

Kicking in Soccer



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International Society of Biomechanics in Sports 2010 Congress, Marquette, MI, USA
19.07.-23.07.2010

Kicking: Art and Sports



Sculpture "Soccer Player"
Renée Sintenis - Berlin, Germany
1927



Soccer Subject
University of Duisburg-Essen, Germany
2005

Outline

- Kicking Movement
- Measurement Technology
- Performance Criteria
- Influence of Footwear
- Research Perspectives

Movement

Measurement Technology

Performance

Footwear

Perspective

Kicking: Complex Motor Movement



Bauer 1990

6 Phases:

- Approach angle
- Plant foot forces
- Swing limb loading
- Hip flexion and knee extension
- Foot to ball contact
- Follow-through

Barfield 1998

5 Phases:

- Approach
- Support leg
- Kicking leg
- Foot to ball contact
- Ball flight

Lees et al. 2010

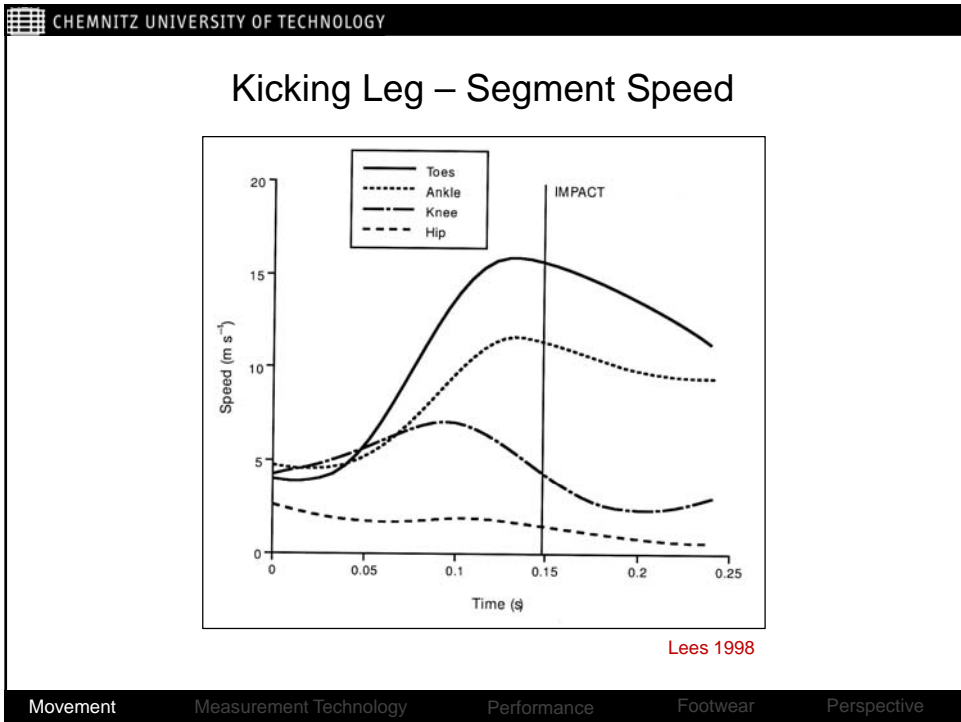
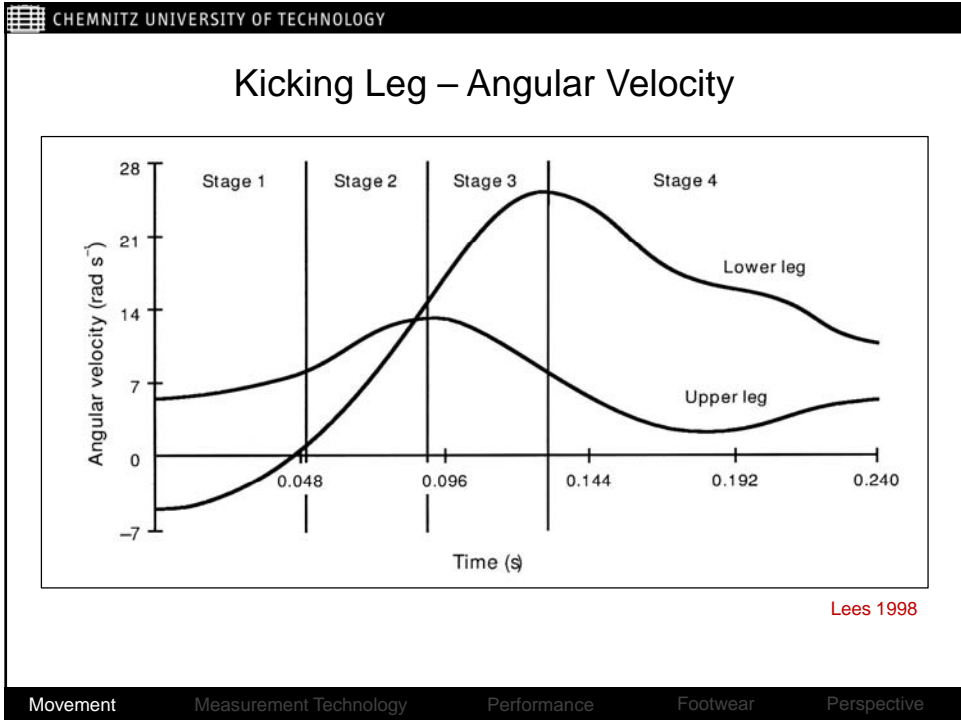
Movement

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Performance

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Key Aspects for Fast and Accurate Kicking

Velocity:

- Kicking Type, Technique
- Skill level, Limb Dominance
- Age, Maturity, Gender
- Muscle Strength & Power

- Approach Speed and Angle
- Energy Transfer between Body Segments

Accuracy:

- Approach Speed
- Kicking Velocity Reduction
- Foot to Ball Contact Point
- Ball Spin

Kellis & Katis 2007

Foot to ball impact characteristics

Foot to Ball Contact: Impact Phase

Duration: 6 - 16 ms
various authors



Open - loop movement

initial

full

final



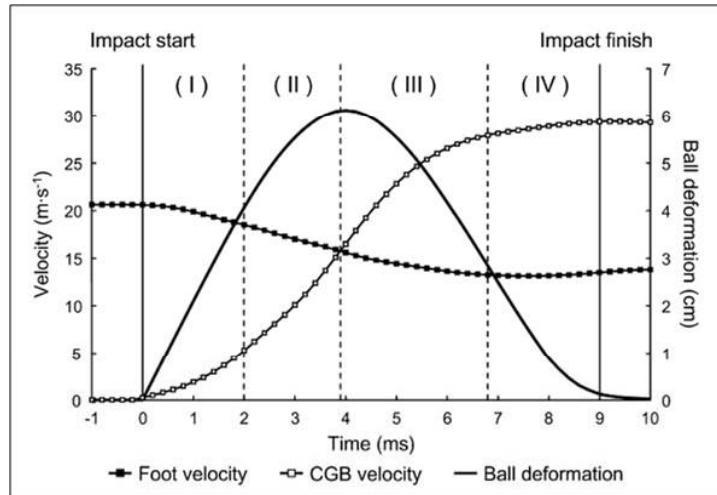
Displacement of the ball



Mixture of impact-like and throwing-like aspects

Tsaousidis & Zatsiorsky 1996

Impact Phase



Shinkai et al. 2009

Movement

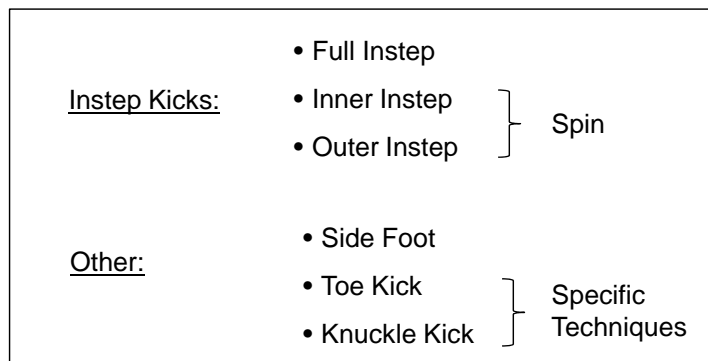
Measurement Technology

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Footwear

Perspective

Kicking Techniques



Movement

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Predominant Kicking Techniques – Purposes

	Full Instep	Inner Instep	Side Foot
Women	51	88	330
Men	42	60	407

Team incidents during a 90 minute soccer game, Althoff et al. 2010



Clearance

Passing, Crossing

Shots on Goal

Movement

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Full Instep Kick

Giovanni van Bronckhorst (Netherlands) – World Cup 2010: Uruguay vs. Netherlands (2-3)

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Inner Instep Kick

Yasuhito Endo (Japan) – World Cup 2010: Denmark vs. Japan (1-3)

Movement Measurement Technology Performance Footwear Perspective

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Side Foot Kick

Elano (Brazil) – World Cup 2010: Brazil vs. North Korea (2-1)

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Kicking Performance

Basic Performance
Criteria

- Levanon & Dapena 1998
- Nunome et al. 2002
- Neilson & Jones 2005
- ...

- Kristensen et al. 2005
- Scurr & Hall 2009
- Sterzing et al. 2009

Movement
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High Speed Video

ID 1 Scene 23 Trigger CENTER Trigger Time 05/08/08 11:56:25.801079 Frame +00000230 ID 0 Scene 20 Trigger CENTER Trigger Time 05/08/08 11:55:56.633257 Frame +00000230
 Nickname zico n 10 CD 1456 Rec 5000 Shutter OPEN mac fx-6000 Nickname zico n 10 CD 1147 Rec 5000 Shutter OPEN mac fx-6000

provided by Shinkai et al. 2009

Movement
Measurement Technology
Performance
Footwear
Perspective

Motion Analysis Systems



Movement

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Radar Gun

- 20 milliwatt Ka band dual horn microwave
- accuracy: 0.1 km/h
- speed range: 1 to 480 km/h
- acquisition time: 0.01 seconds
- update rate: 100 per second



Movement

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Performance

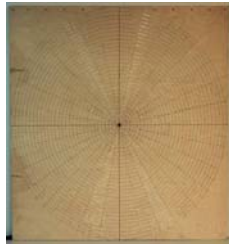
Footwear

Perspective

Measurement Technology for Kicking Accuracy

- Plywood wall laminated with carbon paper for impact imprints

Finnoff et al. 2002



- Circular electronic target (concentric wire frame)
- Ball contact generates electrostatic charges
- Software based determination of ball impact location

Hennig et al. 2009

- Digital camera recording (25 Hz)

Scurr & Hall 2009

Movement

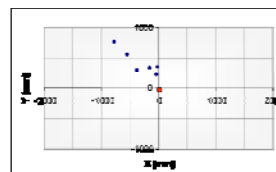
Measurement Technology

Performance

Footwear

Perspective

Kicking Accuracy Measurement Technology



- High speed video capturing of ball impact location (200 Hz)

CMOS Camera HCC-1000, VDS Vosskühler, Germany

- Accuracy determination: distance ball center to bull's eye

MaxTRAQ 2.06, Innovisions Systems, MI, USA

Sterzing et al. 2009

Movement

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Relation of velocity (VEL) and accuracy (ACC)

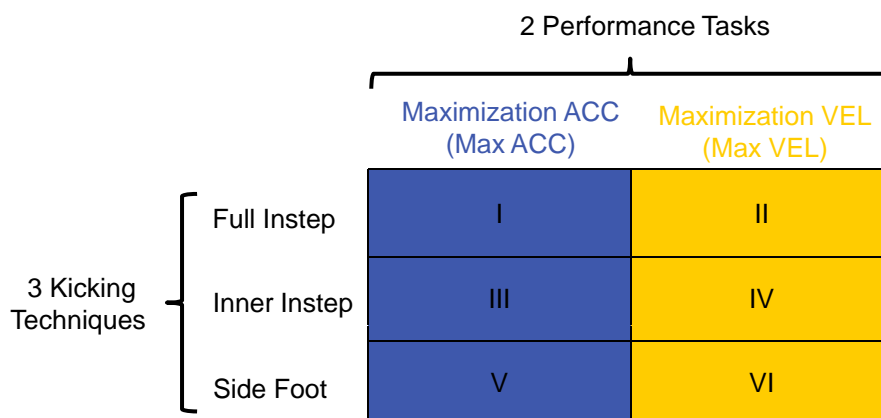
Sterzing et al. 2009



Simultaneous quantification of VEL and ACC of full instep, inner instep and side foot kicks

- Speed - accuracy trade-off
- Variability of VEL and ACC

6 Kicking Conditions

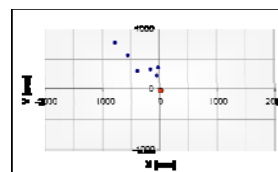


Methods

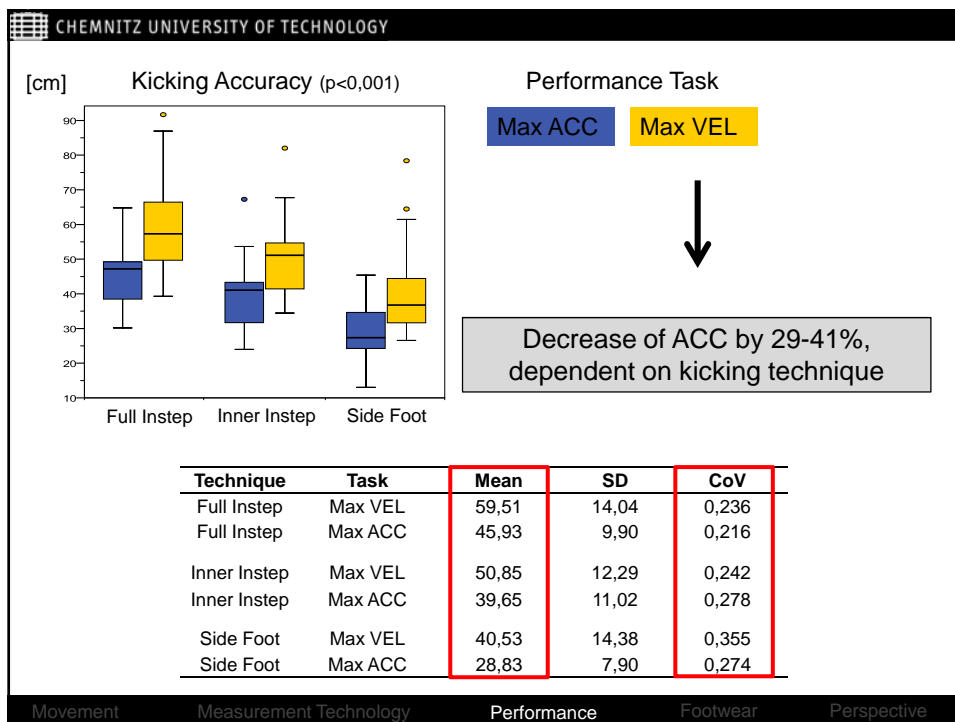
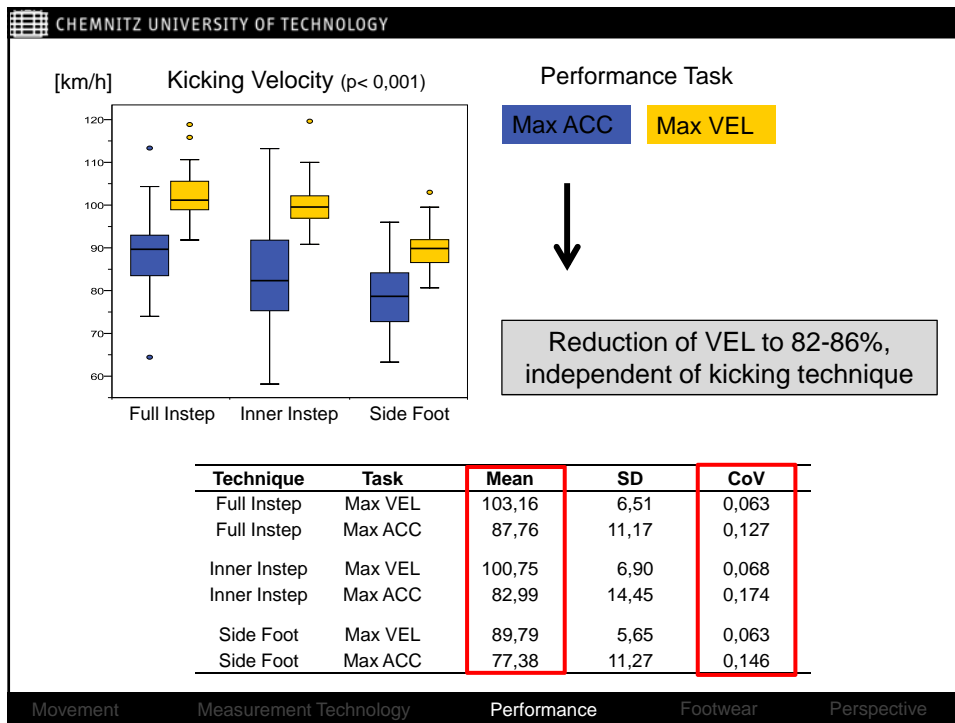
- 19 soccer players (4th - 6th league)
- Kicking of stationary ball – 6 m target distance
- 6 repetitive trials per kicking condition (total: 36 kicks)

- Mean and standard deviation (SD)
 - Coefficient of variability (CoV)
 - Repeated measures ANOVA
 - Post-hoc test (Bonferroni)
- } across subjects
- Coefficient of variability (CoV_{6 repetitive kicks})
- ➔ within subjects

Experimental Set-up



- Radar gun for VEL measurements
Stalker Pro, Applied Concepts, TX, USA
- High speed video capturing of ball impact location (200 Hz)
CMOS Camera HCC-1000, VDS Vosskühler, Germany
- ACC determination: distance ball center to bull's eye
MaxTRAQ 2.06, Innovisions Systems, MI, USA



Within Subject Variability – (CoV₆ repetitive kicks)

		VEL	ACC
Technique	Task	CoV ₆ kicks	CoV ₆ kicks
Full Instep	Max KV	0,034	0,633
Full Instep	Max KA	0,044	0,550
Inner Instep	Max KV	0,032	0,477
Inner Instep	Max KA	0,052	0,613
Side Foot	Max KV	0,029	0,573
Side Foot	Max KA	0,047	0,572

Reduction of velocity **did not lead** to more **constant** accuracy.

Findings

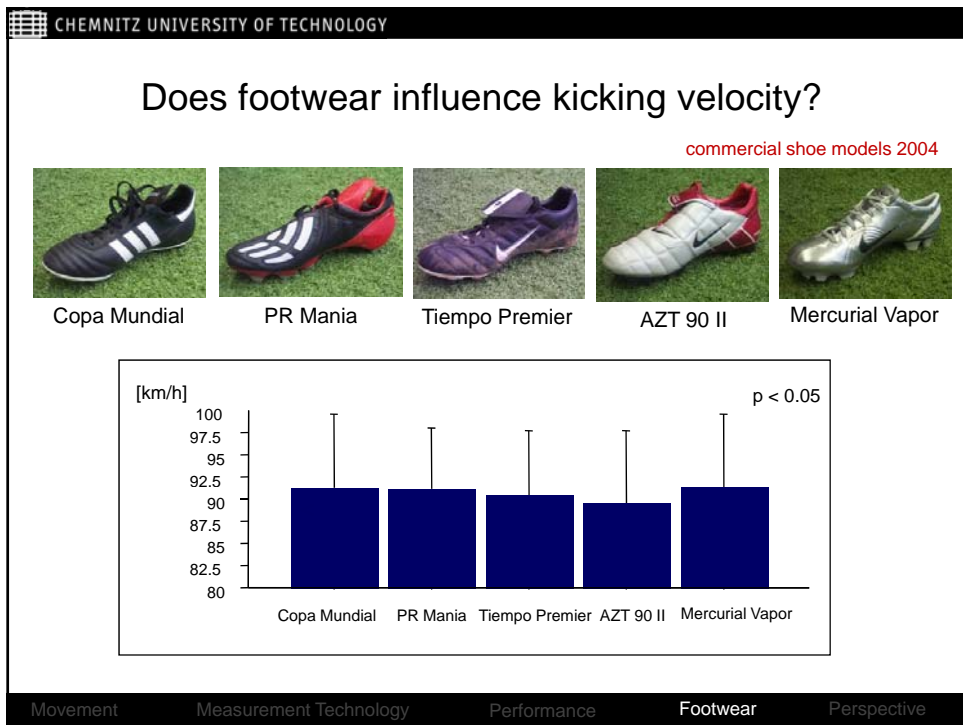
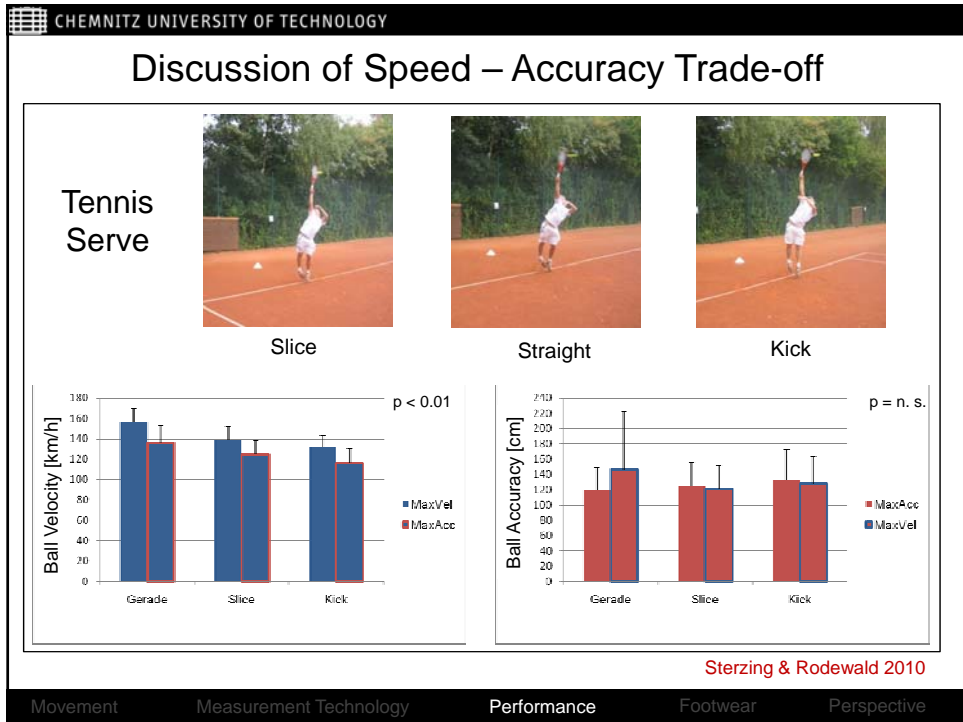
- VEL differences between techniques confirmed
- ACC differences between techniques fundamentally quantified
- VEL and ACC relation appeared stable for the two performance tasks

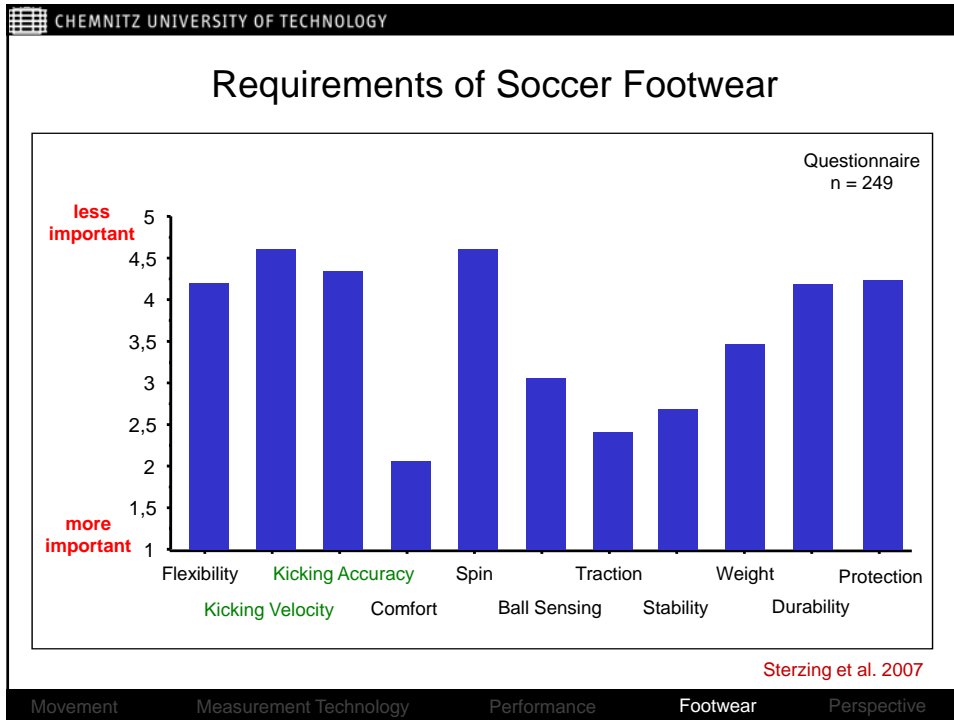
- Variability of VEL extremely low within subjects

→ Motor Input

- Variability of ACC considerably high especially within subjects

→ Motor Output





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Kicking Velocity & Soccer Footwear

The Influence of Soccer Shoes on Kicking Velocity in Full-Instep Kicks

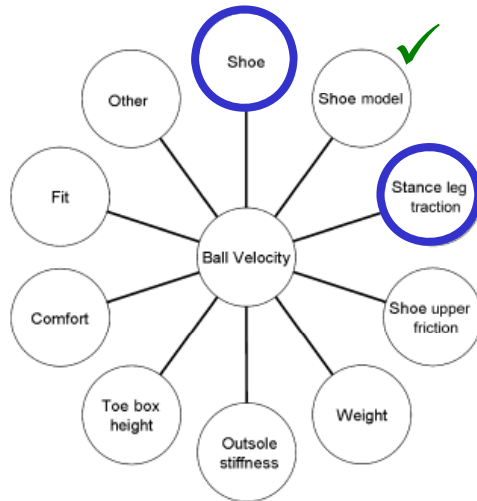
Thorsten Sterzing¹ and Ewald M. Hennig²

¹Department of Human Locomotion, Institute of Sports Science, Chemnitz University of Technology, Chemnitz; and ²Biomechanics Laboratory, Sports and Movement Sciences, University of Duisburg-Essen, Essen, Germany

STERZING, T., and E.M. HENNIG. The influence of soccer shoes on kicking velocity in full-instep kicks. *Exerc. Sport Sci. Rev.*, Vol. 36, No. 2, pp. 91–97, 2008. Soccer shoes enhance the traction required by the stance leg but decrease the quality of the ball contact during full-instep kicking. Shoe features that influence ball velocity include traction, foot protection, foot rigidity, and toe box height. Upper material and general comfort potentially affect ball velocity. In contrast, shoe weight and outsole stiffness do not influence ball velocity. **Key Words:** full-instep kicking, ball velocity, shoe features, stance leg, kicking leg

Movement Measurement Technology Performance **Footwear** Perspective

Systematic Evaluation of Isolated Shoe Features



Movement

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General Testing Procedures

Biomechanics Laboratory
University of Duisburg-Essen



Radar Gun
Stalker Pro



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Footwear

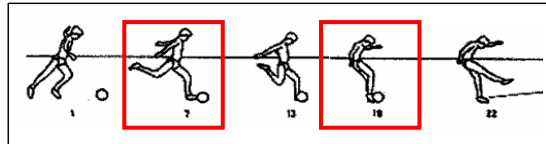
Perspective

General Testing Procedures ctd.

Force Plate – Kistler



Photo Cell Arrangement



Swing Phase Time: foot strike (GRFs) to initial ball movement (photo cell)

Movement

Measurement Technology

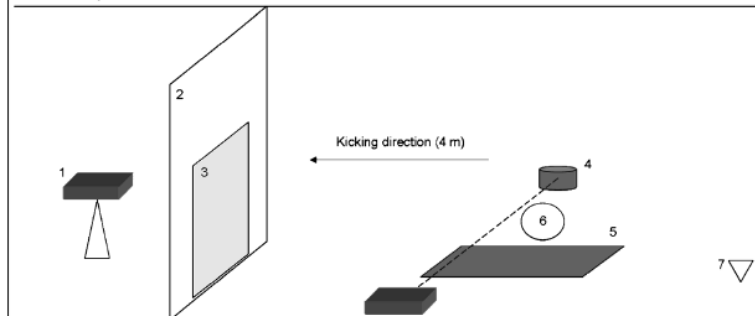
Performance

Footwear

Perspective

General Testing Procedures ctd.

Laboratory environment



Experimental set-up: ¹radar gun, ²goal with ³target area, ⁴photo cell arrangement, ⁵force plate next to ⁶ball, ⁷three-step approach.

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Neutral Shoe Method at Contra Lateral Foot



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General Testing Procedures ctd.

- About 20 experienced soccer players
- Familiarization with laboratory testing environment
Warm-up
Practice trials
- 6 maximum full instep kicks per shoe condition – stationary ball
3-step approach
Standardized resting intervals
Randomization of shoe conditions between subjects
- Ranking of ball velocity
Rating of study specific items

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67:02
URU 1-1 NED

Support Foot Traction

Diego Forlan (Uruguay) – World Cup 2010: Uruguay vs. Netherlands (2-3)

Movement Measurement Technology Performance **Footwear** Perspective

The image shows a soccer player, Diego Forlan, in a yellow jersey with black accents on the sleeves. He is looking to the left. In the background, a scoreboard displays '67:02' and 'URU 1-1 NED'. The scene is set on a green soccer field.

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30:29
DEN 0-2 JPN

Support Foot Traction

Yasuhito Endo (Japan) – World Cup 2010: Denmark vs. Japan (1-3)


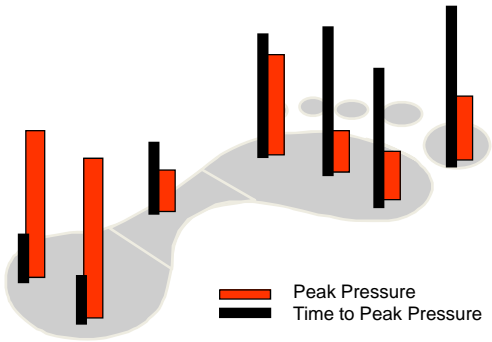
Movement Measurement Technology Performance **Footwear** Perspective

The image shows a close-up of a soccer player's foot, Yasuhito Endo, wearing a silver cleat, positioned on a white soccer ball with green and gold patterns. The ball is on a green field. In the background, a scoreboard displays '30:29' and 'DEN 0-2 JPN'. The player is wearing blue socks.

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Plantar Pressures – Support Foot

Sterzing & Hennig 2005

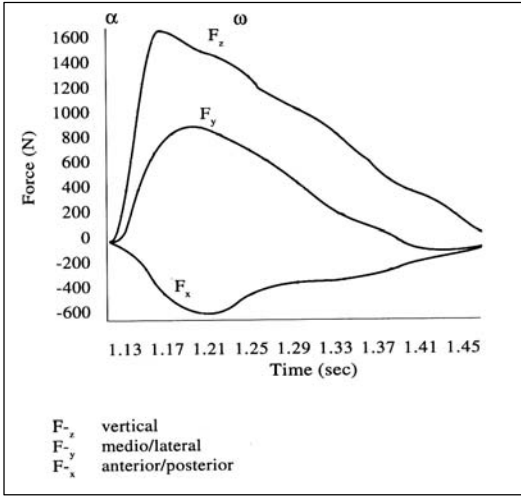



█ Peak Pressure
█ Time to Peak Pressure

Movement Measurement Technology Performance Footwear Perspective

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Plant Foot Forces



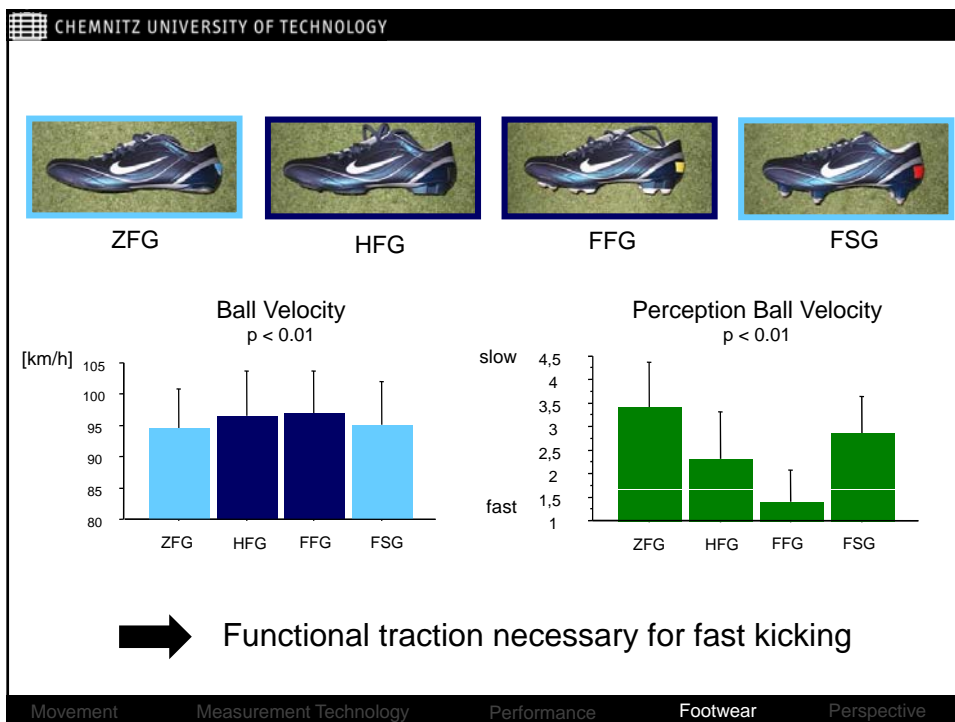
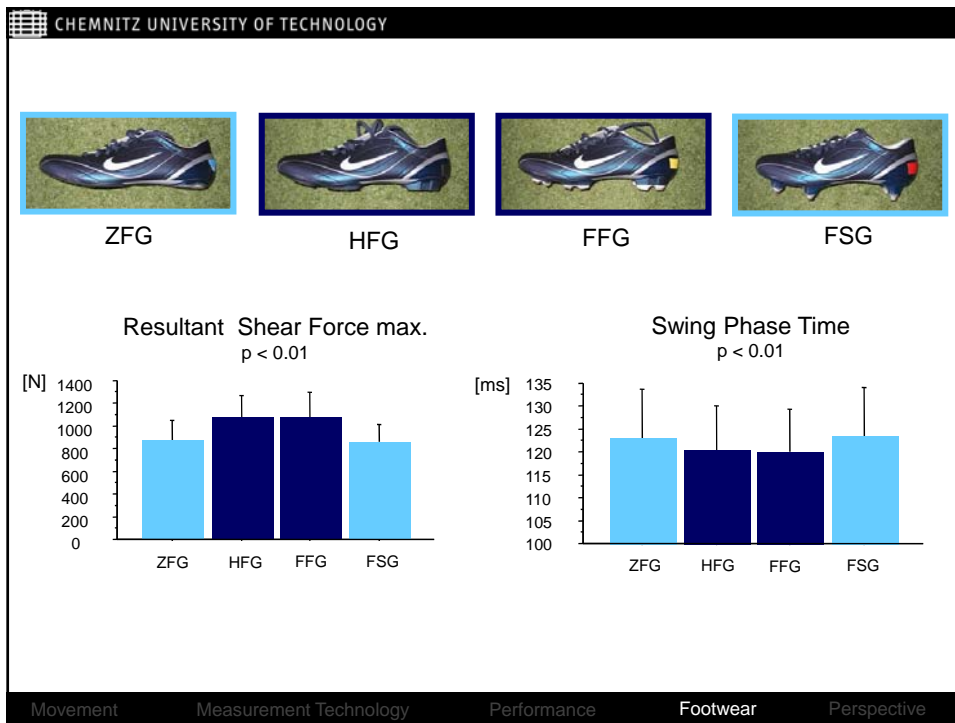
α ω
 1600
 1400
 1200
 1000
 800
 600
 400
 200
 0
 -200
 -400
 -600
 Force (N)

1.13 1.17 1.21 1.25 1.29 1.33 1.37 1.41 1.45
 Time (sec)

F_z vertical
 F_y medio/lateral
 F_x anterior/posterior

Barfield 1995

Movement Measurement Technology Performance Footwear Perspective



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Shod vs. Barefoot Kicking



Regular Soccer




Beach Soccer

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Ball Condition




outdoor – regular

→



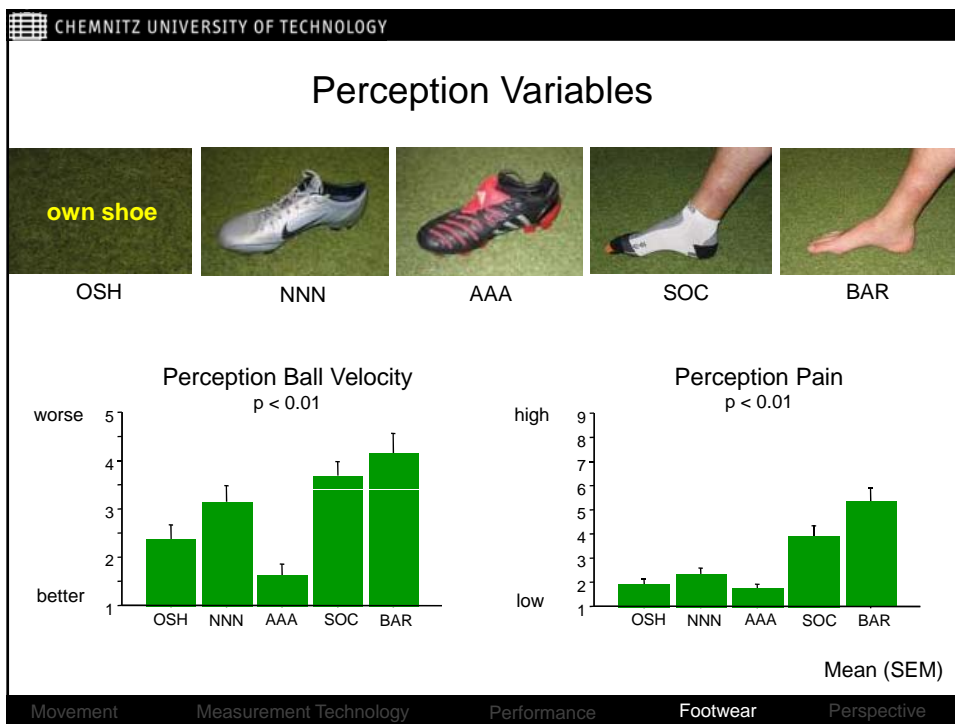
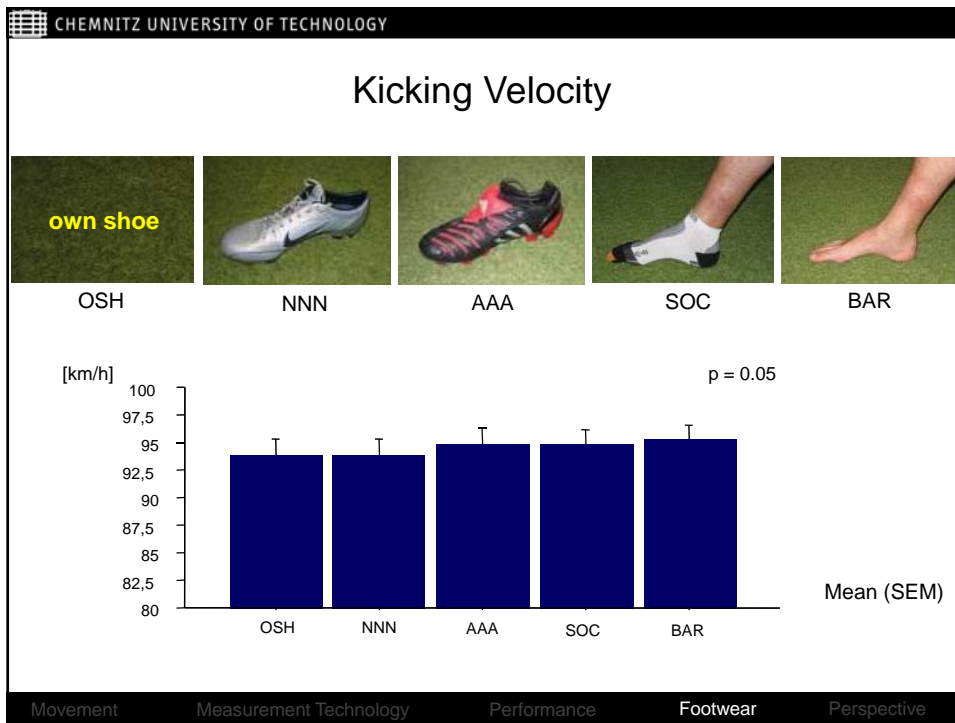
indoor – regular

<ul style="list-style-type: none"> • circumference: 68.6 cm • weight: 436.6 g 	<ul style="list-style-type: none"> • circumference: 71.9 cm • weight: 422.9 g
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Reduction of Skin Pain

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Impact Phase: High Speed Video (1 kHz)

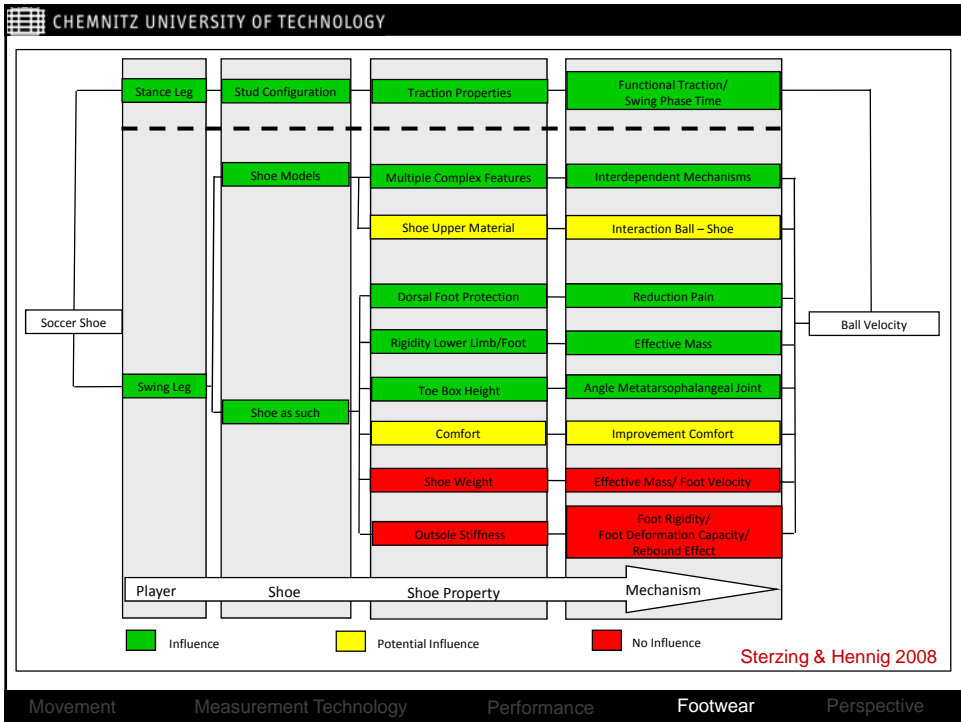
Reduction of „passive, forced plantarflexion“ for barefoot kicks

initial full final

„Passive, forced plantarflexion“ for shod kicks

Lees 1993, Shinkai et al. 2009

Movement Measurement Technology Performance Footwear Perspective



Summary – Kicking Velocity

- Functional, rather than maximal, traction at the support foot is needed.
- Soccer shoes at the kicking foot actually reduces ball velocity.
- Some shoe features influence kicking velocity, others do not.
- Both feet need to be considered for adequate footwear design.



Kicking Foot

Support Foot

Movement

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Kicking Accuracy & Soccer Footwear

Footwear Science
Vol. 2, No. 1, March 2010, 3–11

 Taylor & Francis
Taylor & Francis Group

REVIEW ARTICLE

The influence of soccer shoe design on playing performance: a series of biomechanical studies

Ewald M. Hennig^{a*} and Thorsten Sterzing^b

^aBiomechanics Laboratory, University of Duisburg-Essen, Essen, Germany; ^bDepartment of Human Locomotion,
Chemnitz University of Technology, Chemnitz, Germany

(Received 11 October 2009; final version received 10 February 2010)

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Kicking Accuracy

Chu-Young Park (South Korea) – World Cup 2010: Uruguay vs. South Korea (2-1)

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Kicking Accuracy – Benefit Hypotheses

- **Shape:**
Homogenous pressure distribution between ball and shoe
- **Friction:**
High friction between ball and shoe
- **Spin:**
Spin production allows stable flight path
- **Ball Sensing:**
Better ball sensing
- **Shoe Weight:**
Larger moment of inertia results in more stable swing leg path
- **Support foot stability:**
Enhancement of kicking foot movement control

Hennig & Sterzing 2010

Movement Measurement Technology Performance Footwear Perspective

Set-up

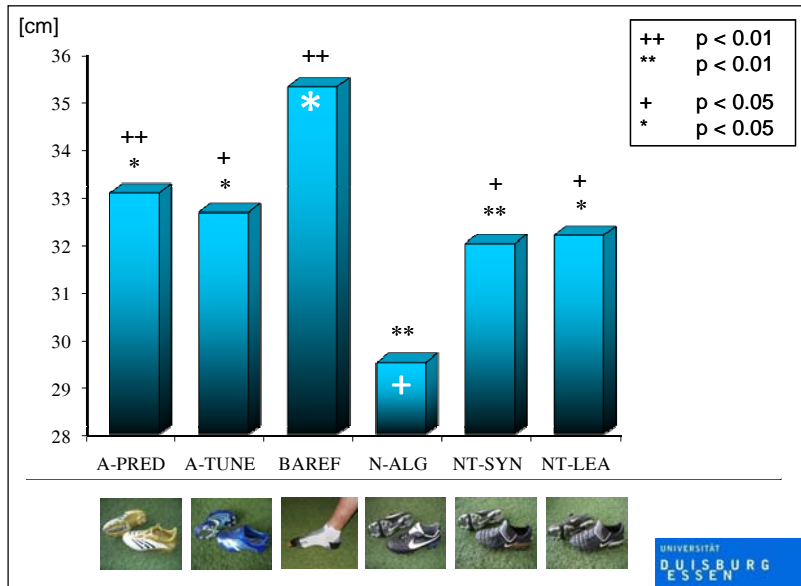


- Circular electronic target (concentric wire frame)
- Ball contact generates electrostatic charges
- Software based determination of ball impact location

Footwear Conditions



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DUISBURG
ESSEN



Discussion: Barefoot vs. Shod Kicks

- Bony structures of the foot may create pressure peaks not allowing a homogenous pressure distribution between ball and foot.
- Shoe upper material may provide an interface providing more homogenous pressure distribution between foot and ball.



Polyurethane soft foam
10 Shore A, 6 mm



Dr. Scholl Silicone Gel Pads

Follow-up Study: Foot Padding

Instep Kicks



Side Foot Kicks



Implementation of Knowledge into Products

provided by Nike Inc., USA



Nike Laser Elite Series
T90 Laser

Soccer shoe specifically designed to enhance accuracy by even pressure

- shape correcting foam inside the shoe
- flat shot shield on top at ball contact area for a full instep kick

Movement

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Research Perspective

Siphiwe Tshabalala (South Africa) – World Cup 2010: South Africa vs. Mexico (1-1)

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Research Perspective

Maicon (Brazil) – World Cup 2010 Brazil vs. North Korea (2-1)

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Research Perspective

Luis Fabiano (Brazil) – World Cup 2010: Brazil vs. Ivory Coast (3-1)

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Research Perspective

Andrés Iniesta (Spain) – World Cup 2010: Netherlands vs. Spain (0-1)

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Status Quo: Review Articles 2007 - 2010

Journal of Sports Science and Medicine (2007) 6, 134-143
http://www.jssm.org

Review article

Biomechanical characteristics and determinants of instep soccer kick

Eleftherios Kellis and Athanasios Katis
Laboratory of Neuromuscular Control and Therapeutic Exercise, Department of Physical Education and Sports Sciences at Serres, Aristotle University of Thessaloniki

The Influence of Soccer Shoes on Kicking Velocity in Full-Instep Kicks

Thorsten Sterzing¹ and Ewald M. Hennig²

¹Department of Human Locomotion, Institute of Sports Science, Chemnitz University of Technology, Chemnitz, and ²Biomechanics Laboratory, School of Sport Science, University of Duisburg-Essen, Essen, Germany

Footwear Science
Vol. 2, No. 1, March 2010, 3-11

STERZING, T., and E.M. HENNING. 2010. The influence of soccer shoe design on playing performance: a series of biomechanical studies. *Footwear Science*, Vol. 2, No. 1, March 2010, 3-11.

REVIEW ARTICLE

The influence of soccer shoe design on playing performance: a series of biomechanical studies

Ewald M. Hennig^{1*} and Thorsten Sterzing²

¹Biomechanics Laboratory, University of Duisburg-Essen, Essen, Germany; ²Department of Human Locomotion, Institute of Sports Science, Chemnitz University of Technology, Chemnitz, Germany

Journal of Sports Sciences, June 2010; 28(6): 805-817

The biomechanics of kicking in soccer: A review

A. LEES¹, T. ASAI², T. B. ANDERSEN³, H. NUNOME⁴, & T. STERZING⁵

¹Research Institute for Sport and Exercise Sciences, Liverpool John Moores University, Liverpool, UK; ²Institute of Health and Sports Science, University of Tsukuba, Tsukuba, Japan; ³Department of Sport Science, University of Aarhus, Aarhus, Denmark; ⁴Research Centre for Health, Physical Fitness and Sports, Nagoya University, Nagoya, Japan and ⁵Institute for Sports Science, Chemnitz University of Technology, Chemnitz, Germany

Movement Measurement Technology Performance Footwear Perspective

Future Directions

- Kicking analysis of non-stationary balls (rolling, bouncing balls)
- Gender
- Ball construction
- Determination of performance influencing variables



University of Nagoya, Japan

Movement

Measurement Technology

Performance

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Thank you very much for your attention!

