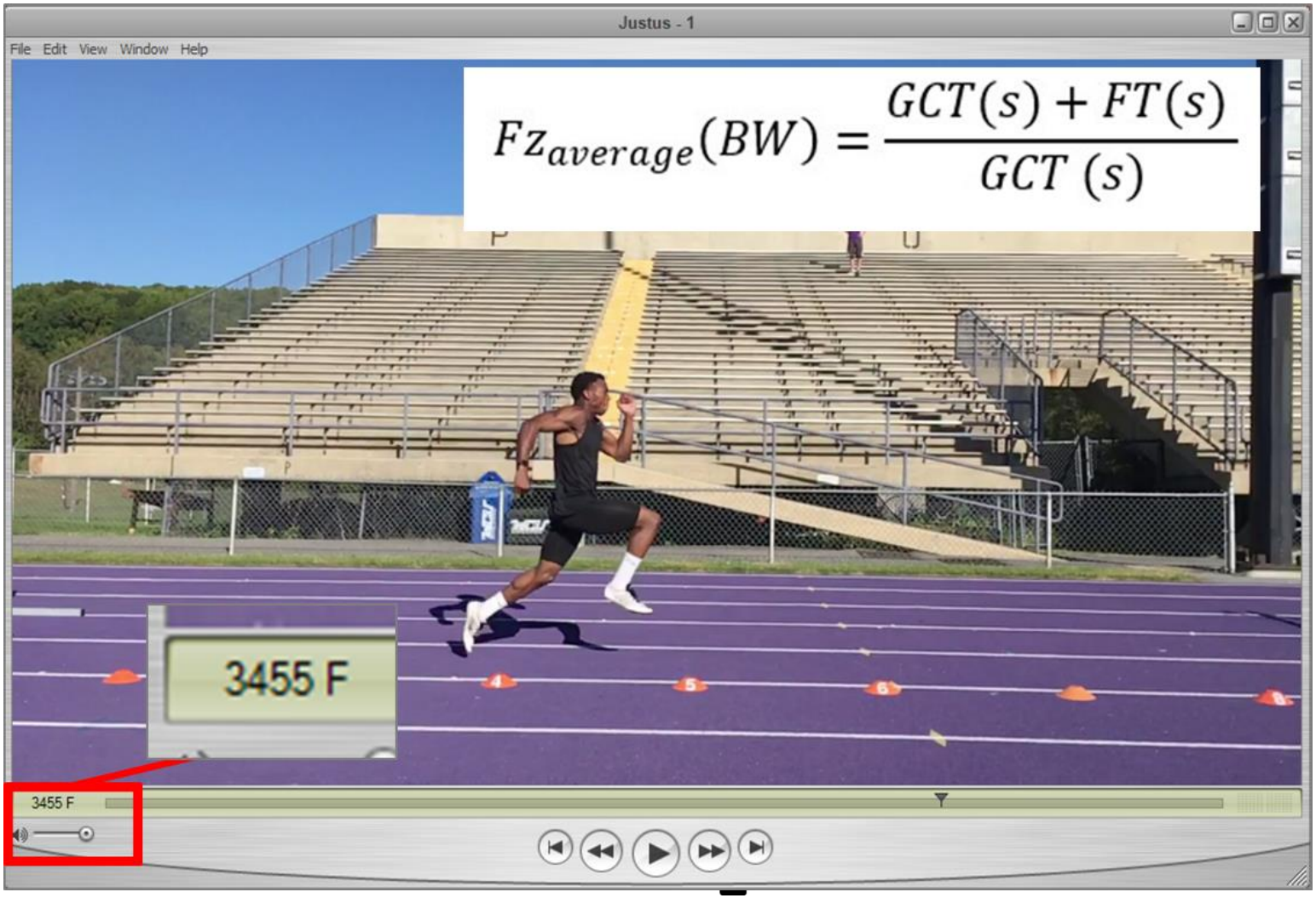
Determining FORCE from MOTION



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*

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RESEARCH ARTICLE

A general relationship links gait mechanics and running ground reaction forces

Kenneth P. Clark[1,2], Laurence J. Ryan[1] and Peter G. Weyand[1,*]

Current Issues in Sport Science 3 (2018)

Running impact forces: from half a leg to holistic understanding

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Validating FORCE determined from MOTION

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Video Measures of Running Ground Contact Times and Vertical Ground Reaction Forces

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WEST CHESTER UNIVERSITY GOLDEN RAMS

ABSTRACT

- **Purpose:** Validate video-based measures of ground contact time (GCT) and vertical ground reaction force (VGRF) compared to a laboratory force plate.
- **Methods:** 20 subjects (13 males, height = 1.76±0.07m, mass = 78.0±9.0 kg; 7 females, height = 1.65±0.07m, mass = 68.3±9.4kg) volunteered and provided written consent. A high-speed camera (HSC, iPad Pro) filming at 240 Hz was placed at three locations designed to replicate a camera panning 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 in-ground laboratory force plate (Kistler 5691A) collecting at 1000 Hz.
- **Results:** Stats are provided in Table 1. The HSC had excellent accuracy for GCT ($R^2 = 0.97$), but was less accurate for calculations of average VGRF ($R^2 = 0.85$).
- **Conclusion:** A HSC filming at 240 Hz can accurately determine GCT during running, but demonstrates more error when calculating VGRF.

BACKGROUND

- GCT and VGRF are important factors for running performance, metabolic rate, and injury risk.[2,7,8,14]
- A lab force plate is the "gold standard" to measure these variables.[4,6,7] However, few field measures have been validated with acceptable accuracy.[1,3,5,9]
- HSC provide a simple and cost effective solution for measuring GCT and CGRF in an applied setting.
- However, no studies have investigated the accuracy of evaluating GCT and VGRF using a HSC during running.
- Thus, we investigated the accuracy of a HSC (iPad Pro filming at 240 Hz) in comparison to a force plate for variables of GCT and VGRF.
- We hypothesize that it would demonstrate less than 5% mean absolute error ($R^2 > 0.95$) for both GCT and VGRF.

METHODS

Research Design: one testing session, within-subjects design

Subjects:

- Healthy, recreationally-trained adults *(n = 20 total)*
- Males (*n = 13*, height: 1.76 ± 0.07 m, mass: 78.0 ± 9.0 kg, leg length: 0.90 ± 0.04 m)
- Females (*n = 7*, height: 1.65 ± 0.07 m, mass: 68.3 ± 9.4 kg, length: 0.87 ± 0.06 m)

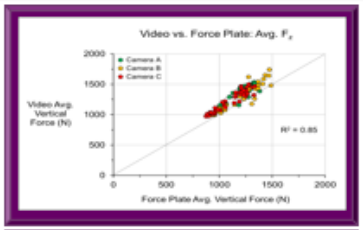
Testing Procedures:

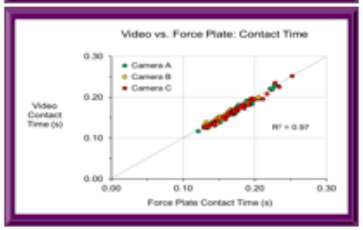
- Dynamic Warm-Up before each test session
- Three running trials at each self-selected speed (jog, run, sprint), with two minutes rest between trials
- Instructed to strike the force plate without altering gait

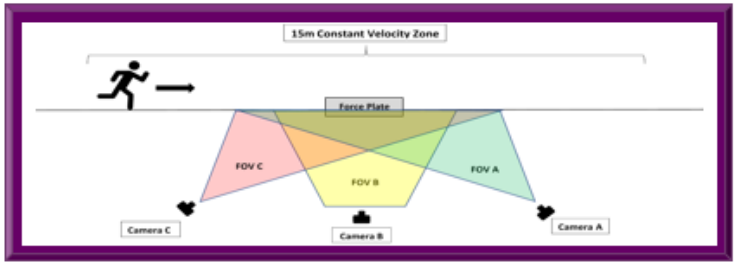
Instrumentation:

- Apple iPad Pro 9.7 filming at 240 frames per second
- Kistler 5691A Force Plate collecting data at 1000 Hz
- Free Lap Automatic Timing System

Calculations: $Fz_{average}(BW) = \frac{GCT(s) + FT(s)}{GCT\ (s)}$







RESULTS

Table 1. Mean Absolute Error and Mean Percentage Error

	iPad Error vs. Force Plate: Contact Time		iPad Error vs. Force Plate: Vertical Force	
	Mean Abs Error (s)	Mean Abs Error (%)	Mean Abs Error (BW)	Mean Abs Error (%)
Mean	0.005	3.2%	0.17	10.7%
SD	0.004	2.2%	0.08	5.2%

CONCLUSIONS

1) A commercially available high-speed camera filming at 240 Hz can accurately determine GCT during running.

2) Caution is warranted when calculating running VGRF using a high speed camera at 240 Hz.

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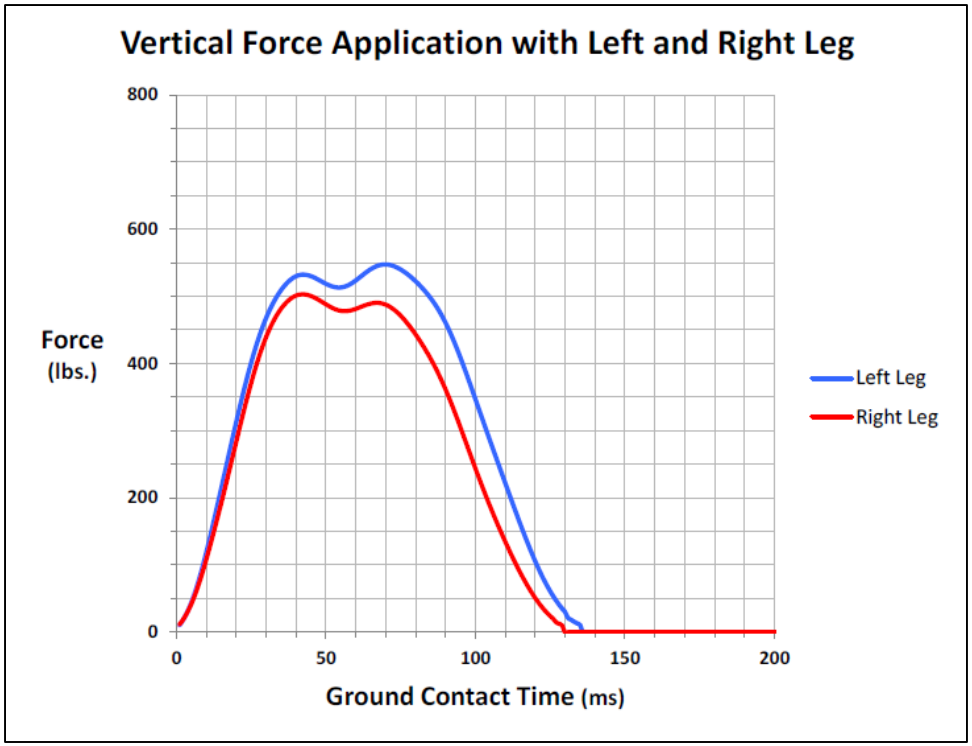
Assessment of Between-Leg Asymmetry



Factor	Left Leg	Right Leg	Left-Right % Difference
Average Ground Contact Time (s)	0.134	0.129	3.4
Average Vertical Force (BW)	1.95	1.73	11.3
Average Vertical Impulse (BW*s)	0.26	0.22	14.3
Average Rate of Vertical Loading (BW/s)	32.3	30.7	5.1

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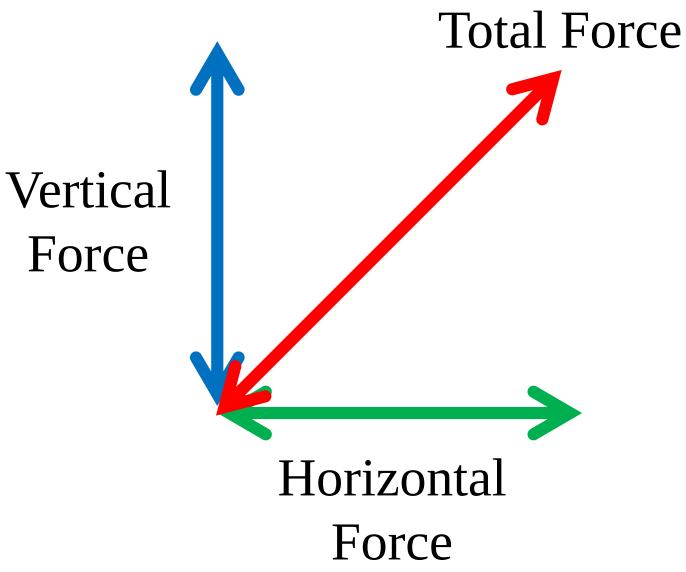
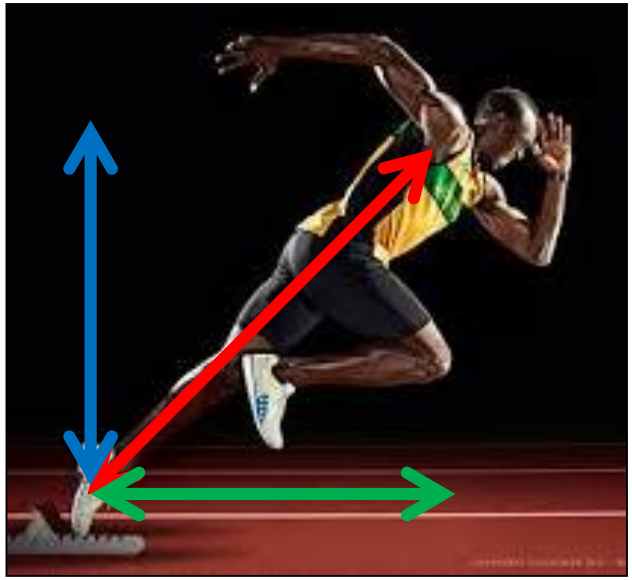
Sprint Acceleration



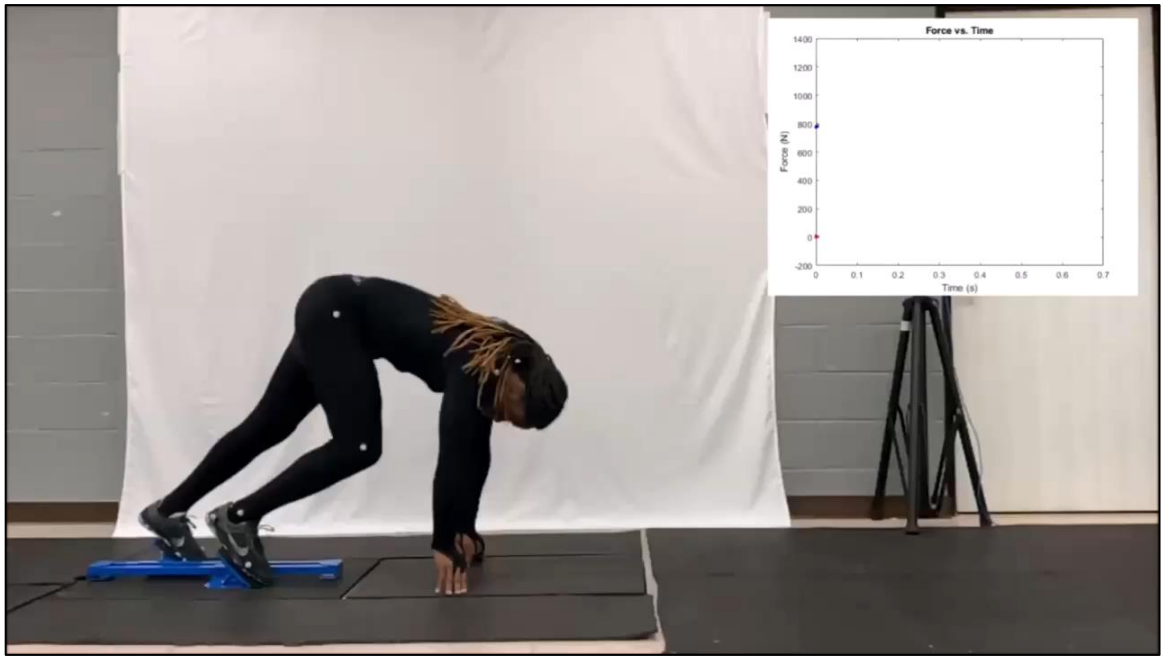


#1) Enough vertical force to support & lift body

#2) rest of force directed horizontally

Sprint Acceleration

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



Blue: Vertical Force

Red: Horizontal Force

Sprinter 100m PR:

10.46 seconds

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

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New OptiTrack Motion Capture System

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New OptiTrack Motion Capture System

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Simultaneous FORCE and MOTION

USA Track & Field Biomechanics Consulting