BREAKING BARRIERS TO SPRINT PERFORMANCE

RESEARCH-BASED, FIELD-PROVEN METHODS

Mike Young, PhD
HPC - Athletic Lab
NC State University
Cary, North Carolina
What limits performance?

Insight from today’s best

General concepts

Maximizing acceleration

Minimizing deceleration

Enhancing capacities
WHAT LIMITS PERFORMANCE?
Research Review
JUST THE FACTS, MA’AM
THE INDEPENDENT EFFECTS OF GRAVITY AND INERTIA ON RUNNING MECHANICS

YOUNG-HUI CHANG*, HSUAN-WEN CATHY HUANG, CHRIS M. HAMERSKI AND RODGER KRAM
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Accepted 15 October; published on WWW 22 December 1999

Summary

It is difficult to distinguish the independent effects of gravity from those of inertia on a running animal. Simply adding mass proportionally changes both the weight (gravitational force) and mass (inertial force) of the animal. We measured ground reaction forces for eight male humans running normally at 3 m·s⁻¹ and under three experimental treatments: added gravitational and inertial forces, added inertial forces and reduced gravitational forces, added inertial forces and reduced gravitational forces. Subjects ran at 110, 120 and 130 % of normal weight and mass, at 110, 120 and 130 % of normal mass and normal weight, maintaining 100 % normal weight and adding 100 % gravitational force, and maintaining 100 % normal weight and adding 100 % inertial force.

Horizontal impulses changed substantially more with weight than with mass. Gravity exerted a greater influence than inertia on both vertical and horizontal forces generated against the ground during running. Subjects changed vertical and horizontal forces proportionately at corresponding times in the step cycle to maintain the orientation of the resultant vector despite the threefold change in mass.
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• Gravity....ugh
• We work to overcome gravity
• Fat don’t fly

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Faster top running speeds are achieved with greater ground forces not more rapid leg movements

PETER G. WEYAND, DEBORAH B. STERNLIGHT, MATTHEW J. BELLIZZI, AND SETH WRIGHT
Concord Field Station, Museum of Comparative Zoology, Harvard University, Bedford, Massachusetts 01730
Received 30 March 2000; accepted in final form 14 September 2000

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More force = more speed
Air time is comparable across speeds
Limb speed....meh

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More force = more speed
Air time is comparable across speeds
Limb speed....meh
Vertical force is KING

Faster top running speeds are achieved with greater ground forces not more rapid leg movements

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Effects of Running Velocity on Running Kinetics and Kinematics

Matt Brughelli, John Cronin, and Anis Chaouchi

1School of Exercise, Biomedical and Health Sciences, Edith Cowan University, Joondalup, Western Australia, Australia;
2Institute of Sport and Recreation Research New Zealand, Auckland University of Technology, Auckland, New Zealand; and
3National Center of Medicine and Science in Sport, Tunisian Research Laboratory “Sport Performance Optimization” (NCMSS), Tunis, Tunisia

Abstract

Brughelli, M., Cronin, J., and Chaouchi, A. Effects of running velocity on running kinetics and kinematics. J Strength Cond Res 24(4): 000–000, 2010—Sixteen semiprofessional Australian football players performed running bouts at incremental velocities of 40, 60, 80, and 100% of their maximum velocity on a Woodway nonmotorized force treadmill. As running velocity increased from 40 to 60%, peak vertical and peak horizontal forces increased by 14.3% (effect size [ES] = 1.0) and 34.4% (ES = 4.2), respectively. The changes in peak vertical and peak horizontal forces from 60 to 80% were 1.0% (ES = 0.0) and 1.0% (ES = 0.9), respectively. Finally, the changes in peak vertical and peak horizontal forces from 80% useful information in terms of exercise selection, assessment, and program design is to investigate the contribution of incremental running velocities on peak vertical and peak horizontal force production. It has been well established that peak vertical (Fv) and peak horizontal forces (Fh) increase (50–100% and >200%) with increasing running velocities from slow to moderate values (i.e., 1.5–6.5 m·s⁻¹) (20,21). However, little is known about how Fv and Fh are affected by greater running velocities (>6.5 m).

Three recent studies have directly investigated the effects of running velocity above 6.5 m·s⁻¹ on Fv. These studies reported that Fv and relative Fv (RFv = Fv divided by body mass) remained constant after running velocities increased above 6.0–7.0 m·s⁻¹ or 70% maximum running velocity (Fvmax) in endurance runners and sprinters (13,14,22). Furthermore, studies that have investigated the relationship...
• Stride length correlates with speed

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KINEMATIC PARAMETERS

• Maximal Velocity: ~12.8 m/s
• Ground Contact Time: ~0.08 sec
• 42-45 steps for sub 9.80 100m
• Stride Frequency: ~5 Hz
• Stride Velocity: ~300 deg / sec
• Stride Lengths: 2.25-2.7m
KINETIC PARAMETERS

- Ground reaction forces approaching 3x bodyweight
- Muscle forces in excess of 7x bodyweight
What do the experts have to say?
The key to speed is applying large forces through appropriate ranges of motion over increasingly shorter periods of time.
To go faster, you need more force

Monday, December 12, 11
Proper force application results in stride length and frequency increases.
The main characteristic of elite sprinting is....transporting elastic energy from one leg to the other in the flight phase and directing the **GROUND REACTION FORCES** in stance.
The key to human speed is simple: applying large mass-specific forces to the ground quickly.

Dr. Peter Weyand
Mechanics is critical – with the level of competition in the sprints, a sprinter cannot be successful without sound mechanics. That said, the most important factor is the genetic ability to generate large amounts of explosive force.
The Force is Powerful!
People Running Ridiculously Fast
Impossible is just a big word thrown around by small men who find it easier to live in the world they've been given than to explore the power they have to change it. Impossible is not a fact. It's an opinion. Impossible is not a declaration. It's a dare. Impossible is potential. Impossible is temporary.

Impossible is nothing.
Conclusion:

We've gotten SOOOOOO much faster!
Conclusion:

We’ve gotten SOOOOOO much faster!

or have we?
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TOP SPRINTERS TODAY
ACCELERATE FASTER & LONGER & DECELERATE LESS
Stride Length x Frequency = Speed?
BUT...
Correlation DOES NOT imply Causation
Old: To increase speed, increase stride length and frequency
Old: To increase speed, increase stride length and frequency

New: Stride length & frequency are inter-related and an effect rather than a cause
STRIDE LENGTH & FREQUENCY
• Stride length and frequency are linked and a consequence not a cause of speed
• Stride length and frequency are linked and a consequence not a cause of speed

• Speed of movement of limbs is of little importance
STRIDE LENGTH & FREQUENCY

• The benefit of greater force application is two-fold
  • Increased stride length
  • Increased stride frequency
• Stride frequency is comprised of two components:

  1. Ground contact time

  2. Flight time

• The best sprinters spend less time on the ground
  ◦ Greater frequency
POINTS TO REMEMBER

• Forces applied to the ground are the most important determinant of running speed

  • Increases stride length and frequency

• Best sprinters apply more force in a shorter period of time
EXAMINING FORCE

• Force is a vector quantity
  • Magnitude
  • Direction
FORCE DEVELOPMENT & SPRINTING

• To increase running speed an athlete must increase force to the ground in the appropriate direction and do so over increasingly shorter periods of time

  • Minimize horizontal braking forces

  • Increase vertical propulsive forces
run fast for long
run fast.
run
run (accelerate)
WHEN DOES 60 = 20?
ACCELERATION MECHANICS

Monday, December 12, 11
EXTENDING ACCELERATION

• Staying in pushing mechanics permits a neuromuscular and metabolic shift that allows for less fatigue later in a race

• Athletes should display:
  • Lower heel recovery
  • Gradual but slow progression of body angles
  • Piston-like action of the legs
LOW DEPARTURE ANGLES
MECHANICS OF UPRIGHT RUNNING
Nature

Nurture

Monday, December 12, 11
Sprinting is a skill
Sprinting fast is an unnatural activity.
MECHANICS OF SPRINTING

• Sprinting well is a combination of nature and nurture

• There are reflexive and innate components as well as trainable components
FRONT SIDE MECHANICS

• Refers to the motions of the leg that occur IN FRONT of the body
BACK SIDE MECHANICS

- Refers to the motions of the swing leg that occur BEHIND the body
Max V Sprinting 101

Big Force
+
Right Direction
+
Minimal Time

____________________
Faster
GOALS OF SPRINTING

- Minimize braking forces
- Increase propulsive forces
Optimizing Mechanics?
SPRINT MECHANICS CHECKLIST
Posture

- Trunk Erect
- Head Level
- Hips Tall
POSTURE ALIGNMENT
Rudder & Mast of the Body
The first most important aspect of speed is POSTURE.
• Movements of the limbs originate from the core of the body

• Proper stabilization and alignment of the core ensures appropriate movements of the limbs
- Postural Stabilization
- Postural Alignment
  - Relaxation
  - Freedom of movement
- Elastic energy production
• The pelvis should rotate in all three planes
POSTURAL TEST!
IMPORTANCE OF POSTURE
IMPORTANCE OF POSTURE
Ground Contact

- Upright posture
- Minimize horizontal distance between foot and hips
- Legs together
- Heel high
Stance Phase

- Upright posture
- Tall hips
- Vertical forces
- Swing leg active
Stance Phase

- Upright posture
- Stepping over knee
Stance Phase

- Upright posture
- High knee
- Swing leg unfolds
Toe Off

- Projection of non-support hip
- High knee
- Neutral / dorsiflexed ankle
- Minimal backside mechanics
Flight

- Appropriate vertical displacement
- Preparation for ground contact
- Downward acceleration of thigh
- Neutral / dorsiflexed ankle
Technical Points

- Fix posture
- Emphasize vertical pushes
  - Push up
- Elbows in front of the body
- High hips
- Run tall
What should I look for in running?
MINIMIZE BRAKING FORCES

- Decreases horizontal velocity
- Caused by excessive step length and positive foot and leg speed at ground contact
EFFECTIVE GROUND CONTACT POSITION
VERTICAL PROPULSIVE FORCES

• Increased vertical propulsive force produce a host of benefits
  • Greater displacement
  • More effective ground contact position
  • Better maintenance of momentum
Amplitude?
Boing?
VERTICAL DISPLACEMENT

- The path of COM will follow a sinusoidal curve when viewed in the sagittal plane
- COM reaches apex in flight
- COM low point during support
To go faster, you need more force. The more force you apply, the higher you will rise off the ground.
INCREASE LEG STIFFNESS
INCREASE LEG STIFFNESS

• Refers of the ability of the leg to act as like a spring
INCREASE LEG STIFFNESS

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• Momentum is developed during acceleration
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• Body will move at same rate unless acted on by unbalanced forces
INCREASE LEG STIFFNESS

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• Two external forces will cause deceleration
INCREASE LEG STIFFNESS

• Refers of the ability of the leg to act as like a spring

• Momentum is developed during acceleration

• Body will move at same rate unless acted on by unbalanced forces

• Two external forces will cause deceleration

• Leg stiffness increases vertical impulse, shortens ground contact and increases elastic return
AMPLITUDE DUE TO GOOD MECHANICS

- Better sprinters will appear to bounce
- Flight times stay the same without an increase in ground contact time
THE MEAT MACHINE

• Absorb shock and control vertical collapse during support

• Balance and control of upper extremity

• Forward and upward propulsion

• Control direction changes in center of mass
To Sprint Faster...
To Sprint Faster.... Sprint!

Monday, December 12, 11
Contact time & the different strength qualities of 100m sprinting.
building low end power
STRENGTH
SHORT BOUNDS
MULTI-THROWS
BUILDING A STIFFER SPRING
Vertical force production is the key component of top-end speed and that in turn influences the ability to maintain a slight increase in stride length and stride frequency.
Stride length is determined by the quality of force application during ground contact. The quality of this force application is related to the degree of stiffness in the supporting leg as well as the speed of forward flexion of the free leg.
Vertical forces become predominant in the maximal velocity phase. Much of the horizontal momentum needs have been established, so vertical force generation becomes critical. These vertical forces enhance stride length and posture.
ECCENTRIC STRENGTH
DEPTH DROPS
DEPTH JUMPS
VERTICAL EMPHASIS PLYOS
STIFFNESS JUMPS
COMPLEXES
ECCENTRIC OVERLOAD
Connect
The dots
CLOSING POINTS

• Today’s top sprinters are accelerating faster and longer

• Today’s top sprinters are decelerating less

• Enhancement of mechanics will improve performance

• Developing physical capacities with an emphasis on eccentric force generation is beneficial
THANKS

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