



This is a presentation of the following published document and is licensed under All Rights Reserved license:

**Bissas, Athanassios ORCID logoORCID: <https://orcid.org/0000-0002-7858-9623> (2022) #Biomechrunning:From Koroivos of Elis to Usain of Jamaica...and into the Future. In: Inaugural Lecture, 9 March 2022, University of Gloucestershire.**

EPrint URI: <https://eprints.glos.ac.uk/id/eprint/11110>

#### **Disclaimer**

The University of Gloucestershire has obtained warranties from all depositors as to their title in the material deposited and as to their right to deposit such material.

The University of Gloucestershire makes no representation or warranties of commercial utility, title, or fitness for a particular purpose or any other warranty, express or implied in respect of any material deposited.

The University of Gloucestershire makes no representation that the use of the materials will not infringe any patent, copyright, trademark or other property or proprietary rights.

The University of Gloucestershire accepts no liability for any infringement of intellectual property rights in any material deposited but will remove such material from public view pending investigation in the event of an allegation of any such infringement.

PLEASE SCROLL DOWN FOR TEXT.

09 March 2022



UNIVERSITY OF  
GLOUCESTERSHIRE

**#Biomechrunning:  
From Koroivos of Elis to Usain of  
Jamaica...and into the Future**

Athanassios Bissas

Professorial Inaugural Lecture

# Summary



Sprint running is one of the oldest athletic events that has dominated the athletics scene since the first ancient Olympic games in 776 BC. Has this happened through an evolution process where this competitive gait has managed to adapt and modernise itself to remain contemporary? If this is the case, how do the sprinters of the 21st century compare to the ancient runners competing barefoot on plain dirt surface? What does the future of sprinting look like?

Having spent over two decades studying sprint running through a biomechanical lens, Professor Bissas will philosophise about this pure, uncomplicated and aesthetic mode of human locomotion that obeys unfailingly the laws of classical mechanics.

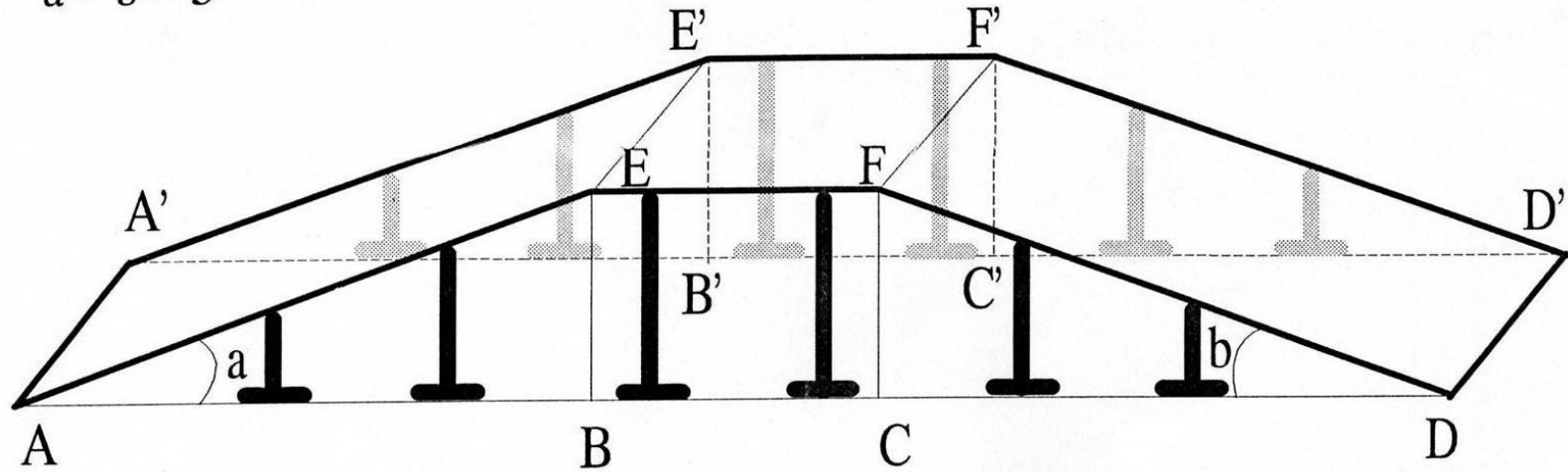








$AE = FD = A'E' = F'D' = 20 \text{ m}$   
 $EF = E'F' = 10 \text{ m}$   
 $AA' = EE' = FF' = DD' = 1.20 \text{ m}$   
 $AB = CD = A'B' = C'D'$   
 $BC = B'C'$   
 $a = b = 3^\circ$



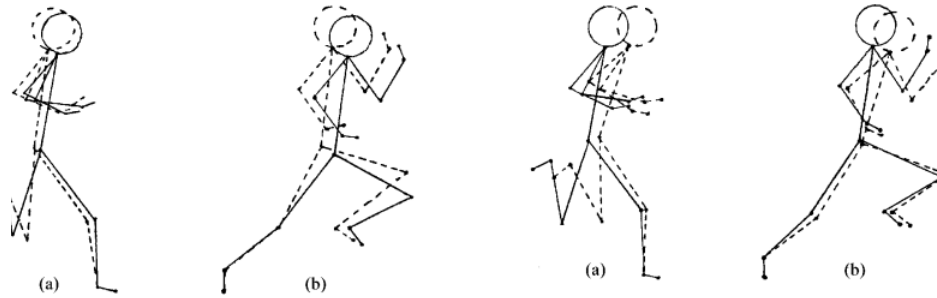




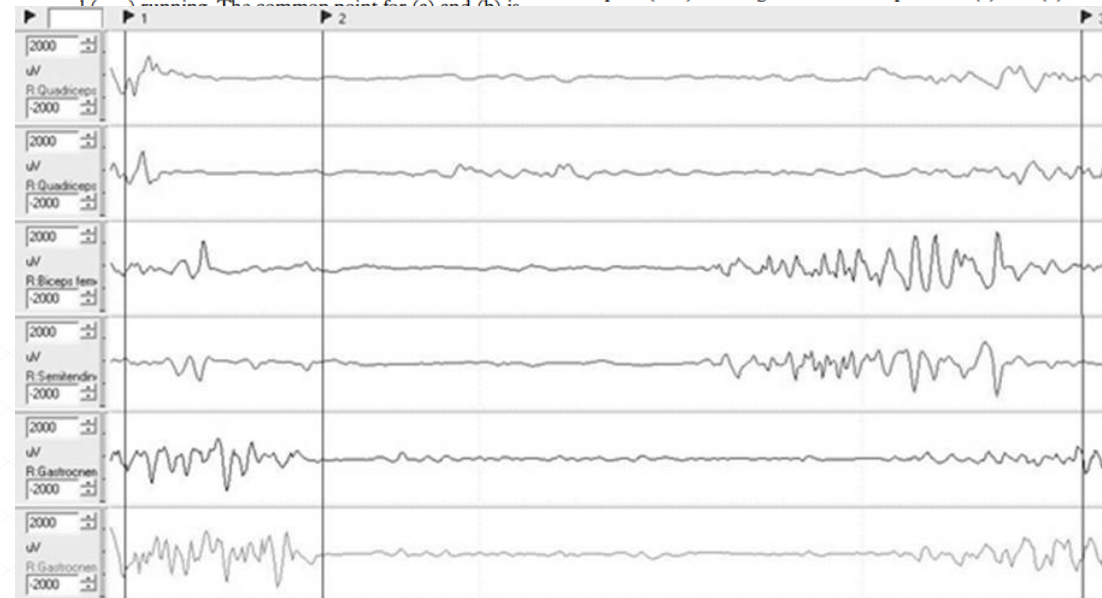
**Table 3.** Postural characteristics of maximum sprinting at touchdown (mean ± s of the three trials)

	Trunk angle (°)	Shank angle (°)	Knee angle (°)	Thigh angle (°)	Hip angle (°)	Thigh to thigh angle (°)
Uphill	73 ± 4.0*	88 ± 2.1*	144 ± 4.8	57 ± 6.8	129 ± 8.0	31 ± 4.5*
Downhill	82 ± 3.8	100 ± 4.0*	155 ± 7.0*	54 ± 4.9	136 ± 5.2*	40 ± 7.0*
Horizontal	80 ± 5.0	92 ± 3.5	145 ± 4.1	52 ± 5.6	131 ± 6.2	54 ± 8.2

\*Significantly different from horizontal sprint running ( $P < 0.05$ ) as determined by repeated-measures analysis of variance and *post-hoc* Tukey tests.



**Fig. 5.** The 'averaged' postural characteristics of the participants at touchdown (a) and take-off (b) for horizontal (—) and uphill (---) running. The common point for (a) and (b) is...

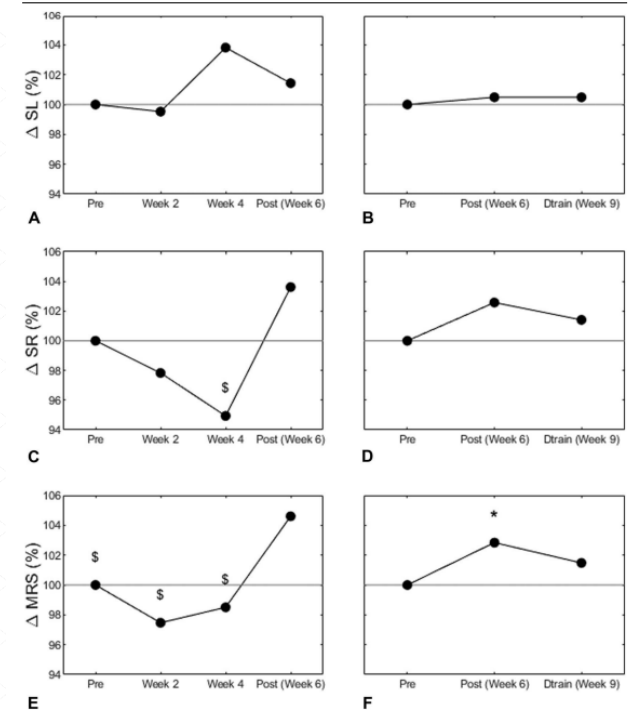


hill Training and Detraining (2022) 36:1

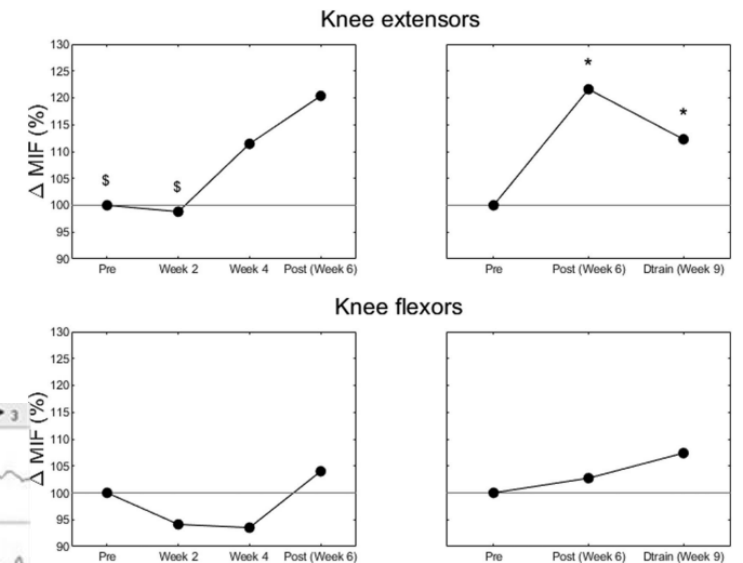
Journal of Strength and Conditioning Research™ | www

hill Training and Detraining (2022) 36:1

Journal of Strength and Conditioning Research™



**Figure 2.** Time series kinematic data of relative changes for the progressive (left column) and training-detraining (right column) U+D groups with the 100% values corresponding to pre-training values. 2A = SL progressive changes; 2B = SL training-detraining changes; 2C = SR progressive changes; 2D = SR training-detraining changes; 2E = MRS progressive changes; 2F = MRS training-detraining changes. \*Significantly different from pre-training ( $p < 0.05$ ) and significantly different from post-training ( $p < 0.05$ ) as determined by repeated-measures analysis of variance and Tukey's HSD post hoc tests. SL = step length; SR = step rate; MRS = maximum running speed.



**Figure 3.** Time series strength data of relative MBIF changes for the progressive (left column) and training-detraining (right column) U+D groups with the 100% values corresponding to pre-training values. \*Significantly different from pre-training ( $p < 0.05$ ) and significantly different from post-training ( $p < 0.05$ ) as determined by repeated-measures analysis of variance and Tukey's HSD post hoc tests.

**Combined Uphill and Downhill Sprint Running Training Is More Efficacious**

- UD > U, D, H, WT, PL
- UD increases maximum speed by 3 – 8%
- UD increases stride frequency by 3 – 4%
- UD improves contact and flight times by 2 – 8% and 2 – 5%
- UD increased leg strength by 15 – 26%
- UD increase the neural input to the leg muscles by 38%

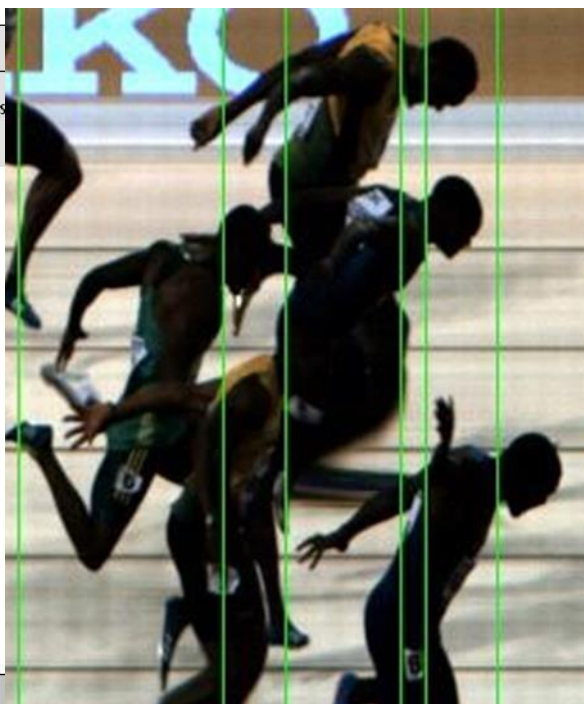
$\pm 0.18$  Hz,  $p < 0.05$ ), and their knee extensors' maximum isometric force by 21% (from  $2,242 \pm 489$  to  $2,712 \pm 498$  N,  $p < 0.05$ ) after training. The time course of changes showed declines for weeks 1–4 (1.4–5.1%), but an ascending trend of improvement compensated all losses by the end of week 6 ( $p < 0.05$ ). During detraining, no decreases occurred. No changes were observed for the H and C groups. The minimum period to produce positive effects was 6 weeks, with a very good standard of performance maintained 3 weeks after training. U+D training will prove useful for all athletes requiring fast adaptations, and it can fit into training mesocycles because of its low time demands.

**Key Words:** detraining, leg strength, quadriceps femoris, running, sprinting, time-course

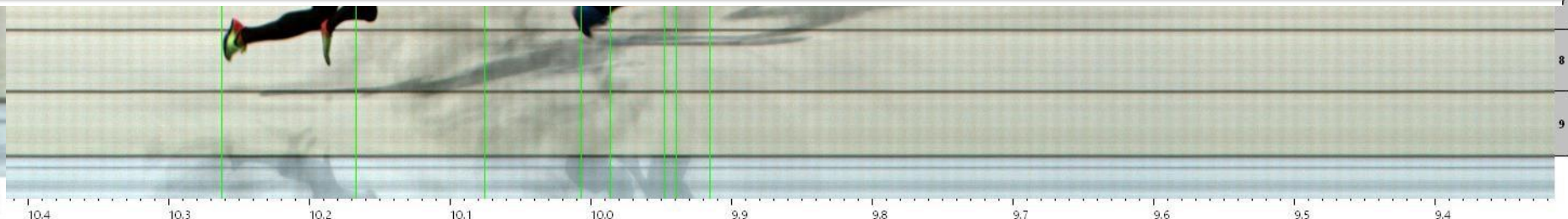
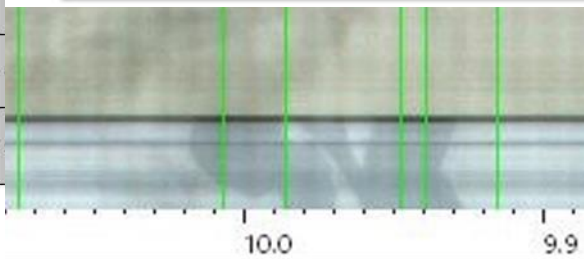
higher ( $p < 0.05$ ) in Fast vs. Medium (+1.0%) and Slow (+2.2%), as well as in Medium vs. Slow (+10.0%). Twelve, eight and seven out of 21 variables significantly distinguished Fast from Slow, Fast from Medium and Medium from Slow sprinters, respectively. Propulsive phase was significantly shorter in Fast vs. Medium (-17.5%) and Slow (-29.4%) as well as in Medium vs. Slow (-14.4%). Fast sprinters had significantly higher vertical and leg stiffness values than Medium (+44.1% and +18.1%, respectively) and Slow (+25.4% and +22.0%, respectively). MRS at 30–35 m increased with performance level during a 35-m sprint and was achieved through shorter contact time, longer step length, faster step rate, and higher vertical and leg stiffness.

spring mass characteristics

For an Olympic level sprinter a 3% increase in speed (only for a 10-m segment of the race) means 0.03 s faster (6 cm difference)



PLACE	NAME	COUNTRY	DATE of BIRTH	LANE	RESULT
1	Justin GATLIN	USA	10 Feb 82	8	9.92
2	Christian COLEMAN	USA	6 Mar 96	5	9.94
3	Usain BOLT	JAM	21 Aug 86	4	9.95

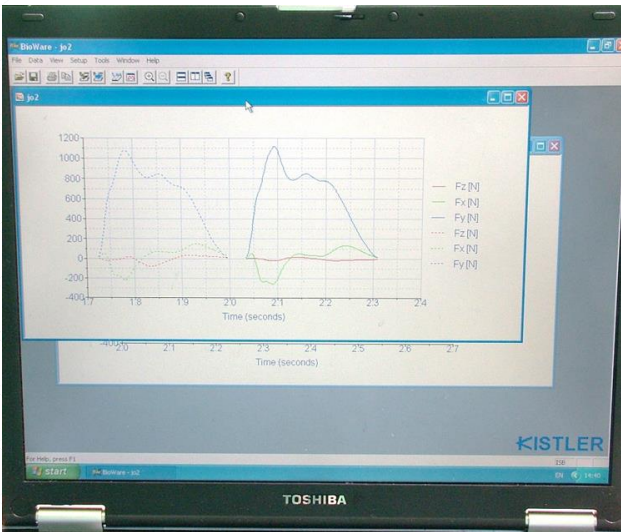








es that racewalkers must have no visible (to the human eye) loss  
round and that  
und until the "ve



- ✓
- ~
- <

from first  
study were



Proceed to next  
video →



ORIGINAL RESEARCH article

Front. Sports Act. Living, 08 August 2019 | <https://doi.org/10.3389/fspor.2019.00009>



**Brian Hanley<sup>\*</sup>, Catherine B. Tucker and Athanassios Bissas<sup>†</sup>**

*Carnegie School of Sport, Leeds Beckett University, Leeds, United Kingdom*

# Assessment of IAAF Racewalk Judges' Ability to Detect Legal and Non-legal Technique

IAAF Rule 230.2 states that racewalkers must have no visible (to the human eye) loss of contact with the ground and that their advancing leg must be straightened from first

Eighty-three judges of different IAAF Levels (and none) viewed the panned videos online and indicated whether each athlete was racewalking legally. Flight times shorter than 0.033 s were detected by fewer than 12.5% of judges, and thus indicated non-visible loss of contact. Flight times between 0.040 and 0.045 s were usually detected by no more than three out of eight judges. Very long flight times ( $\geq 0.060$  s) were detected by nearly all judges. The results also showed that what judges generally considered straightened knees ( $> 177^\circ$ ) was close to a geometrically straight line. Within this inexact

definition, IAAF World Championship-standard Level III judges were most accurate, being more likely to detect anatomically bent knees and less likely to indicate bent knees when they did not occur. For the second part, the men racewalked down a 45-m

## Mechanical and neural function of triceps surae in elite racewalking

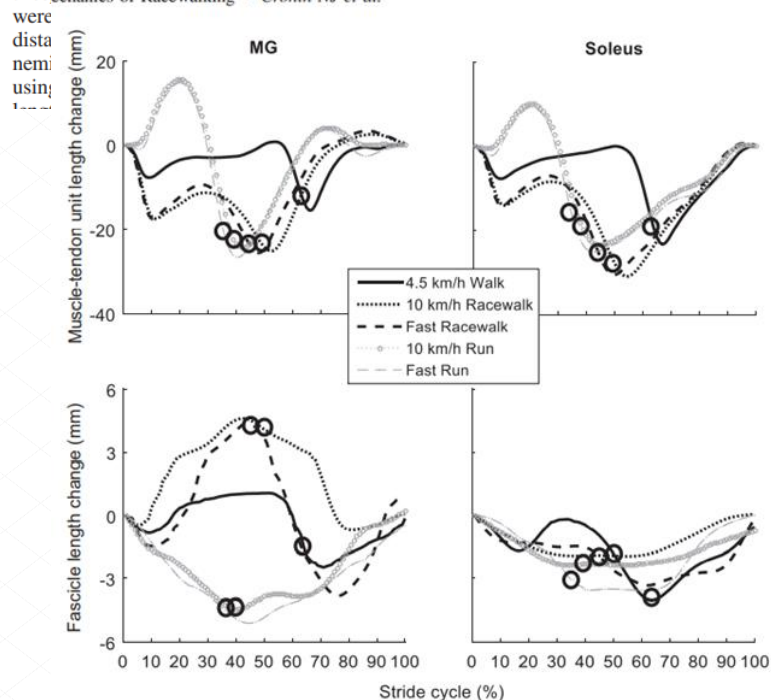
Neil J. Cronin,<sup>1</sup> Brian Hanley,<sup>2</sup> and Athanassios Bissas<sup>2</sup>

<sup>1</sup>University of Jyväskylä, Neuromuscular Research Center, Department of Biology of Physical Activity, University of Jyväskylä, Finland; and <sup>2</sup>School of Sport, Carnegie Faculty, Leeds Beckett University, United Kingdom

Submitted 4 April 2016; accepted in final form 23 May 2016

**Cronin NJ, Hanley B, Bissas A.** Mechanical and neural function of triceps surae in elite racewalking. *J Appl Physiol* 121: 101–105, 2016. First published June 2, 2016; doi:10.1152/jappphysiol.00310.2016.—Racewalking is a unique event combining mechanical elements of walking with speeds associated with running. It is currently unclear how racewalking technique impacts lower limb muscle-tendon function despite the relevance of this to muscle economy and overall performance. The present study examined triceps surae neuromechanics in 11 internationally competitive racewalkers (age  $25 \pm 11$  yr) walking and running

triceps surae neuromechanics of Racewalking • Cronin NJ et al.

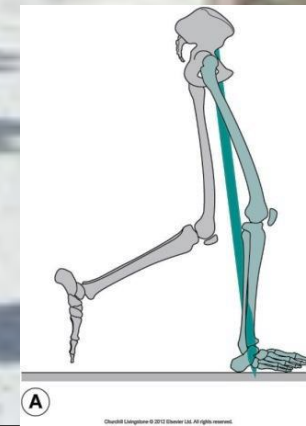
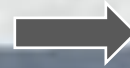
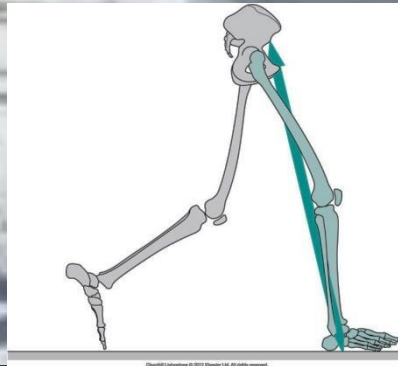
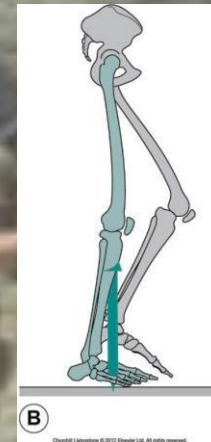
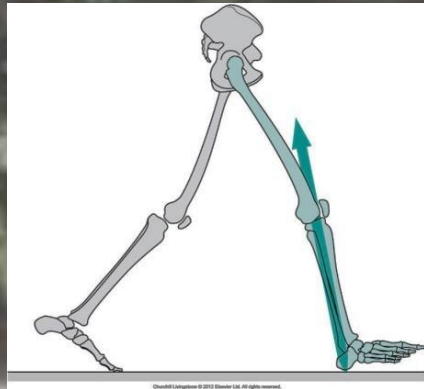
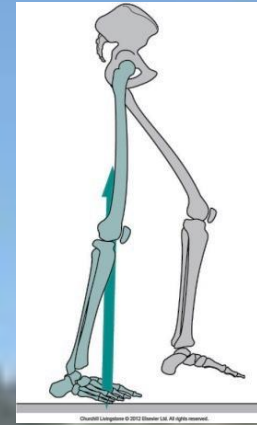
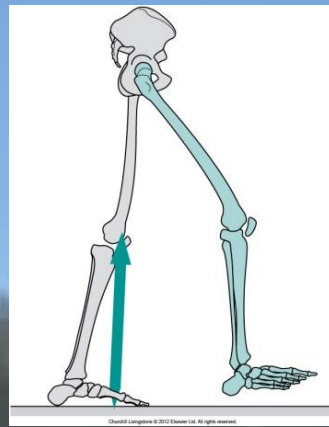
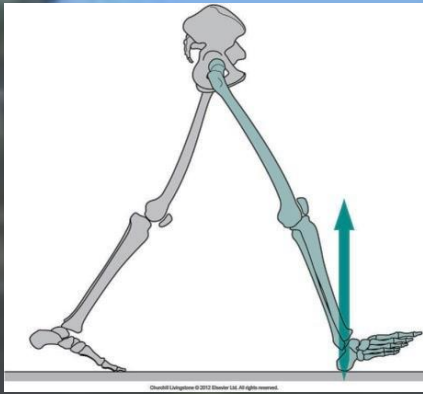
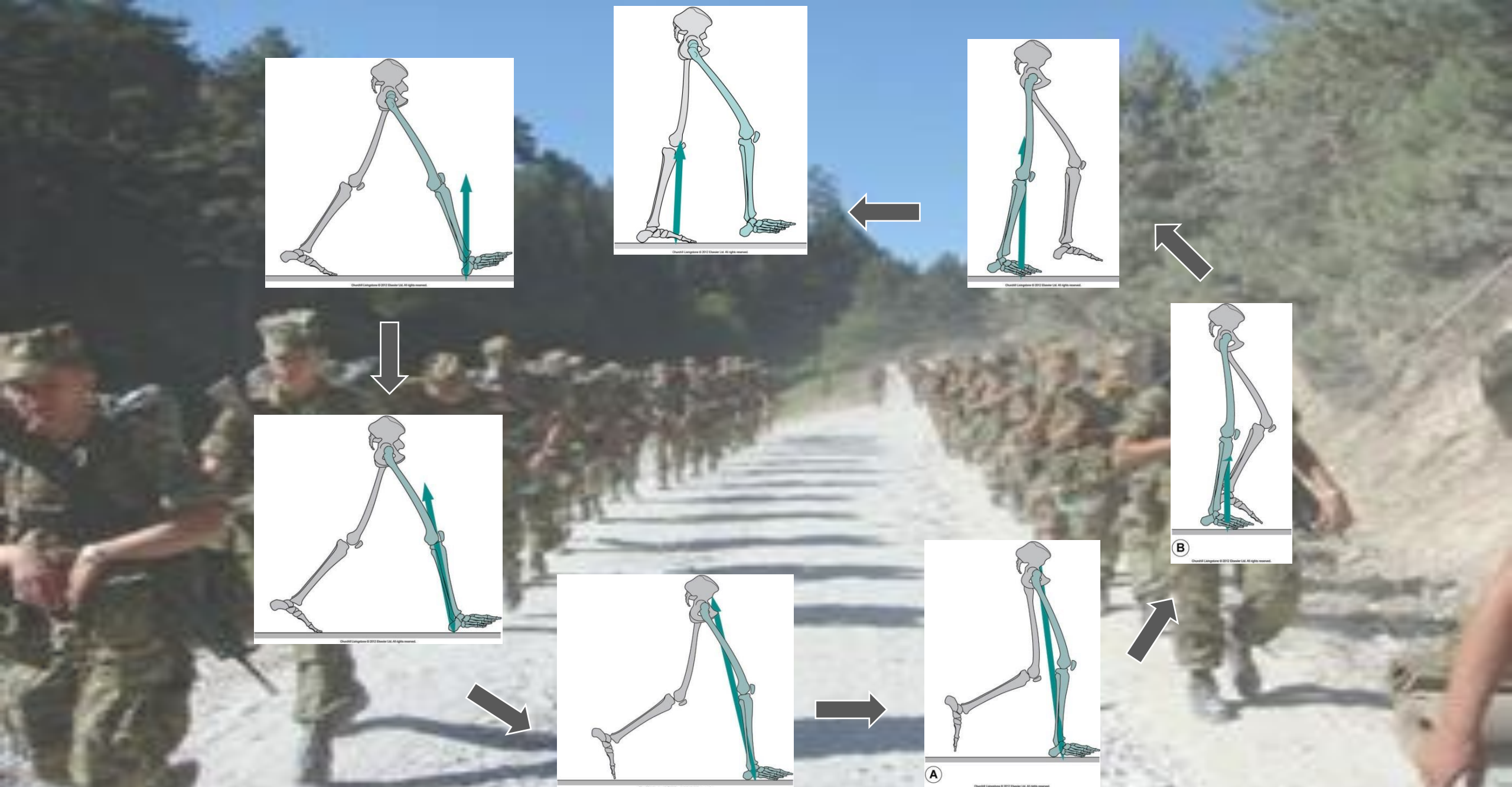


velocities (e.g., Ref. 9). Similarly, during running, Farris and Sawicki (10) showed that the medial gastrocnemius shortens slowly, whereas the elastic Achilles tendon acts as an efficient spring.

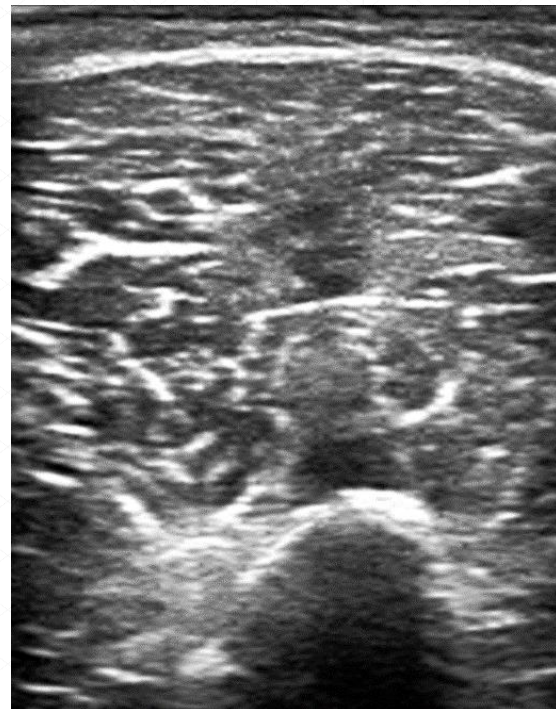
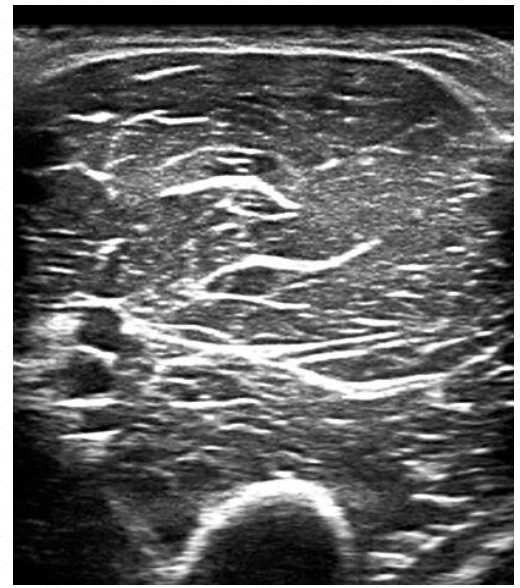
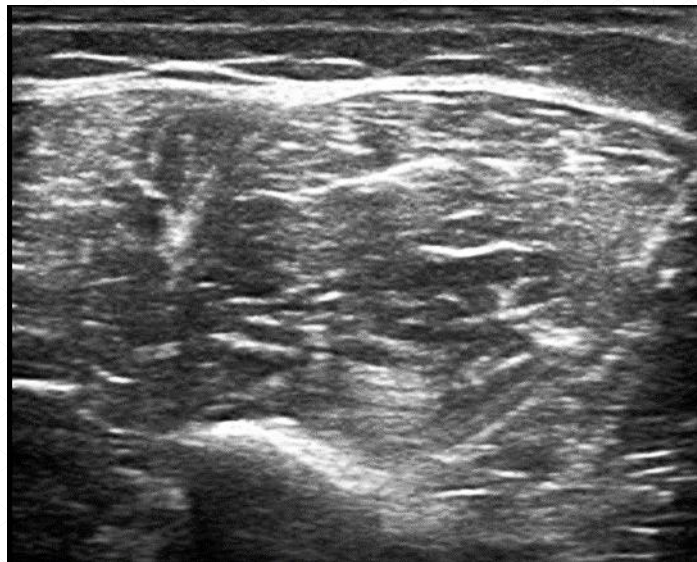
However, walking and running are two clearly distinct gaits and represent efficient ways of moving at slow and fast speeds, respectively. Racewalking is a unique event within the Olympic track and field program that essentially combines some of the

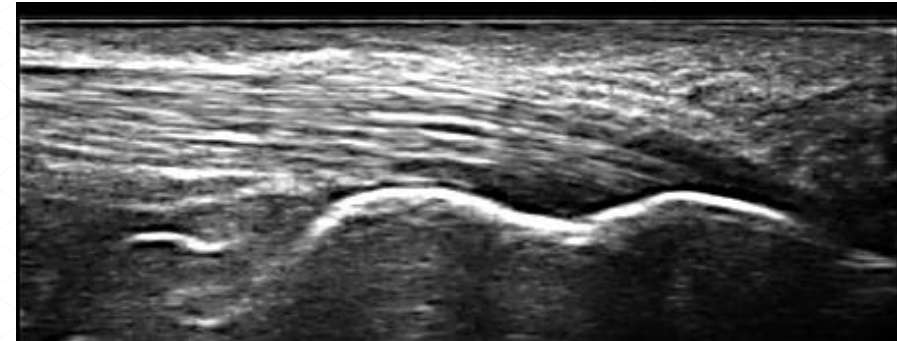
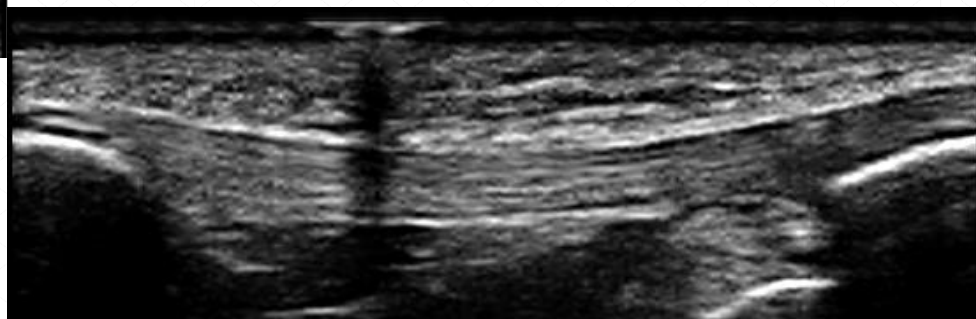
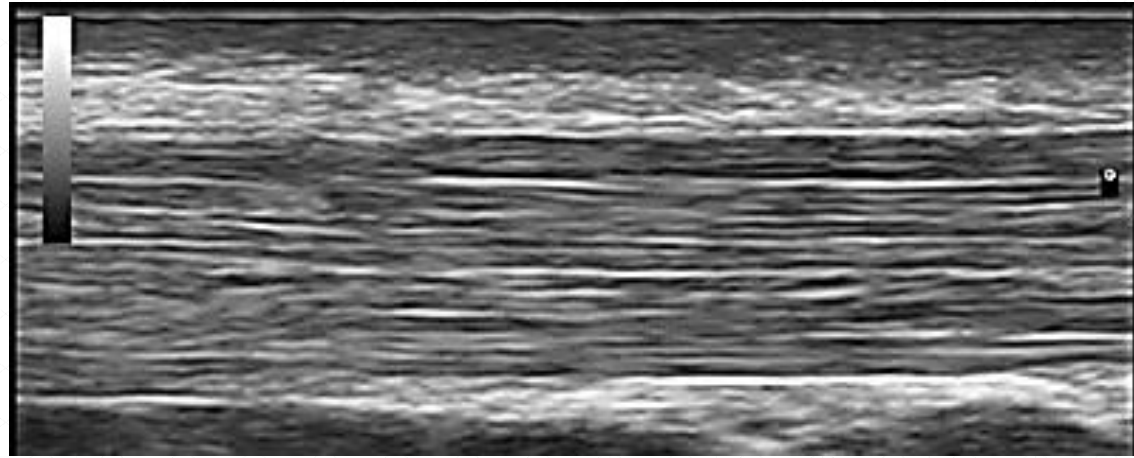
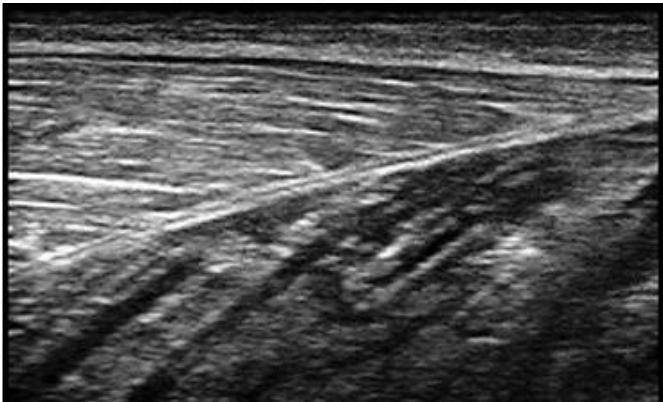
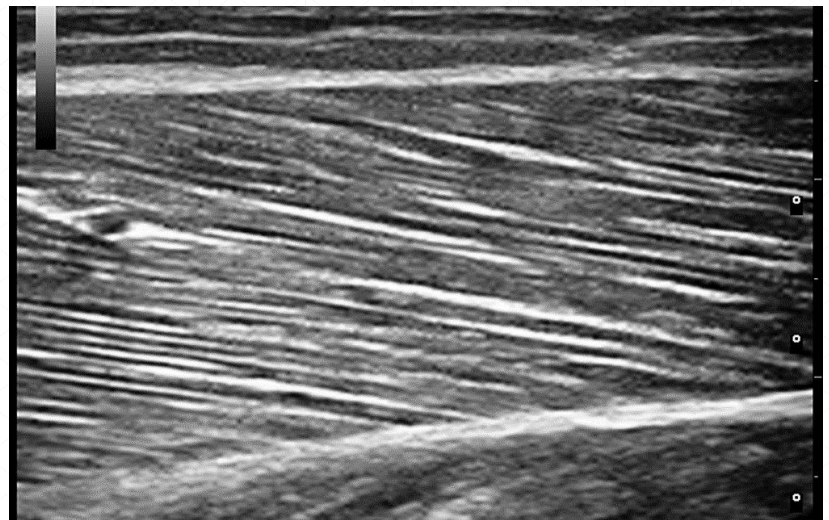
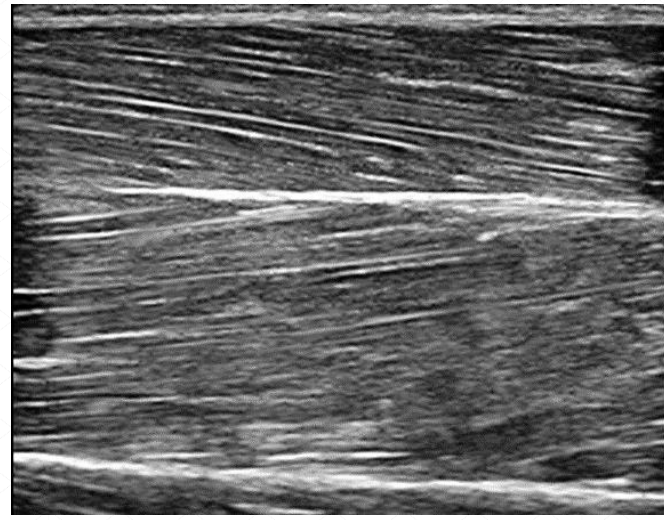
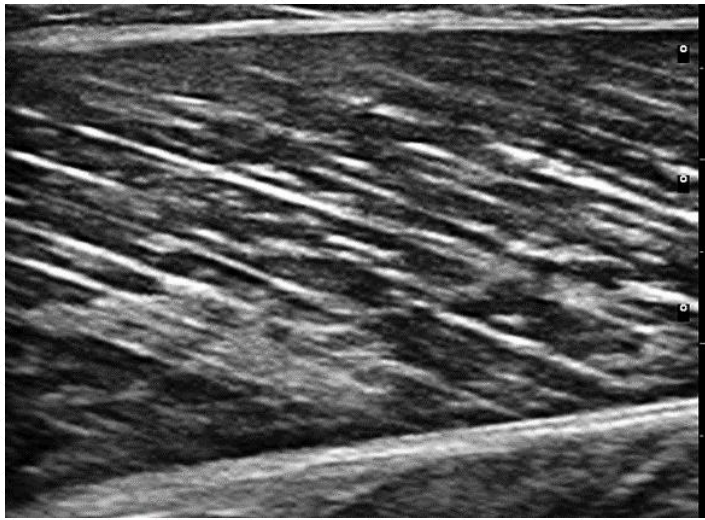
traits of a walking gait with speeds usually associated with running, and it is currently unclear how the technique in the muscle-tendon function of lower leg muscles is affected. It has been shown that increasing walking speed from slow to fast is associated with faster muscle fascicle shortening velocities (e.g., Ref. 9).







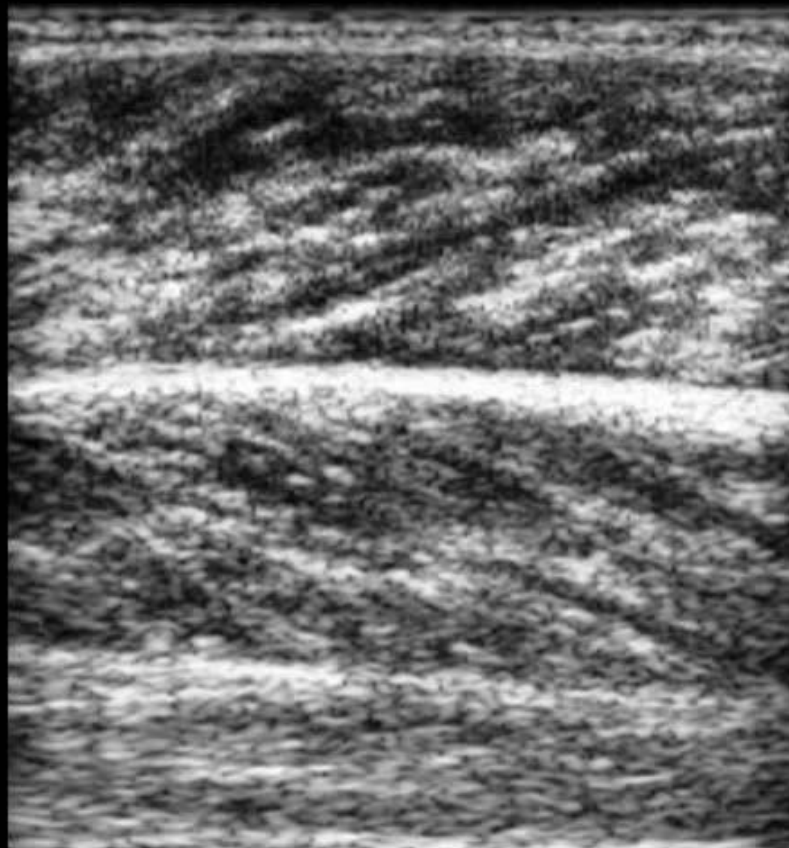




PALIYANNIS, THEODOROS, ID: 4H,  
 B F 7.5 MHz G 52%  
 D 5 cm XV -  
 PRC 1-1-L PRS 1  
 PST 1 MV -

25 NOV 20  
 0:00:00.45

Dynamic LA522



## Muscle-tendon morphology and function following long-term exposure to repeated and strenuous mechanical loading

Athanassios Bissas<sup>1</sup> | Konstantinos Havenetidis<sup>2</sup> | Josh Walker<sup>1</sup> |  
 Brian Hanley<sup>1</sup> | Gareth Nicholson<sup>1</sup> | Thomas Metaxas<sup>3</sup> | Kosmas Christoulas<sup>3</sup> |  
 Neil J. Cronin<sup>4,5</sup>

<sup>1</sup>Carnegie School of Sport, Leeds Beckett University, Leeds, UK

<sup>2</sup>Faculty of Physical & Cultural Education, Hellenic Army Academy, Vari, Greece

<sup>3</sup>Laboratory of Evaluation of Human Biological Performance, Department of Physical Education and Sport Science, Aristotle University of Thessaloniki, Thessaloniki, Greece

<sup>4</sup>Neuromuscular Research Center, Faculty of Sport and Health Sciences, University of Jyväskylä, Jyväskylä, Finland

<sup>5</sup>Department for Health, University of Bath, Bath, UK

### Correspondence

Athanassios Bissas, School of Sport & Exercise, University of Gloucestershire, Gloucester, UK.  
 Email: abissas@glos.ac.uk

### Present address

Athanassios Bissas, School of Sport & Exercise, University of Gloucestershire, Gloucester, UK and Athletics Biomechanics, Leeds, UK

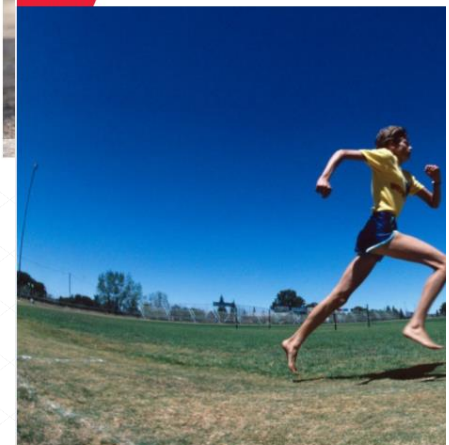
We mapped structural and functional characteristics of muscle-tendon units in a population exposed to very long-term routine overloading. Twenty-eight military academy cadets (age = 21.00 ± 1.1 years; height = 176.1 ± 4.8 cm; mass = 73.8 ± 7.0 kg) exposed for over 24 months to repetitive overloading were profiled via ultrasonography with a senior subgroup of them (n = 11; age = 21.4 ± 1.0 years; height = 176.5 ± 4.8 cm; mass = 71.4 ± 6.6 kg) also tested while walking and marching on a treadmill. A group of eleven ethnicity- and age-matched civilians (age = 21.6 ± 0.7 years; height = 176.8 ± 4.3 cm; mass = 74.6 ± 5.6 kg) was also profiled and tested. Cadets and civilians exhibited similar morphology (muscle and tendon thickness and cross-sectional area, pennation angle, fascicle length) in 26 out of 29 sites including the Achilles tendon. However, patellar tendon thickness along the entire tendon was greater ( $P < .05$ ) by a mean of 16% for the senior cadets compared with civilians. Dynamically, cadets showed significantly smaller ranges of fascicle length change and lower shortening velocity in medial gastrocnemius during walking (44.0% and 47.6%,  $P < .05-.01$ ) and marching (27.5% and 34.3%,  $P < .05-.01$ ) than civilians. Furthermore, cadets showed lower normalized soleus electrical activity during walking (22.7%,  $P < .05$ ) and marching (27.0%,  $P < .05$ ). Therefore, 24-36 months of continuous overloading, primarily occurring under aerobic conditions, leads to more efficient neural and mechanical behavior in the triceps surae complex, without any major macroscopic alterations in key anatomical structures.

Gear-obsessed editors choose every product we re

## Wear Minimal Shoes to Monitor Your Total Mile

A new study finds that minimalist footwear can st carefully.

BY HAILEY MIDDLEBROOK AUG 29, 2018



## Barefoot running cons

Posted by Athletics Weekly | Mar 28, 2014 |

John Shepherd considers whether barefoot is the way to go

# Foot strike patterns and collision forces in habitually barefoot versus shod runners

Daniel E. Lieberman<sup>1</sup>, Madhusudhan Venkadesan<sup>1,2\*</sup>, William A. Werbel<sup>3\*</sup>, Adam I. Daoud<sup>1\*</sup>, Susan D'Andrea<sup>4</sup>, Irene S. Davis<sup>5</sup>, Robert Ojiambo Mang'Eni<sup>6,7</sup> & Yannis Pitsiladis<sup>6,7</sup>

Humans have engaged in endurance running for millions of years<sup>1</sup>, but the modern running shoe was not invented until the 1970s. For most of human evolutionary history, runners were either barefoot or wore minimal footwear such as sandals or moccasins with smaller heels and little cushioning relative to modern running shoes. We wondered how runners coped with the impact caused by the foot colliding with the ground before the invention of the modern shoe. Here we show that habitually barefoot endurance runners often land on the fore-foot (fore-foot strike) before bringing down the heel, but they sometimes land with a flat foot (mid-foot strike) or, less often, on the heel (rear-foot strike). In contrast, habitually shod runners mostly rear-foot strike, facilitated by the elevated and cushioned heel of the modern running shoe. Kinematic and kinetic analyses show that even on hard surfaces, barefoot runners who fore-foot strike generate smaller collision forces than shod rear-foot strikers. This difference results primarily from a more plantarflexed foot at landing and more ankle compliance during impact, decreasing the effective mass of the body that collides with the ground. Fore-foot- and mid-foot-strike gaits were probably more common when humans ran barefoot or in minimal shoes, and may protect the feet and lower limbs from some of the impact-related injuries now experienced by a high percentage of runners.

Running can be most injurious at the moment the foot collides with the ground. This collision can occur in three ways: a rear-foot

transient,  $M_{\text{body}}$  is the body mass,  $v_{\text{com}}$  is the vertical speed of the centre of mass,  $v_{\text{foot}}$  is the vertical speed of the foot just before impact and  $g$  is the acceleration due to gravity at the Earth's surface.

Impact transients associated with RFS running are sudden forces with high rates and magnitudes of loading that travel rapidly up the body and thus may contribute to the high incidence of running-related injuries, especially tibial stress fractures and plantar fasciitis<sup>6-8</sup>. Modern running shoes are designed to make RFS running comfortable and less injurious by using elastic materials in a large heel to absorb some of the transient force and spread the impulse over more time<sup>9</sup> (Fig. 1b). The human heel pad also cushions impact transients, but to a lesser extent<sup>5,10,11</sup>, raising the question of how runners struck the ground before the invention of modern running shoes. Previous studies have found that habitually shod runners tend to adopt a flatter foot placement when barefoot than when shod, thus reducing stresses on the foot<sup>12-15</sup>, but there have been no detailed studies of foot kinematics and impact transients in long-term habitually barefoot runners.

We compared foot strike kinematics on tracks at preferred endurance running speeds ( $4-6 \text{ m s}^{-1}$ ) among five groups controlled for age and habitual footwear usage (Methods and Supplementary Data 2). Adults were sampled from three groups of individuals who run a minimum of 20 km per week: (1) habitually shod athletes from the USA; (2) athletes from the Rift Valley Province of Kenya (famed for endurance running<sup>16</sup>)

Credit: Getty Images

Evolutionary biologist Daniel E. Lieberman caused an international stir

## LETTERS

[Search jobs](#)
[Sign in](#)
[Search](#)
[UK edition](#)

# The Guardian

News website of the year

[Lifestyle](#)
[More](#)

[Home & garden](#)
[Money](#)
[Cars](#)

Best for most

lots of runners, but body? One cushioned-

[Cart](#) 0

## Good for the

that does not limit sensation

26, 2019

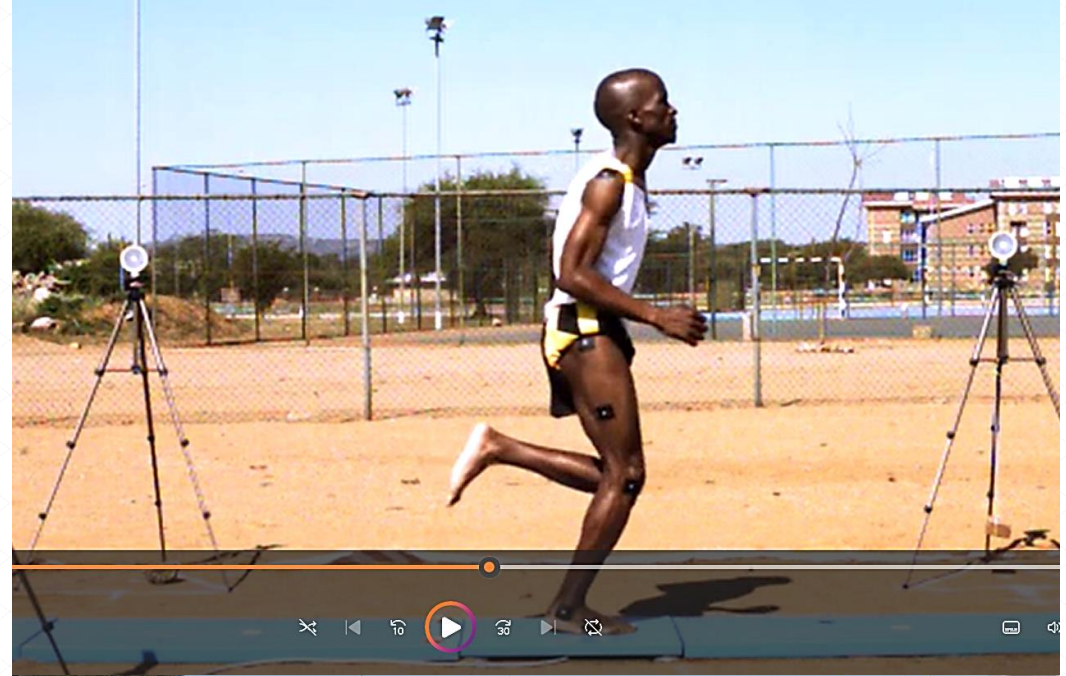
READ THIS NEXT

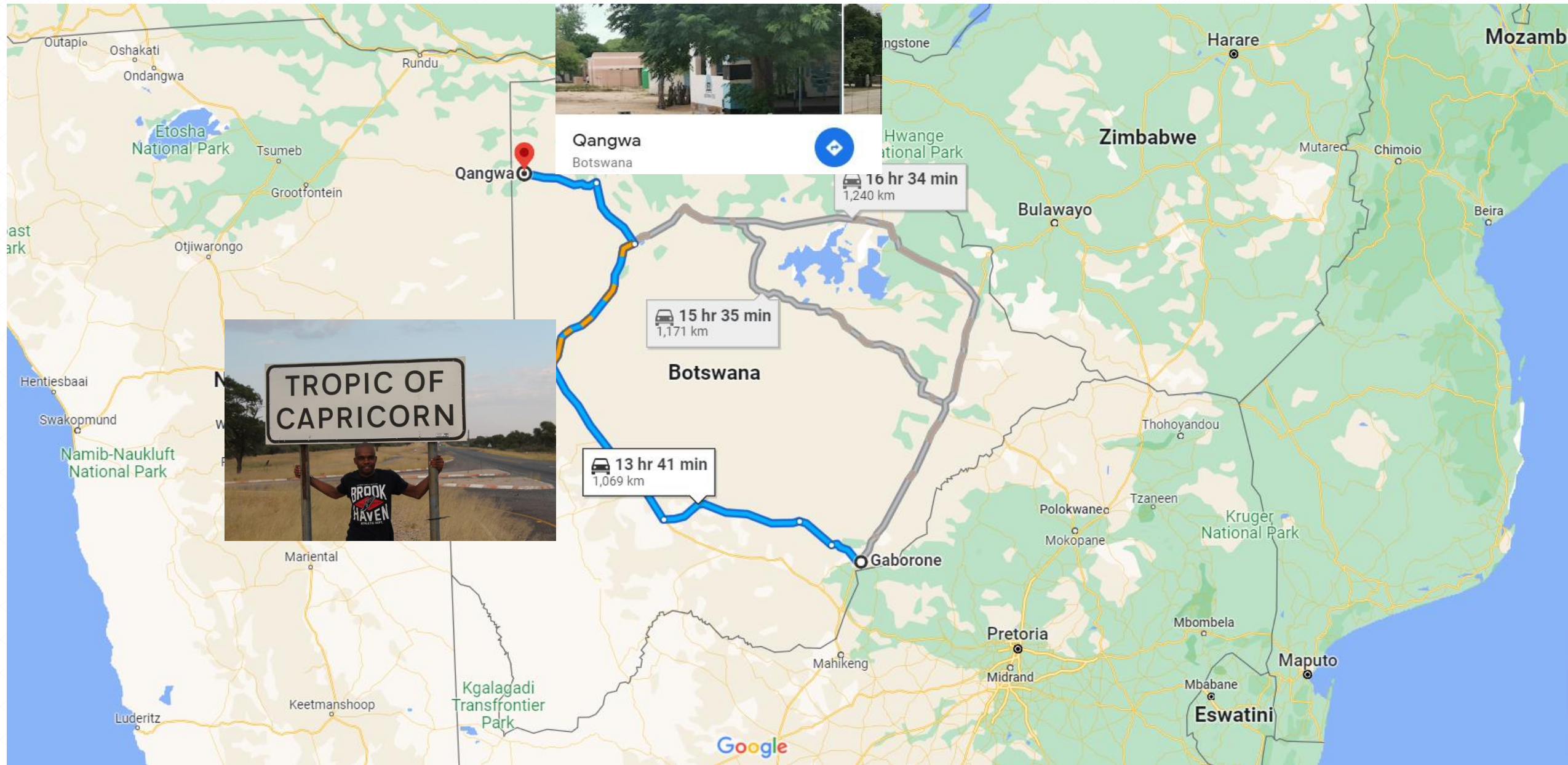
**THE BODY**  
 The Science of Barefoot Personal Journey  
 Aylin Woodward

**WELLNESS**  
 Going Barefoot and 8 Otl Improve Balance  
 Get-Fit Guy Brock Armstrong

Some Barefoot Runners Back on Heels  
 Katherine Harmon

















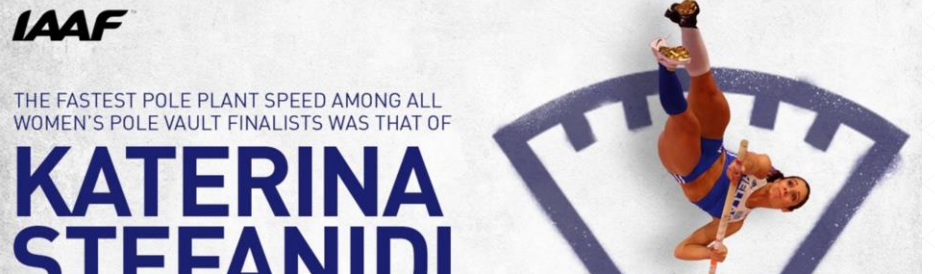
**IAAF**  
**BIOMECHANICS RESEARCH PROJECT**  
*Development department*

WATCH EUROSPORT ANYTIME, ANYWHERE

ATHLETICS

# IAAF RELEASES BIOMECHANICAL STUDY REPORTS FROM LONDON WORLD CHAMPIONSHIPS

July 15 (Reuters) - Athletics' global governing body on Sunday released 38 in-depth reports as part of the largest biomechanical study in the sport's history after measuring and analysing data from last year's World Championships in London.



ATHLETICS AFRICA

HOME PAGE > NEWS > WORLD

LONDON 2017 / WORLD

# Biggest biomechanics research project billed for London 2017

Leeds Beckett University, in cooperation with the IAAF, will carry out the biggest biomechanics research project ever conducted in athletics during next month's IAAF World Championships London 2017.



## RUN & BEE

# Running form like your first nothing wrong or right about it



You simply need to move the way you did when you were a child, which was natural to you. That is tougher than you would think.



For a few years, the popular notion in running circles is that while running, it's your midfoot or forefoot that should be the first part of foot to touch the ground. First landing on the heel is considered no less than a running blasphemy. You are told that you are doomed. This assumption has been based on running form of elite runners - the wrong. Amateur runners shouldn't imitate the elite runners without knowing why. In any case a recently published biomechanical report for the IAAF World Championships London 2017 Marathon 'tosses' this assumption on its head. The author, Dr. Brian Macrae from Carnegie Mellon University, found that as many as 70 per cent of runners landed on their heel. 27 per cent on their midfoot and only three per cent on their forefoot. I am simply building a case for you. You don't need to follow others blindly. If it feels right, it's your basic quest. Your running form is largely determined by your genetics. There is nothing right about it. It's just that you need to move the way you did when you were a child, which was natural to you. That is tougher than you would think. I would go to the extent that you shouldn't bother too much about where your foot lands. Focus on being soft. Most athletes are soft on their feet. They are soft on their feet almost from birth. Now going to overemphasize on being soft on your feet is like trying to improve your running form by using the human body as a machine. It'll take you a long time to undo that. Don't be more importantly, copy those who have been doing it for decades. Running is about covering your own ground.

**LEARNING TO FIND A SPOT IN THE**

I WOULD SAYING BOTHE YOU LA SHUL VNU ID E



**John Burn-Murdoch** @jburnmurdoch  
Senior #dataviz journalist and Baseline sport statistics columnist at @FinancialTimes. Strong takes, weakly held

London  
ft.com/john-burn-murdoch...  
Joined June 2009

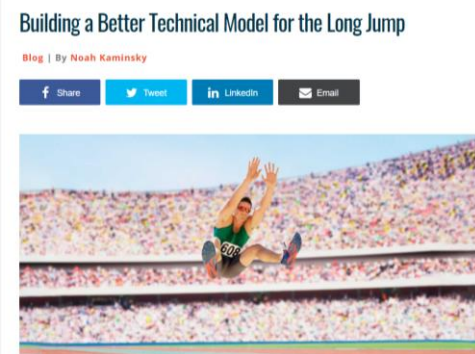


**Most Read**

No Practices? Go Get Faster Anyway (A Four-Week Speed Training Plan)  
Curved Treadmills: Pros and Cons That You Should Know  
Top 10 Resistance Band Exercises Athletes Should Use

**Featured**

5 Common Misconceptions About GPP (General Physical Preparedness)  
Reactive Strength Ratio: A New Way of Evaluating and Monitoring Plyometrics  
Improving the Quality of Life In and After Sport for Female Athletes with Sam Moore

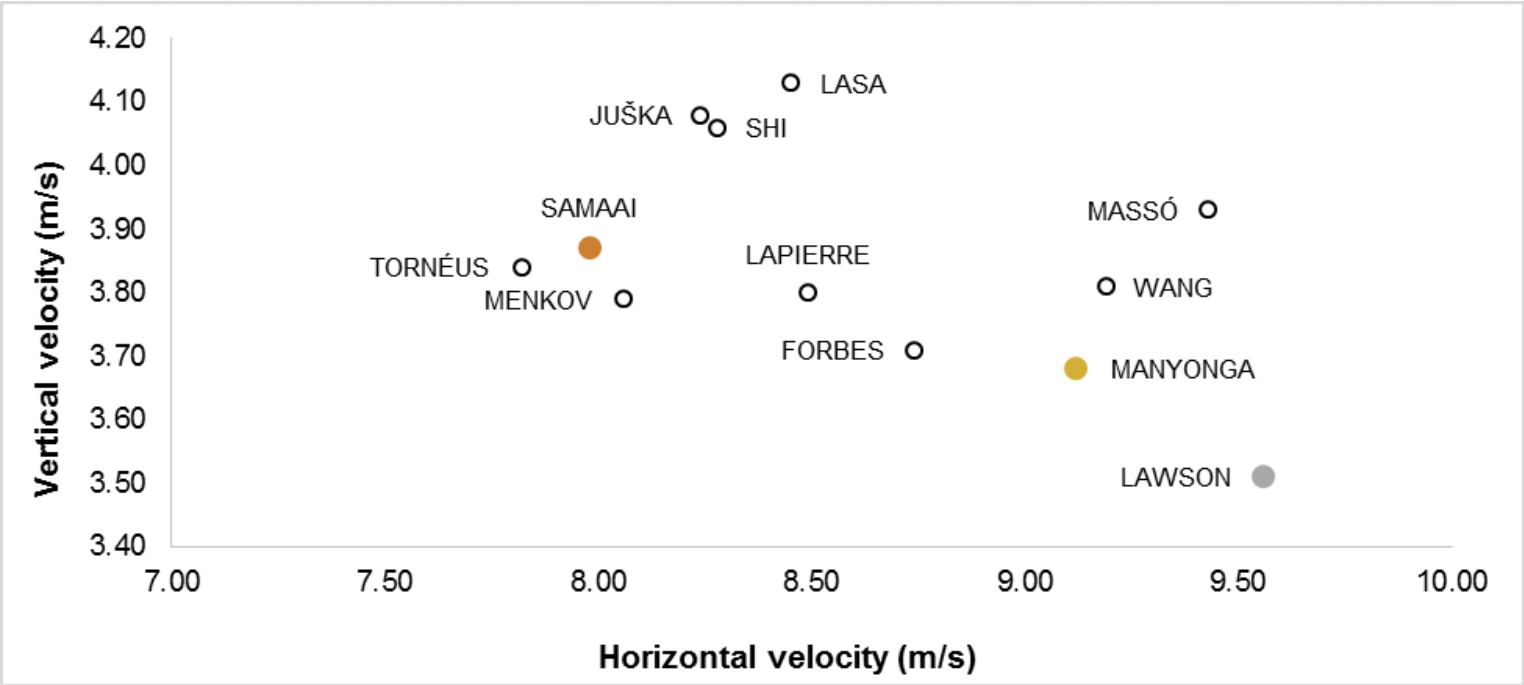
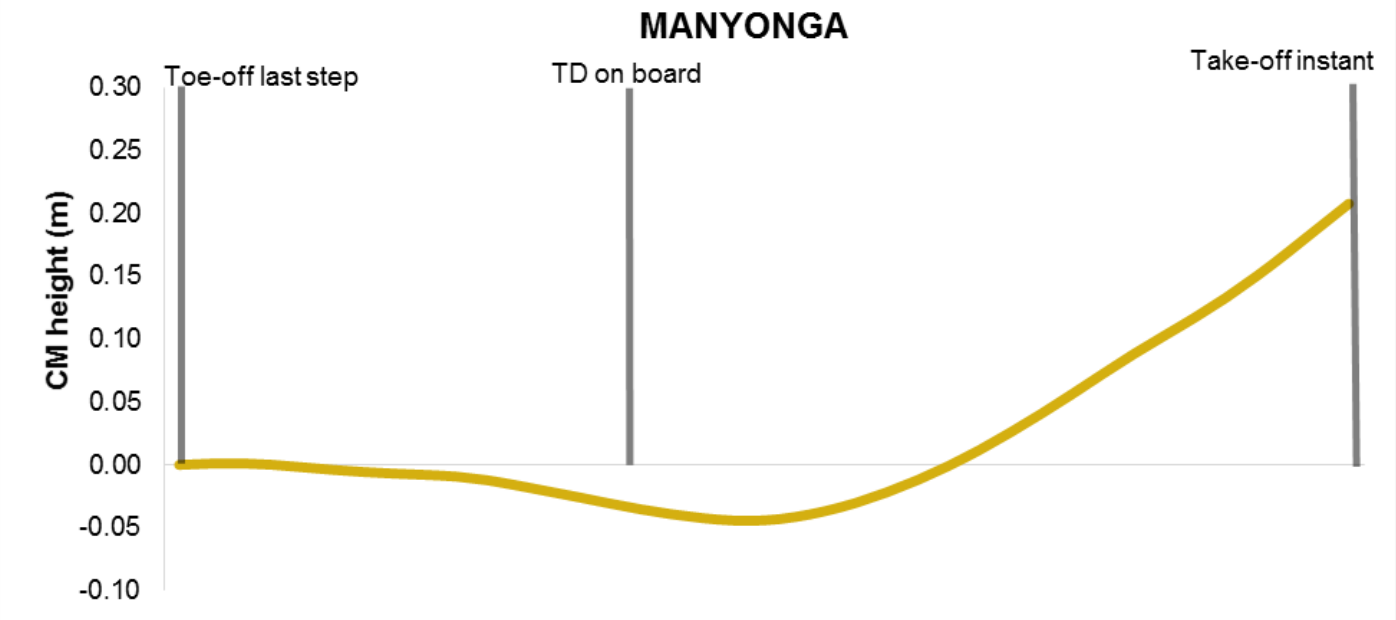
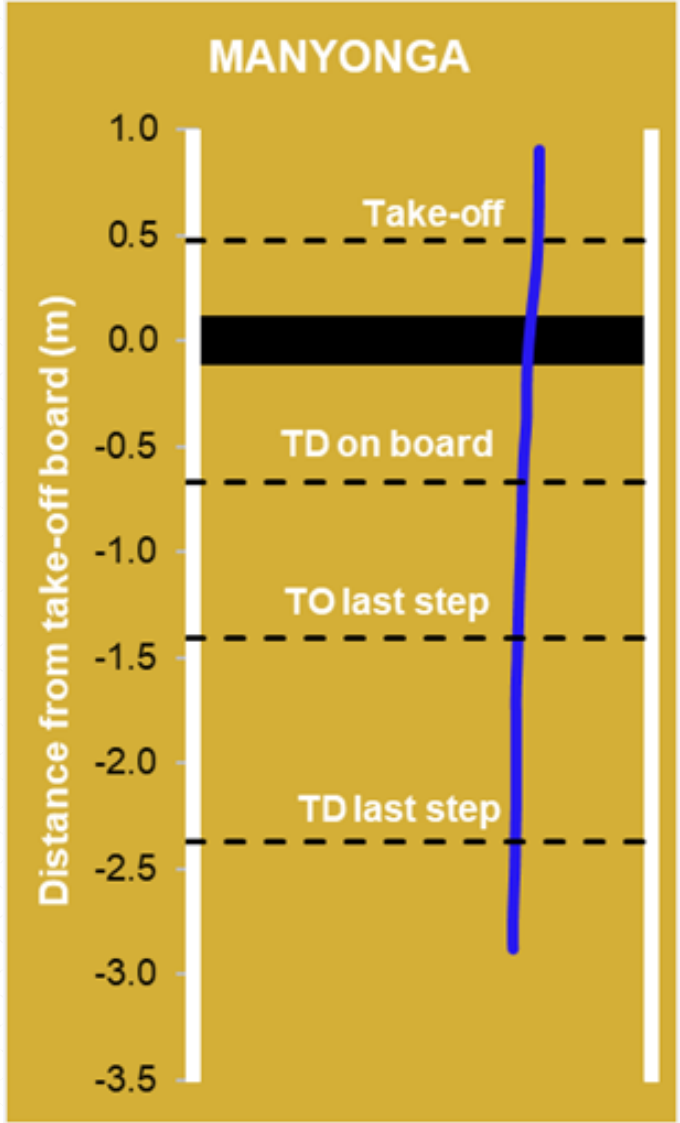


# STRIDE LENGTH WAS KEY FOR MO FARAH

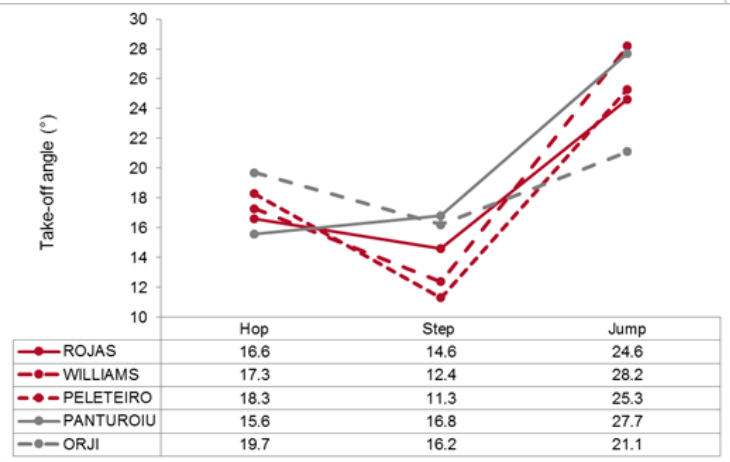
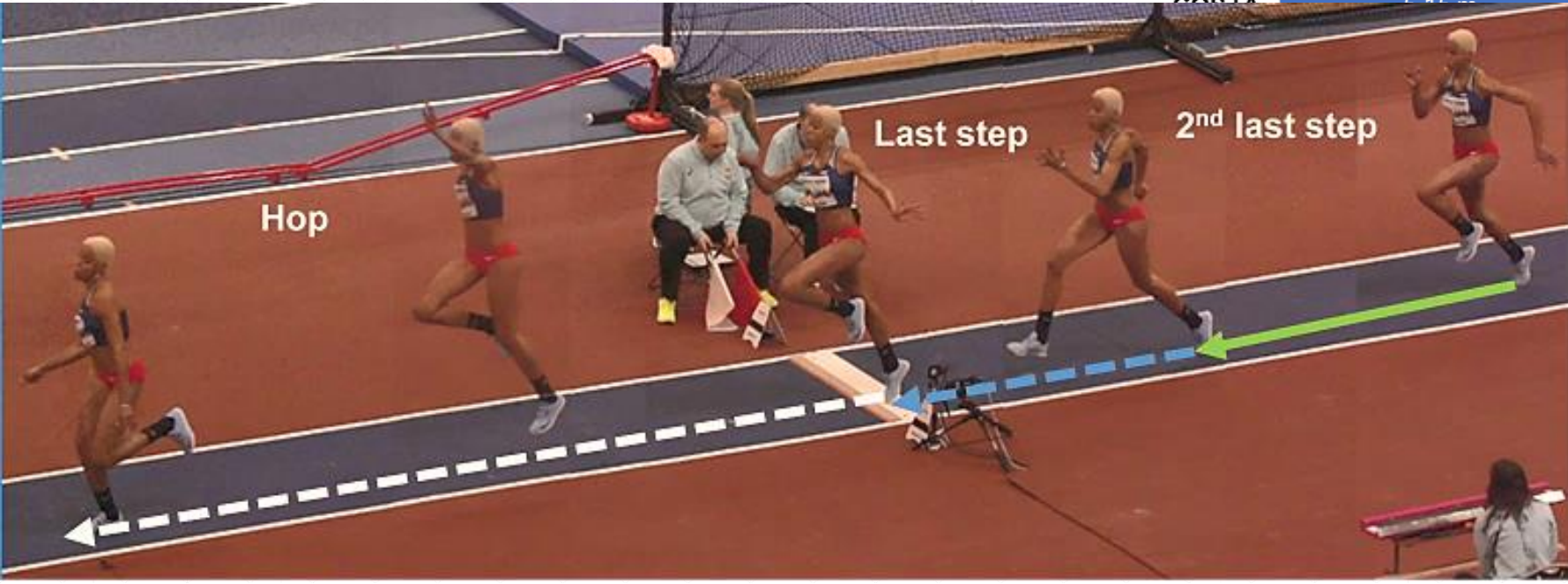
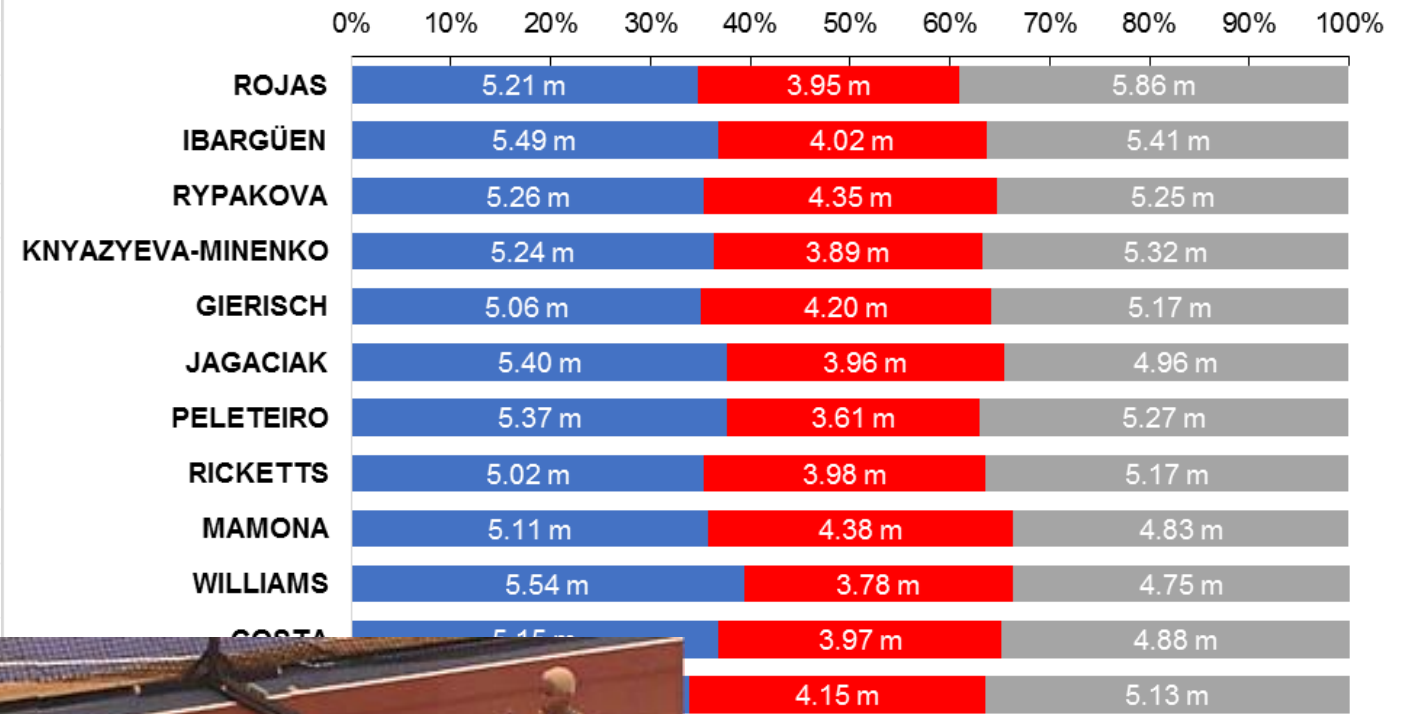
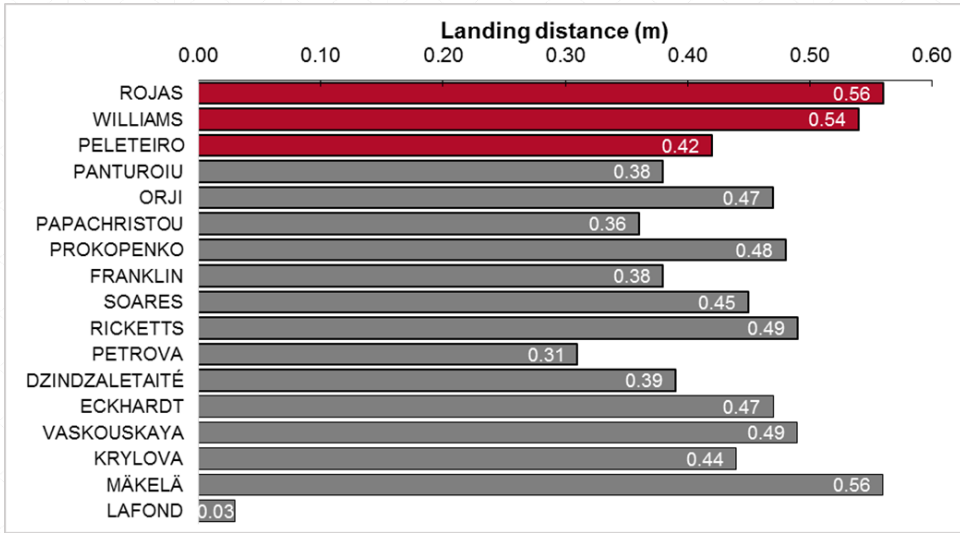
SPORTS SCIENTISTS FROM LEEDS BECKETT UNIVERSITY STUDIED EVERY DETAIL OF THE MEN'S 10,000m FINAL AT THE LONDON WORLD CHAMPIONSHIPS. PETA BEE REPORTS ON THEIR INITIAL FINDINGS



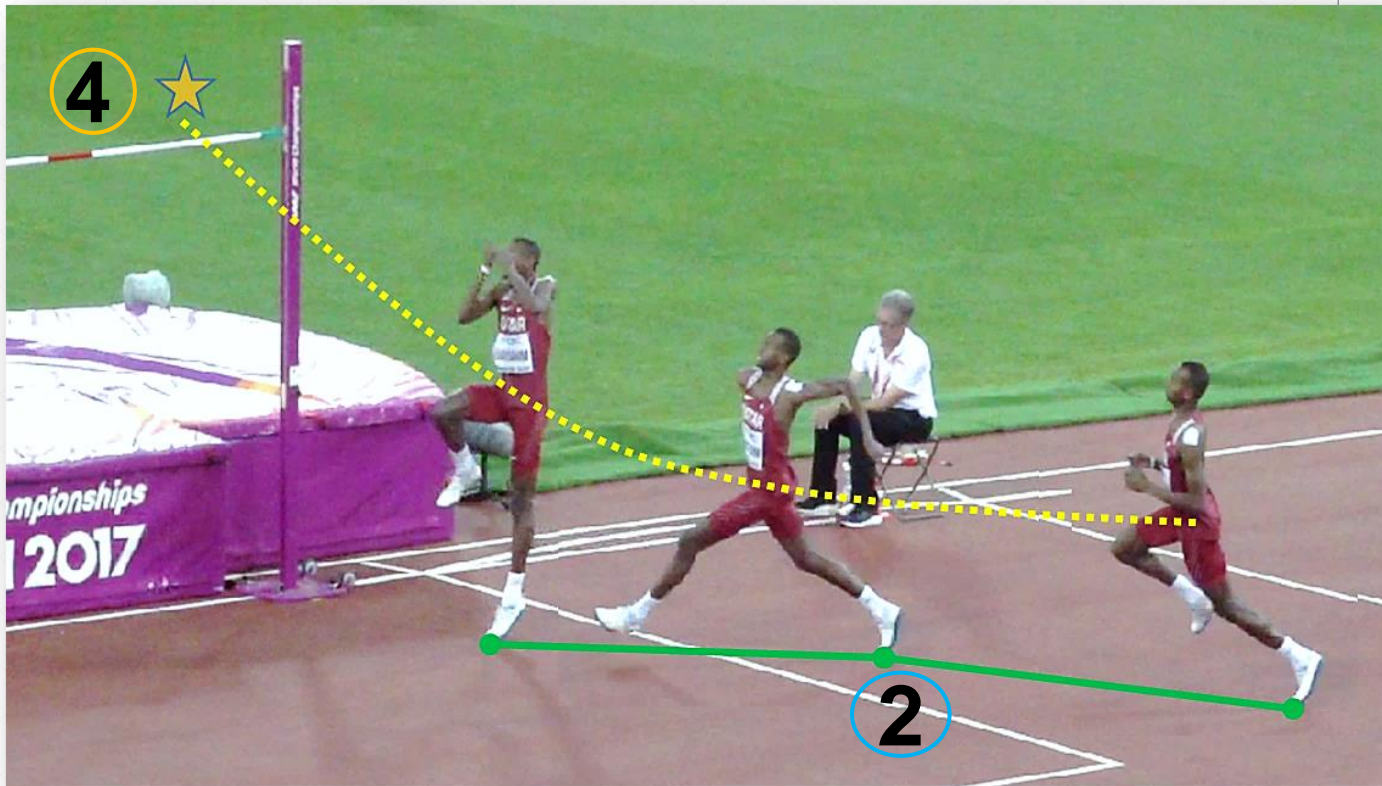
# LONG JUMP ...



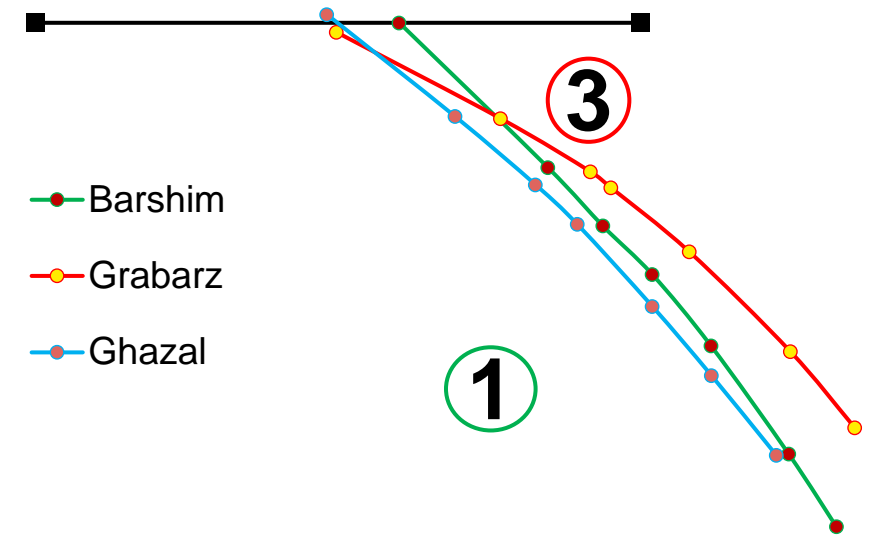
# TRIPLE JUMP ...



# HIGH JUMP ...



## CURVATURE OF THE APPROACH



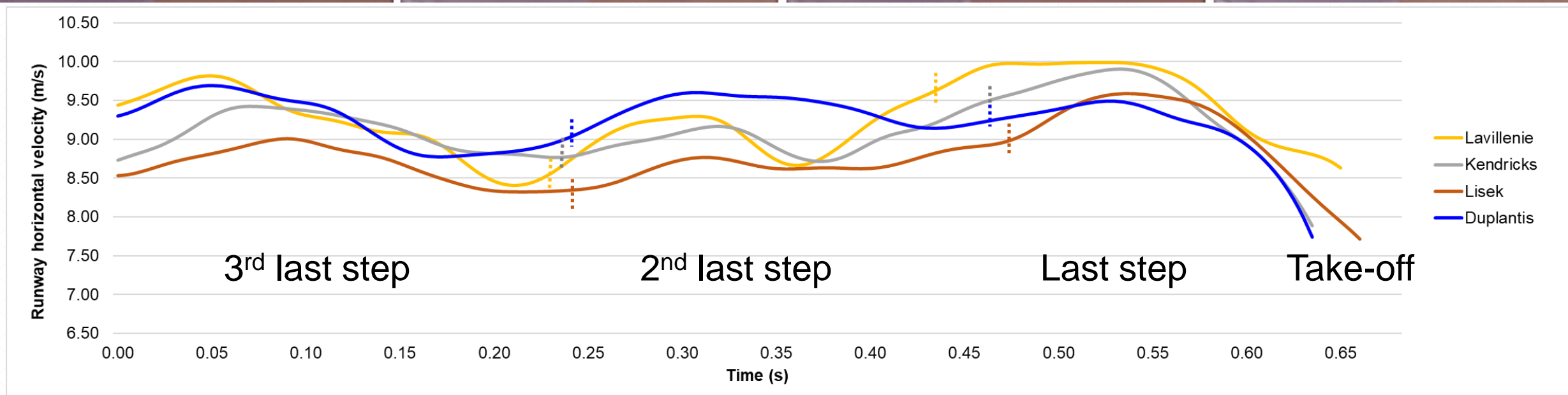
**1** GENTLY CURVED APPROACH

**2** SHORT CONTACT TIMES

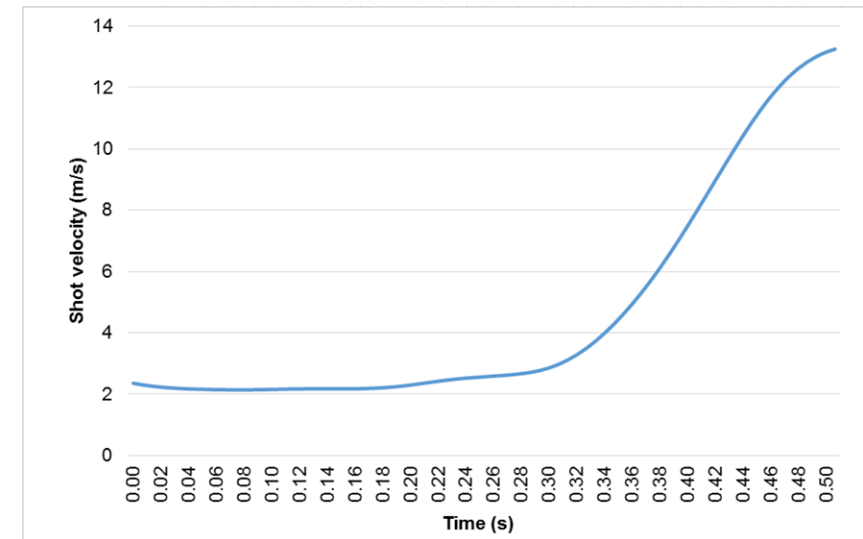
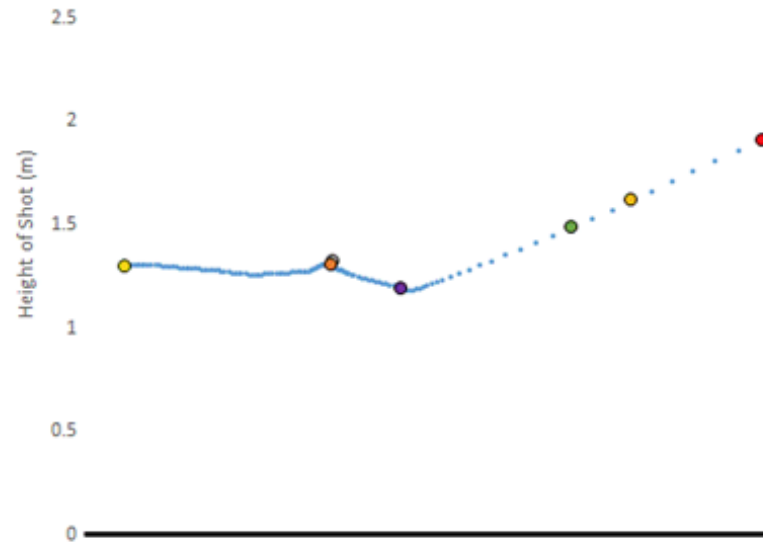
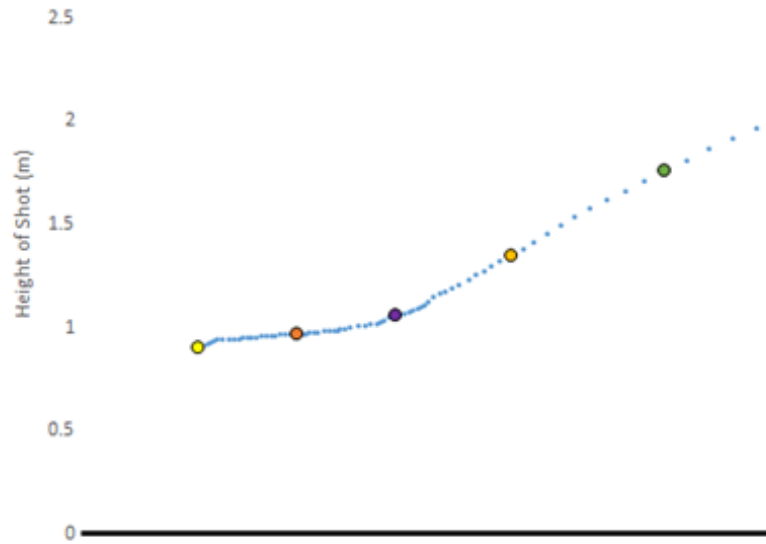
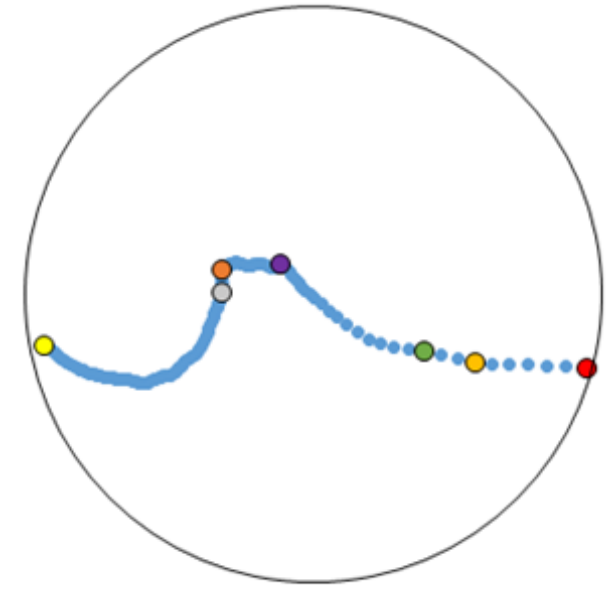
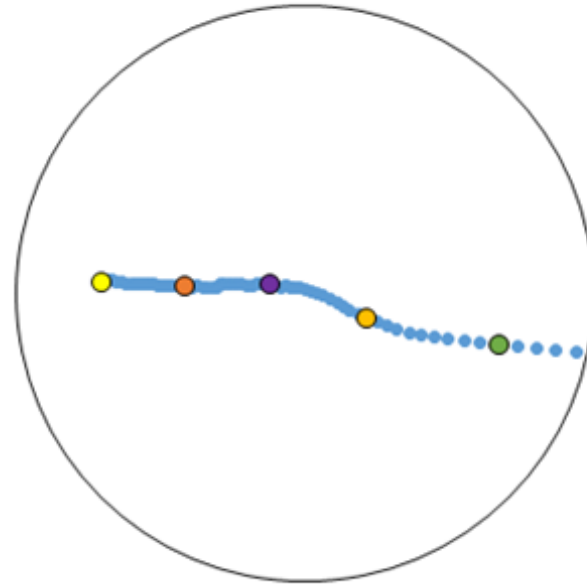
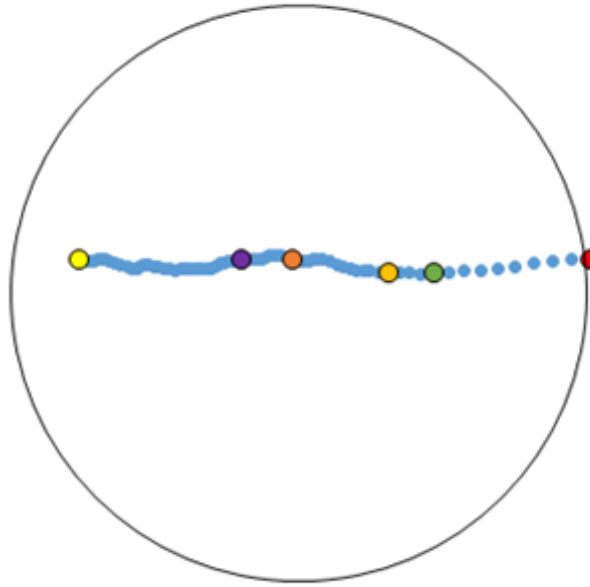
**3** LARGE TAKE-OFF DISTANCE

**4** BAR CLEARANCE

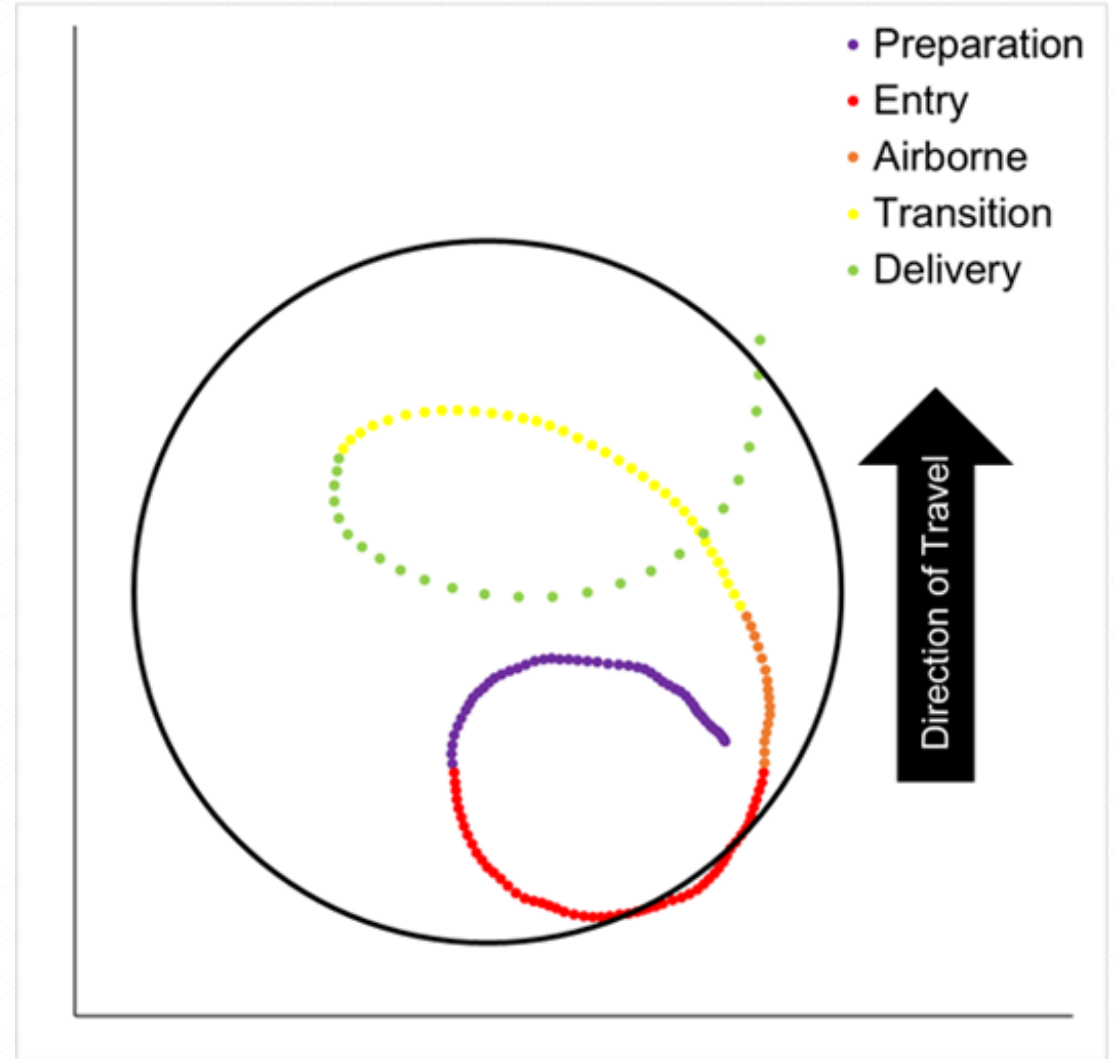
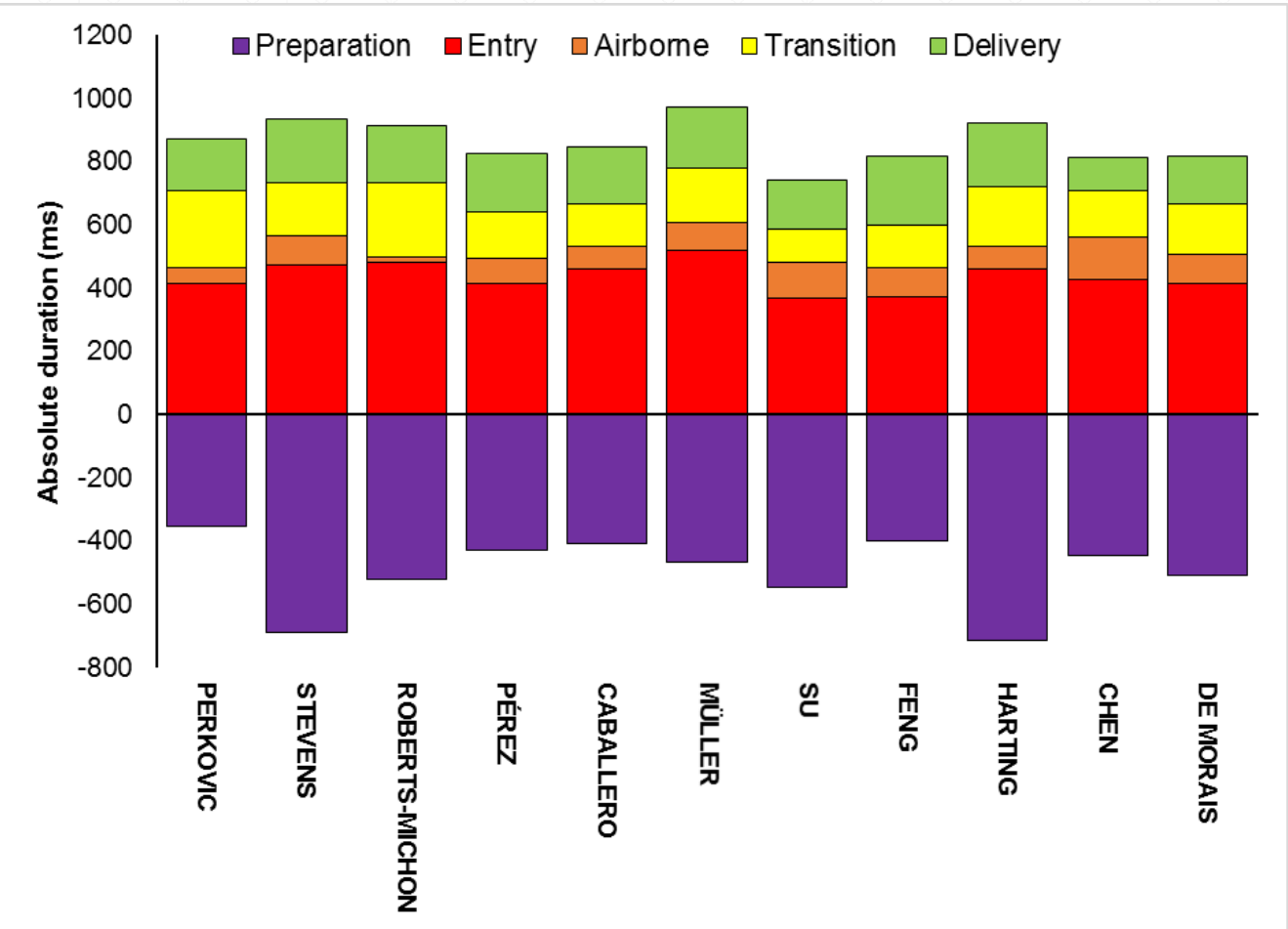
# POLE VAULT ...



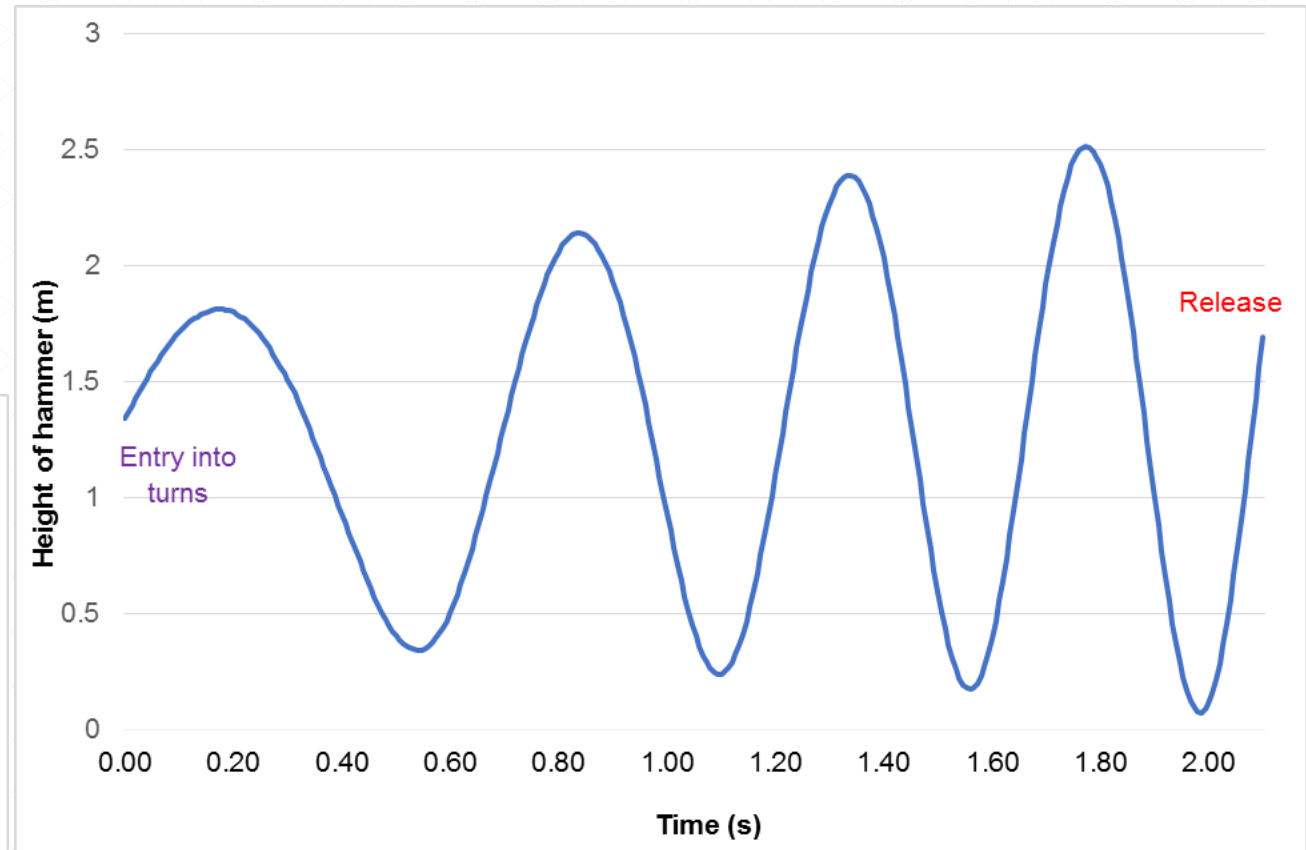
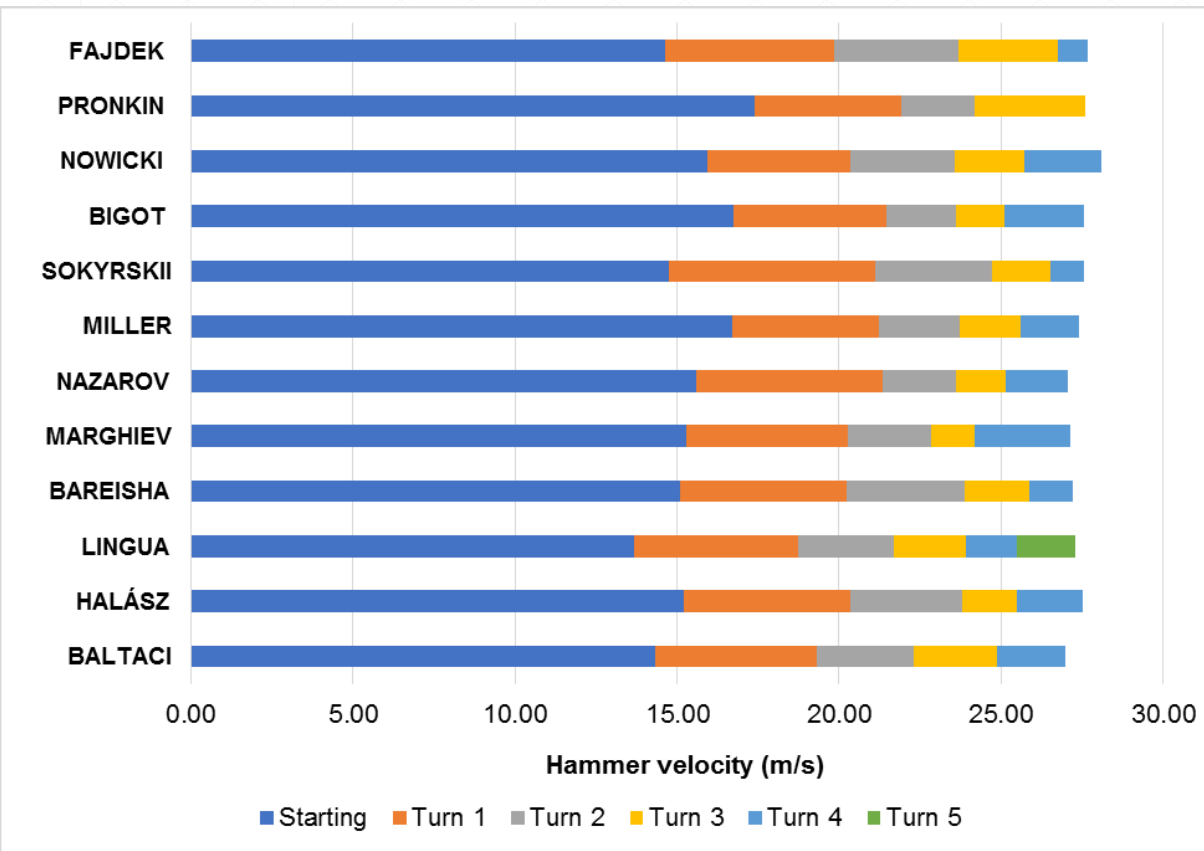
# SHOT PUT ...



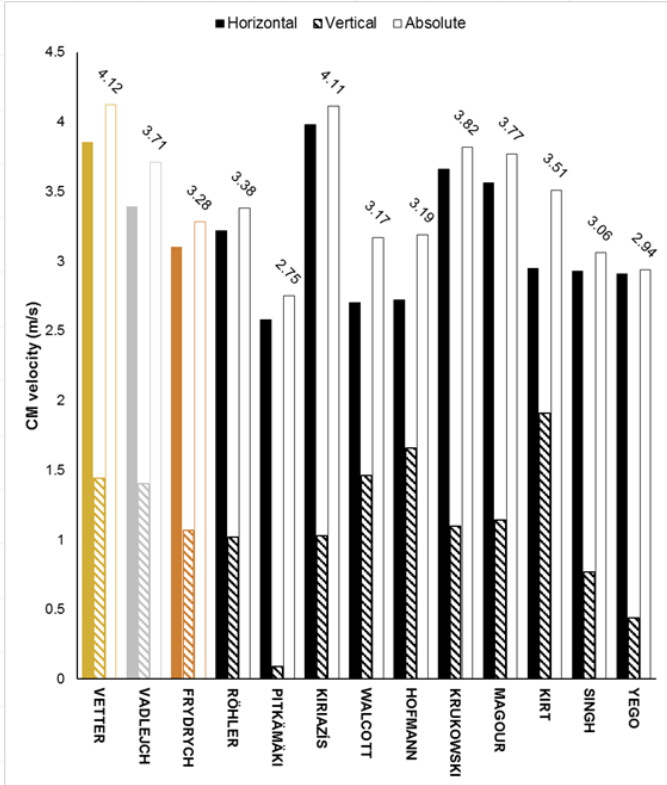
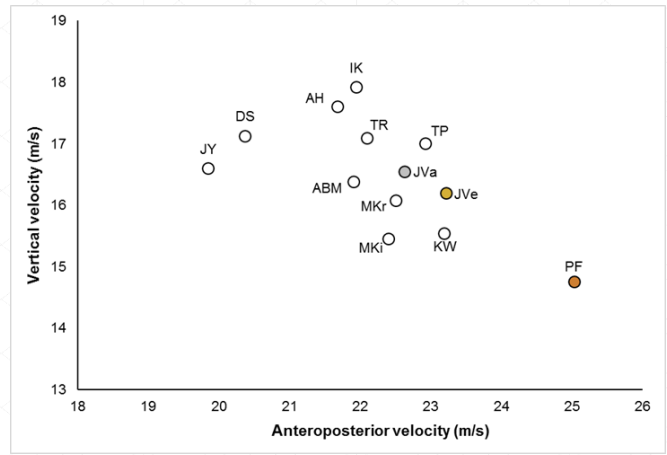
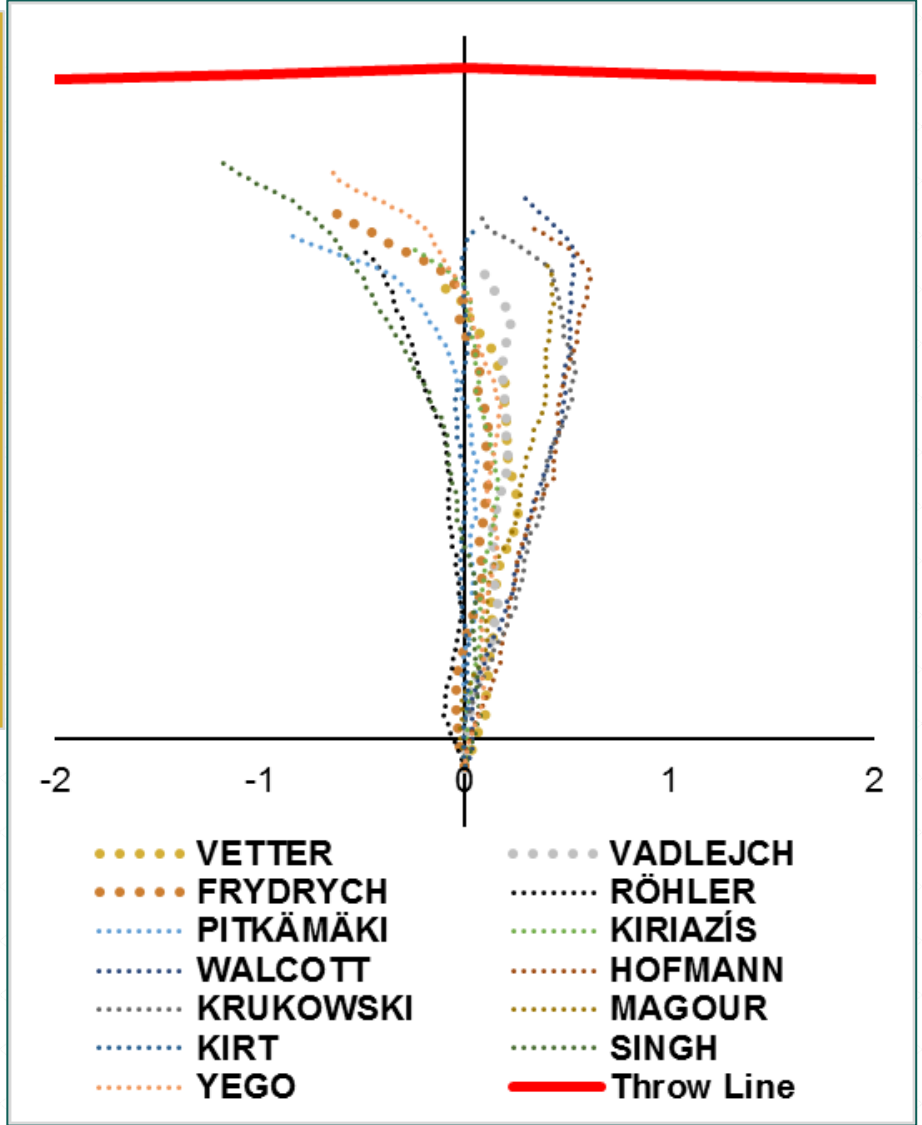
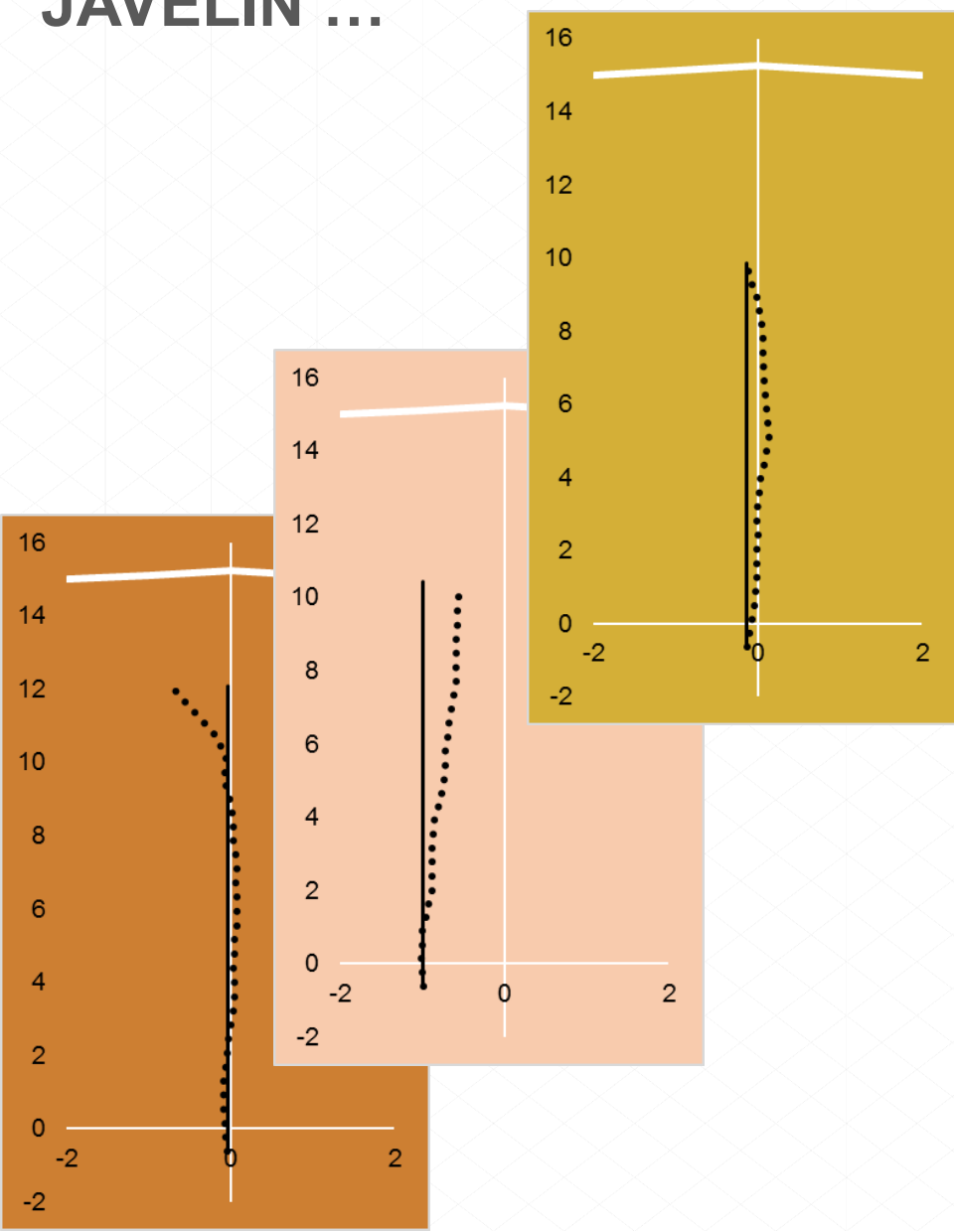
# DISCUS ...



# HAMMER THROW ...



# JAVELIN ...



# MEN'S 4 x 100 METRE RELAY ...



NATION	TOTAL TIME	RUN TIME	TRANSITION TIME	FINAL RANKING
<b>Great Britain &amp; N.I.</b>	37.47 s	31.885 s	<b>5.585 s</b>	<b>1<sup>st</sup></b>
<b>United States</b>	37.52 s	31.885 s	<b>5.635 s</b>	<b>2<sup>nd</sup></b>



Most marathon runners at the 2017 IAAF World Championships were rearfoot strikers, and most did not change footstrike pattern



Brian Hanley<sup>a,\*</sup>, Athanassios Bissas<sup>a</sup>, Stéphane Merlino<sup>b</sup>, Allison H. Gruber<sup>c</sup>

<sup>a</sup> *Carnegie School of Sport, Leeds Beckett University, United Kingdom*

SPORTS BIOMECHANICS

<https://doi.org/10.1080/14763141.2020.1856916>

**Routledge**  
Taylor & Francis Group



## Footstrike patterns and race performance in the 2017 IAAF World Championship men's 10,000 m final

Brian Hanley<sup>id</sup><sup>a</sup>, Catherine B. Tucker<sup>id</sup><sup>a</sup>, Athanassios Bissas<sup>id</sup><sup>a,b</sup>, Stéphane Merlino<sup>c</sup> and Allison H. Gruber<sup>id</sup><sup>d</sup>

**frontiers**  
in Sports and Active Living

ORIGINAL RESEARCH  
published: 06 August 2020  
doi: 10.3389/fspor.2020.00102



## Men's and Women's World Championship Marathon Performances and Changes With Fatigue Are Not Explained by Kinematic Differences Between Footstrike Patterns

Brian Hanley<sup>1\*</sup>, Athanassios Bissas<sup>1,2</sup> and Stéphane Merlino<sup>3</sup>

<sup>1</sup> *Carnegie School of Sport, Leeds Beckett University, Leeds, United Kingdom*, <sup>2</sup> *School of Sport and Exercise, University of Gloucestershire, Gloucester, United Kingdom*, <sup>3</sup> *Development Department, World Athletics, Monte Carlo, Monaco*

Men

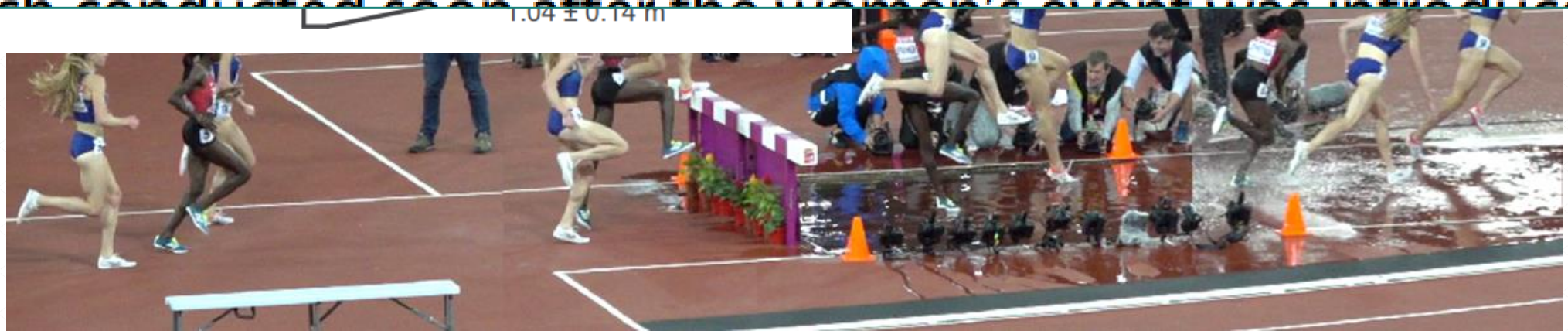
Clearance height

■  $0.67 \pm 0.06$  m

ump phase in World Championship men and women steeplechasers. Coefficient of variation cts (sex-based comparisons) that were significant at  $P < 0.05$  are shown in bold with their

Women	<i>P</i>	<i>d</i>
$1.96 \pm 0.19$ (9.6%)	<b>0.035</b>	<b>0.88</b>
$18.41 \pm 1.34$ (7.3%)	<b>0.002</b>	<b>1.36</b>

a change in the depth or dimensions of the water jump pit. For women to experience similar foot-water and uphill resistances as men and improve performances and times more in line with the sex-based differences in flat races, a device that changes the pit's dimensions for women could be considered by the IAAF. Previous research conducted soon after the women's event was introduced



1.04 ± 0.14 m



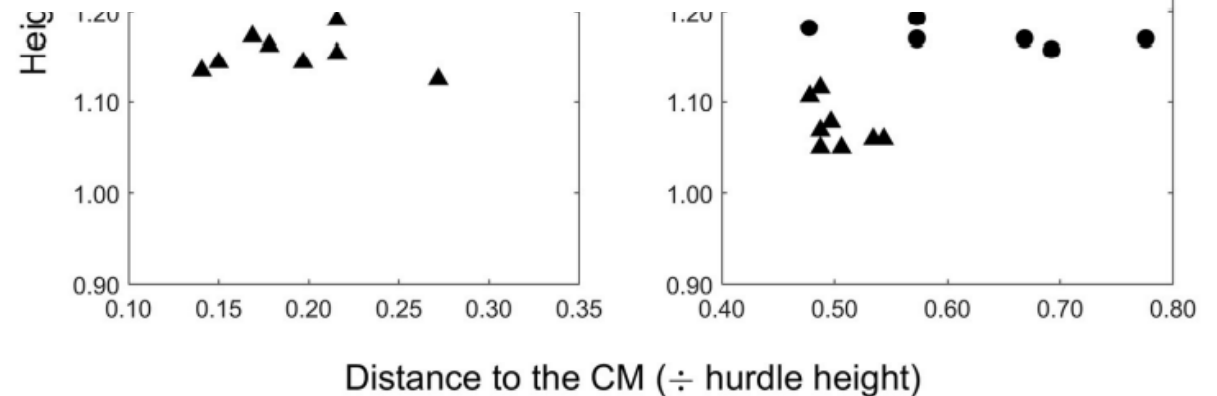
role in supporting the body effectively regarding moving into the subsequent landing step. Women were also able to take off farther from the hurdle in relative terms, meaning a less demanding task and affecting the step lengths achieved between the hurdles. Overall, the lower hurdle heights for women, relative to stature, provide them with a kinematic and potentially mechanical advantage over the men.



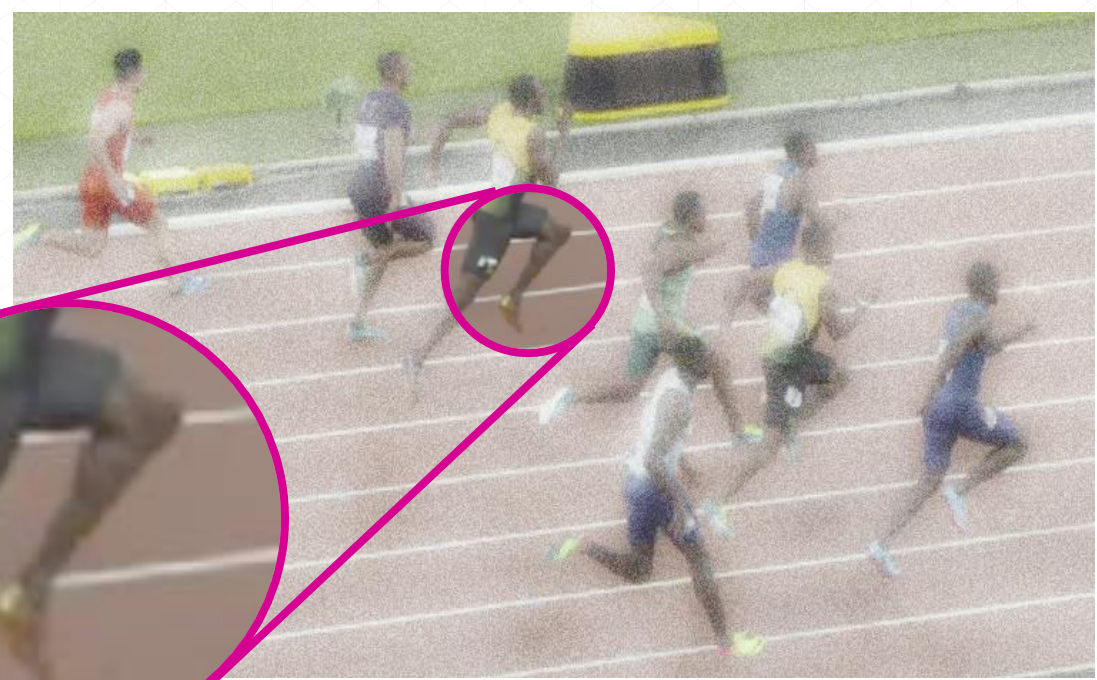
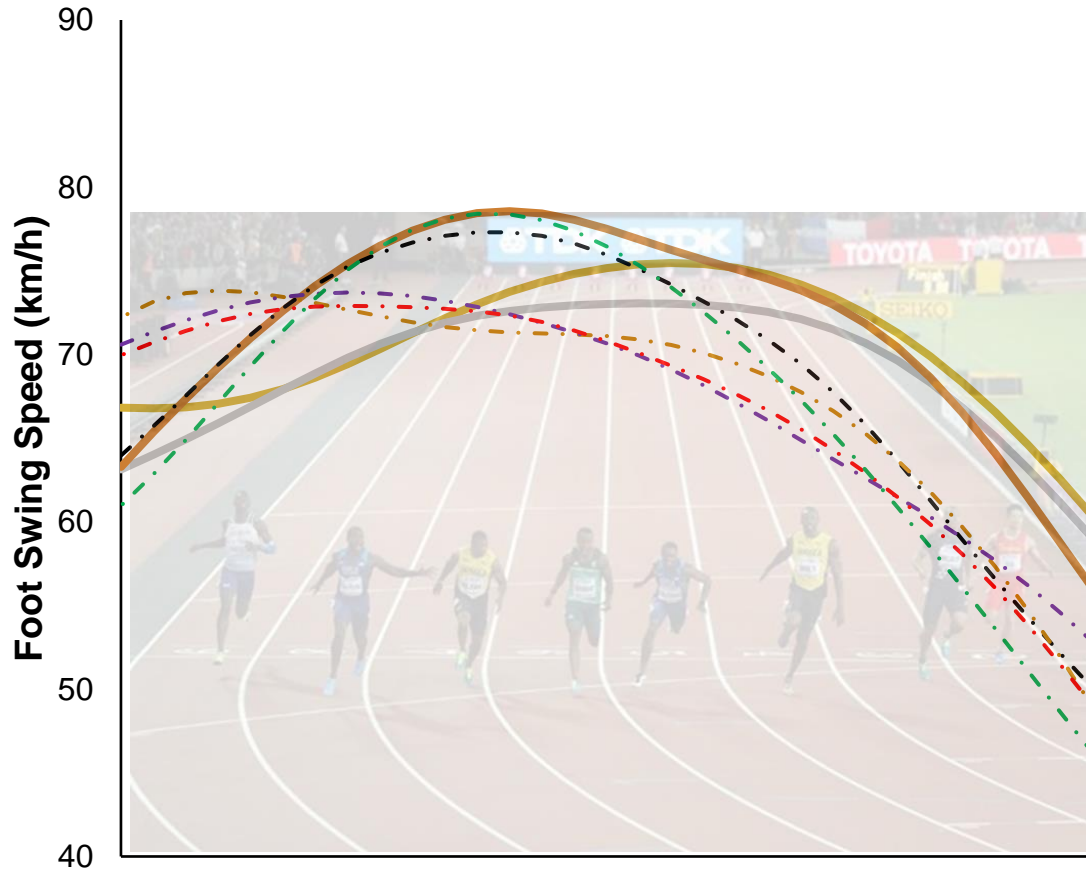
### Kinematic and temporal differences between world-class men's and women's hurdling techniques

Athanassios Bissas<sup>1,2,3\*</sup>, Giorgos P. Paradisis<sup>4</sup>, Brian Hanley<sup>1</sup>, Stéphane Merlino<sup>5</sup>, Josh Walker<sup>1</sup>

- <sup>1</sup> Carnegie School of Sport, Leeds Beckett University, Leeds, United Kingdom
- <sup>2</sup> Athletics Biomechanics, Leeds, United Kingdom
- <sup>3</sup> School of Sport and Exercise, University of Gloucestershire, Gloucester, United Kingdom
- <sup>4</sup> School of Physical Education & Sport Science, National & Kapodistrian University of Athens, Athens, Greece
- <sup>5</sup> Development Department, World Athletics, Monte Carlo, Monaco







**BOLT = 78.6 km/h**

**GATLIN = 75.5 km/h**

**COLEMAN = 73.0 km/h**

ORIGINAL ARTICLE

## Asymmetry in sprinting in men and women sprinters

Athanasios Bissas<sup>1</sup> | Josh W. Tucker<sup>1</sup> | Catherine B. Tucker<sup>1</sup> | Nils Jongerus<sup>2</sup> | Pierre-Jean Vazel<sup>4</sup> | Olivier Girard<sup>5</sup>

<sup>1</sup>Carnegie School of Sport, Leeds Beckett University, Leeds, UK

<sup>2</sup>Athletics Sector, School of Physical Education & Sport Science, National & Kapodistrian University of Athens, Athens, Greece

<sup>3</sup>International Relations & Development Department, World Athletics, Monte Carlo, Monaco

<sup>4</sup>Athlétisme Metz Métropole, Metz, France

<sup>5</sup>School of Human Sciences (Exercise and Sport Science), University of Western Australia, Crawley, Perth, WA, Australia

### Correspondence

Olivier Girard, School of Human Sciences, Exercise and Sport Science, University of Western Australia, Perth, WA, Australia. Email: oliv.girard@gmail.com

### Present address

Athanasios Bissas, School of Sport and Exercise, University of Gloucestershire, Gloucester, UK

Nils Jongerus, European School of Physiotherapy, Amsterdam University of Applied Sciences, Amsterdam, The Netherlands

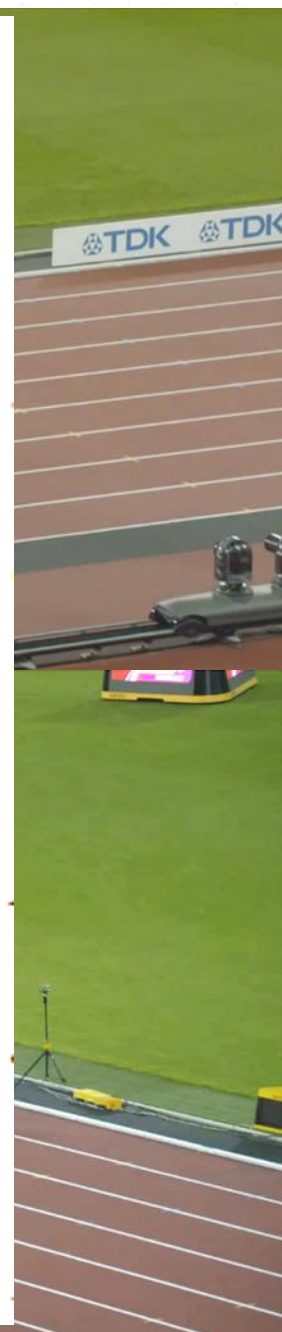
### Funding information

The data collection and initial data

# 5 | CONCLUSION

Low to moderate asymmetry is a natural phenomenon in elite sprinting and overall sprinters' performance is generally not related to their asymmetry magnitudes. However, SA scores in biomechanical parameters of sprinting varied with the parameter, and at times with the phase, of interest, reinforcing the individual nature of asymmetry. Furthermore, sprinting mechanical asymmetries were largely unaffected by sex as it was evidenced in some of the fastest male and female sprinters in the world. Our results offer a novel benchmark for the expected magnitude of asymmetry in world-class sprinters during maximum velocity sprinting and provide a basis of comparison for future studies.

We a  
ated  
eigh  
Cha  
capt  
from  
trem  
horiz  
dime  
sym  
and  
<3%  
ied v  
score  
(all  
phas  
not r  
is a r  
para  
valu  
perf  
  
KEY  
runni  
cham



IAAF World Indoor Championships™  
**BIRMINGHAM 2018**  
**1-4 MARCH**





# World-Class Male Sprinters and High Hurdlers Have Similar Start and Initial Acceleration Techniques

Ian N. Bezodis<sup>1</sup>, Adam Brazil<sup>2</sup>, Hans C. von Lieres und Wilkau<sup>1</sup>, Matthew A. Wood<sup>1</sup>, Giorgos P. Paradisis<sup>3</sup>, Brian Hanley<sup>4</sup>, Catherine B. Tucker<sup>4</sup>, Lysander Pollitt<sup>4</sup>, Stéphane Merlino<sup>5</sup>, Pierre-Jean Vazel<sup>6</sup>, Josh Walker<sup>4</sup> and Athanassios Bissas<sup>4†</sup>

OPEN ACCESS

Journal of Biomechanics 124 (2021) 110554

Contents lists available at ScienceDirect

Journal of Biomechanics

journal homepage: [www.elsevier.com/locate/jbiomech](http://www.elsevier.com/locate/jbiomech)



ELSEVIER



## Kinematic factors associated with start performance in World-class male sprinters

Josh Walker<sup>a</sup>, Athanassios Bissas<sup>a,b,c,\*</sup>, Giorgos P. Paradisis<sup>d</sup>, Brian Hanley<sup>a</sup>, Catherine B. Tucker<sup>a</sup>, Nils Jongorius<sup>a,e</sup>, Aaron Thomas<sup>a</sup>, Hans C. von Lieres und Wilkau<sup>f</sup>, Adam Brazil<sup>g</sup>, Matthew A. Wood<sup>f</sup>, Stéphane Merlino<sup>h</sup>, Pierre-Jean Vazel<sup>i</sup>, Ian N. Bezodis<sup>f</sup>

<sup>a</sup> Carnegie School of Sport, Leeds Beckett University, Leeds, UK

<sup>b</sup> Athletics Biomechanics, Leeds, UK

<sup>c</sup> School of Sport and Exercise, University of Gloucestershire, Gloucester, UK

<sup>d</sup> Athletics Sector, School of Physical Education & Sport Science, National & Kapodistrian University of Athens, Athens, Greece

<sup>e</sup> European School of Physiotherapy, Amsterdam University of Applied Sciences, Amsterdam, the Netherlands

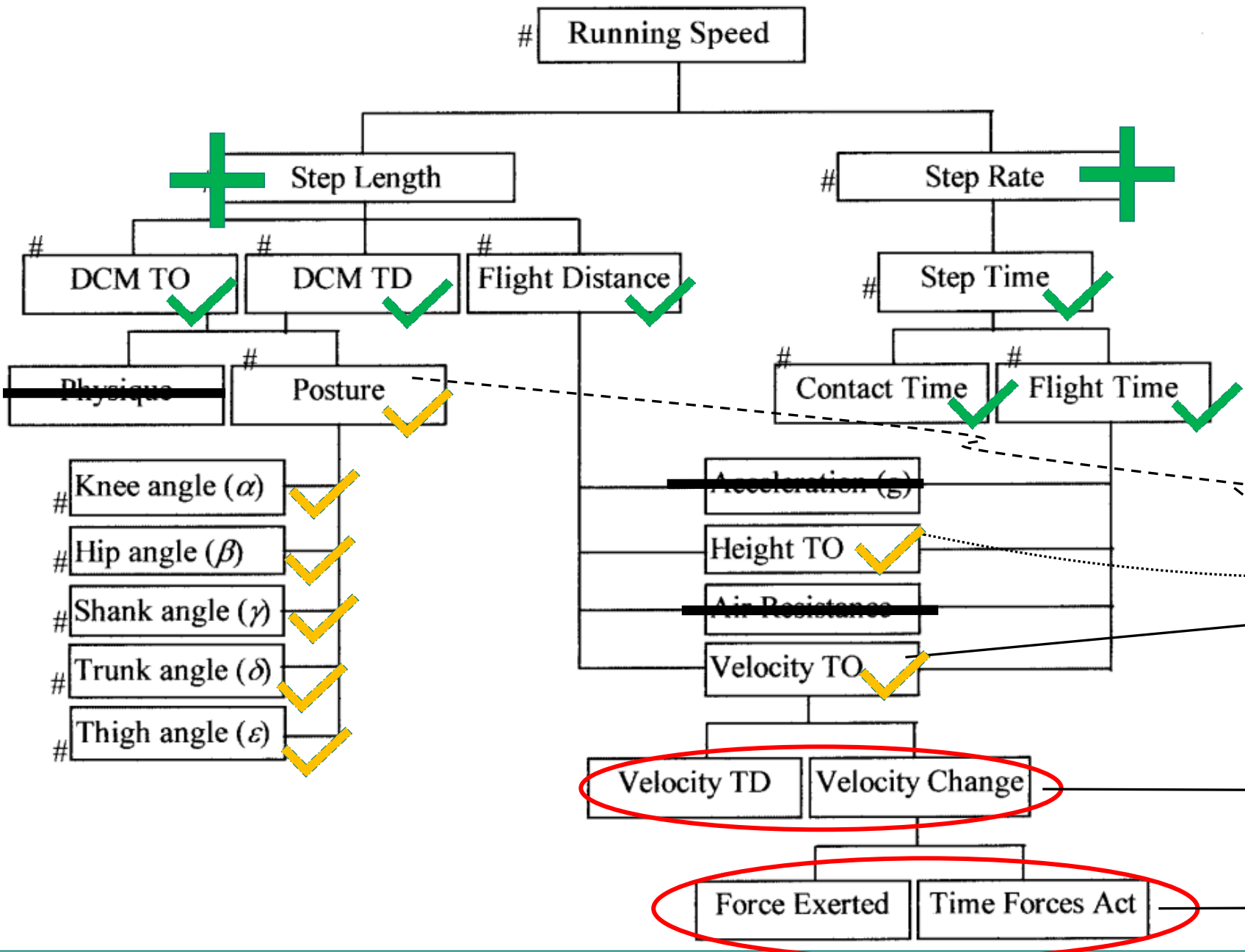
<sup>f</sup> Cardiff School of Sport and Health Sciences, Cardiff Metropolitan University, Cardiff, UK

<sup>g</sup> Department for Health, University of Bath, Bath, UK

<sup>h</sup> International Relations & Development Department, World Athletics, Monaco

<sup>i</sup> Athlétisme Metz Métropole, Metz, France





(Impulse – Momentum Relationship)

$$\begin{aligned}
 F &= ma \\
 F &= m \Delta v / \Delta t \\
 F \Delta t &= m \Delta v \\
 F \Delta t &= m(v_{TO} - v_{TD}) \\
 \text{thus} \\
 v_{TO} &= F \Delta t / m + v_{TD}
 \end{aligned}$$

$$R = \frac{v^2 \sin 2\theta}{g}$$

$$R = \frac{v^2 \sin \theta \cos \theta + v \cos \theta \sqrt{(v \sin \theta)^2 + 2gh}}{g}$$

× mass = Momentum

Impulse

