SPECIAL INSIGHTS INTO PHYSIOLOGY OF TENNIS
Alexander Ferrauti
SPECIAL INSIGHT INTO PHYSIOLOGY OF TENNIS

Book of Abstracts

22nd annual Congress of the
EUROPEAN COLLEGE OF SPORT SCIENCE
SPORT SCIENCE IN A METROPOLITAN AREA
5th - 8th July 2017

Book of Abstracts

Edited by:
Ferrauti, A., Pfaffen, R., Giersberger-Seidenflecker, E., Joliner, T.,
Bartmus, U., Becher, L., De Marees, M., Muhlbauer, I.,
Schouette, A., Wiewelhove, T., Solekidis, E.

6th World Congress of Racket Sport Science

Prof. Dr. Alexander Ferrauti
SPECIAL INSIGHT INTO PHYSIOLOGY OF TENNIS

6th World Congress of Racket Sport Science

Prof. Dr. Alexander Ferrauti
International Master Degree: *Sport Exercise & Health Sciences* (M. Sc.)
Enrollment until 15th July 2018
SPECIAL INSIGHTS INTO PHYSIOLOGY OF TENNIS

Alexander Ferrauti

1. PHYSIOLOGY OF TENNIS MATCH PLAY
2. PHYSIOLOGY OF TENNIS ON-COURT DRILLS
3. PHYSICAL FITNESS TESTING & TRAINING
4. CHO, CAFFEINE & CREATINE SUPPLEMENTATION
5. TRANSFER TO BADMINTON & TABLE TENNIS
1 PHYSIOLOGY OF TENNIS MATCH PLAY

6th World Congress of Racket Sport Science

Prof. Dr. Alexander Ferrauti
Physiological responses in tennis and running with similar oxygen uptake
1 PHYSIOLOGY OF TENNIS MATCH PLAY

Energy metabolism and oxygen kinetics differ extremely between running and tennis.

LAUFEN
W.R. (VO2 = 1,695 l/min)

TENNIS
W.R. (VO2 = 1,737 l/min)
1  PHYSIOLOGY OF TENNIS MATCH PLAY

**SPECIAL INSIGHT INTO PHYSIOLOGY OF TENNIS**

---

**Running**

- 0 min: 8.3 ng/ml
- 120 min: 15.0 ng/ml

**Tennis**

- 0 min: 8.8 ng/ml
- 120 min: 31.7 ng/ml

**Significance:**

- **:** p < 0.01

---

Prof. Dr. Alexander Ferrauti

6th World Congress of Racket Sport Science

RUHR-UNIVERSITÄT BOCHUM
1 PHYSIOLOGY OF TENNIS MATCH PLAY

(Ferrauti et al. 2002)
1 PHYSIOLOGY OF TENNIS MATCH PLAY

(Ferrauti et al. 2002)
1 PHYSIOLOGY OF TENNIS MATCH PLAY

**(Ferrauti et al. 2002)**

![Graph showing fat oxidation during running and tennis](image)

- **Fat oxidation [kcal/min]**
- **Fat oxidation [%]**
- **n=12**
- **[min]**

Running vs. Tennis:
- Fat oxidation [kcal/min]
- Fat oxidation [%]

(Ferrauti et al. 2002)
1 PHYSIOLOGY OF TENNIS MATCH PLAY
THE PHYSIOLOGICAL DEMANDS OF HITTING AND RUNNING IN TENNIS ON DIFFERENT SURFACES

JAIMÉ FERNANDEZ-FERNANDEZ, VANESSA KINNER, AND ALEXANDER FERRAUTI

Department of Coaching Science, Faculty of Sports Science, Ruhr-University, Bochum, Germany
BH max (112 km/h)  

FH max (121 km/h)
energy demands of hitting

n=12 male players (23.9 ± 2.5 yrs; 186 ± 5 cm; 79.9 ± 5.9 kg)

(Fernandez-Fernandez et al. 2010)
1 PHYSIOLOGY OF TENNIS MATCH PLAY

6th World Congress of Racket Sport Science

Prof. Dr. Alexander Ferrauti
1 PHYSIOLOGY OF TENNIS MATCH PLAY

**Ground contact times [s]**

**Clay**

- B: 0.33 ± 0.01
- S: 0.92 ± 0.02
- 1: 0.47 ± 0.03
- 2: 0.23 ± 0.01
- 3: 0.25 ± 0.02
- 4: 0.20 ± 0.01

**Carpet**

- B: 0.35 ± 0.01
- S: 0.47 ± 0.02
- 1: 0.38 ± 0.03
- 2: 0.24 ± 0.01
- 3: 0.24 ± 0.02
- 4: 0.22 ± 0.01

---

6th World Congress of Racket Sport Science

Prof. Dr. Alexander Ferrauti
R. Federer (SUI) – R. Nadal (ESP)

5:7/6:4/6:7
Urine catecholamine concentrations and psychophysical stress in elite tennis under practice and tournament conditions

A. Ferrauti, G. Neumann, K. Weber, J. Keul*
1 PHYSIOLOGY OF TENNIS MATCH PLAY

**Epinephrine [µg/100 mg creat]**

- **Training**: 0.97
- **Tournament**: 3.66

**Energetic Drive**

- **Training**: 6.3
- **Tournament**: 7.7

**Glucose [mg/dl]**

- **Training**: 93.9
- **Tournament**: 134.2

**Blood Lactate [mmol/l]**

- **Training**: 1.6
- **Tournament**: 3.1

(Ferrauti et al. 2001)
Blood Lactate Values during Match Play

- **Training n=63/10**: Maximum: TO: 8.0, TR: 6.1 mmol/l
- **Tournament n=70/10 players**: Maximum: TO: 21.4, TR: 11.1%

- **>4 mmol/l**: TO: 21.4, TR: 11.1%
rally patterns influence LA concentration
n=6 male players (22.3±2.1 yrs; 182±6 cm; 74.9±5.1 kg)
rally patterns influence LA concentration

n=6 male players (22.3±2.1 yrs; 182±6 cm; 74.9±5.1 kg)

LA [mmol/l]

BW 6 s intensive 20 s rest
BW 24 s intensive + 20 s rest
4.5 mmol/l
1.0 mmol/l
rally patterns influence LA concentration

n=6 male players (22.3±2.1 yrs; 182±6 cm; 74.9±5.1 kg)
pre start nervousness

(n=26 tournament players)

- pre evening: 2.35 (very low)
- next morning: 5.08 (very high)
- warm-up: 4.85
- start match play: 4.02
- end 1. set: 4.46
- own match point: 6.67 (very high)
- match point opponent: 3.94

(Ferrauti 1999)
**Post Exercise Urine Catecholamines**

(n=26 tournament players)

\[ y = 6.835 - 0.651 \times \]

\[ r = -0.595 ** \]

(Ferrauti et al. 2001)
post exercise urine catecholamines

(n=26 tournament players)

(Ferrauti et al. 2002)
Estimating external loads and internal demands by positioning systems and innovative data processing approaches during intermittent running activities in team and racquet sports

Matthias W. Hoppe, Christian Baumgart, Jürgen Freiwald
University of Wuppertal, Department of Movement and Training Science, Wuppertal, Germany
PHYSIOLOGY OF TENNIS MATCH PLAY

![Graph showing EE (J·kg⁻¹) vs. Time (min) with lines for Total, Aerob, and Anaerob with EE values of 2383 kJ, 70.9%, and 29.1% respectively.]
2 PHYSIOLOGY OF TENNIS ON-COURT DRILLS

RUHR-UNIVERSITÄT BOCHUM

6th World Congress of Racket Sport Science

Prof. Dr. Alexander Ferrauti
blood lactate in tennis drills

- 8 x 4 x 4 fh-winner
- baseliner 2 players
- 3 x 8 x 1 sprint
- baseliner 1 player
- 4 x 4 x 8 fh-winner
- 3 x 4 x 12 fh-winner
- baseliner 1 defensive
- 4 x 4 x 4 fh/bh-drill
- 3 x 8 x 2 sprints
- 3 x 4 x 6 fh/bh-drill

LA [mmol/l⁻¹]

The effect of recovery duration on running speed and stroke quality during intermittent training drills in elite tennis players

ALEXANDER FERRAUTI,¹* BABETTE M. PLUIM² and KARL WEBER¹

¹Institute of Sports Games, German Sport University Cologne, Carl-Diem-Weg 6, D-50933 Cologne, Germany and ²Royal Netherlands Lawn Tennis Association, Displayweg 4, 3821 BT Amersfoort, The Netherlands
exercise: passing-shot sprints (t₁, t₂, t₃)
2 PHYSIOLOGY OF TENNIS ON-COURT DRILLS

ANOVA

rest p = 0.001 **
sprints p = 0.019 *
rest x sprints p = 0.039 *

blood lactate

[mmol/l]

passing-shot sprints

10 s rest

15 s rest
2 PHYSIOLOGY OF TENNIS ON-COURT DRILLS

running speed ($t_3$)

- $10$ s rest
- $15$ s rest

passing-shot sprints

<table>
<thead>
<tr>
<th></th>
<th>1-5</th>
<th>6-10</th>
<th>11-15</th>
<th>16-20</th>
<th>21-25</th>
<th>26-30</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.30</td>
<td>1.35</td>
<td>1.40</td>
<td>1.45</td>
<td>1.50</td>
<td>1.55</td>
</tr>
<tr>
<td>$15$ s</td>
<td>1.30</td>
<td>1.35</td>
<td>1.40</td>
<td>1.45</td>
<td>1.50</td>
<td>1.55</td>
</tr>
</tbody>
</table>
V stroke

[km/h]

passing-shot sprints

10 s rest

15 s rest

90 100 110 120 130

1-5 6-10 11-15 16-20 21-25 26-30

10 s rest

15 s rest
Tips for Coaches

- there is no „good“ or „bad“ drill, but a „wrong“
- define training goal before constructing drills
- adjust intensity, duration and recovery according to the goals
- establish feedback agreements with players
- Attention!
  Coaches usually underestimate intensity
3 PHYSICAL FITNESS TESTING & TRAINING

SPECIAL INSIGHT INTO PHYSIOLOGY OF TENNIS

PHYSICAL FITNESS TESTING & TRAINING

RUHR-UNIVERSITÄT BOCHUM

6th World Congress of Racket Sport Science

Prof. Dr. Alexander Ferrauti
SCHWERPUNKT / ORIGINALARBEIT

Conception for Fitness Testing and individualized training programs in the German Tennis Federation

Alexander Ulbricht, Jaime Fernandez-Fernandez, Alexander Ferrauti
Department of Training and Exercise Science, Faculty of Sports Science, Ruhr-University Bochum, Germany
The Hit & Turn Tennis Test: An acoustically controlled endurance test for tennis players

ALEXANDER FERRAUTI, VANESSA KINNER, & JAIME FERNANDEZ-FERNANDEZ

Department of Coaching Science, Faculty of Sports Science, Ruhr Universität Bochum, Bochum, Germany
3 PHYSICAL FITNESS TESTING & TRAINING

HIT AND TURN
TENNIS TEST

Ein akustisch gesteueter Ausdauertest für Tennisspieler zur Ableitung der maximalen Sauerstoffaufnahme
**Hit & Turn Tennis Test (HTT)**

- Translation of the multistage 20 m shuttle run test (Léger et al. 1988) on tennis demands.
  - The Hit and Turn Tennis test is an acoustically controlled and progressive Fitness Test.
  - The test can be easily carried out with a racket on a tennis court by one or more players at the same time.
  - The object of the test is to follow as long as possible the audible signals and to hold up the required footwork.
  - The player has to run along the base line and to hit a forehand or backhand shot in the respective corners just in time with the signals.
  - The maximum achieved test level is assessed and can be used to estimate the maximum oxygen uptake.

*developed by Ruhr-University Bochum (2008)*

*under support of ITF and DTB*

contact: alexander.ferrauti@rub.de

© 2008 Prof. Dr. Alexander Ferrauti, Ruhr-University Bochum, Faculty of Sport Science
HTT test materials
### 3 PHYSICAL FITNESS TESTING & TRAINING

<table>
<thead>
<tr>
<th>n=12 regional players</th>
<th>VO(_2) peak</th>
<th>L(_4) mmol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carpet/Carpet</td>
<td>0.942**</td>
<td>0.848**</td>
</tr>
<tr>
<td>Carpet/Clay</td>
<td>0.713**</td>
<td>0.880**</td>
</tr>
<tr>
<td>Validity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HTT/Ballmachine Test</td>
<td>0.961**</td>
<td>0.756**</td>
</tr>
<tr>
<td>HTT/Treadmill Test</td>
<td>0.619 *</td>
<td>0.617 *</td>
</tr>
</tbody>
</table>

**NR (n=14) \( f(x)=2.0x + 30.0 \ \{8,16\} \)**

**RR (n=13) \( f(x)=1.2x + 40.0 \ \{8,12\} \)**

**VO\(_2\) [mmol·min\(^{-1}\)·kg\(^{-1}\)]**

Level: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16
### Norm Values for Male Tournament Players

<table>
<thead>
<tr>
<th>VO$_{2\text{est}}$ [ml/min/kg]</th>
<th>Strokes</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td>4.9</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>4.8</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>4.7</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>4.6</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>4.5</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>4.4</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>4.3</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>4.2</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>4.1</td>
<td>46.0</td>
</tr>
<tr>
<td>10</td>
<td>4.0</td>
<td>48.0</td>
</tr>
<tr>
<td>11</td>
<td>3.9</td>
<td>50.0</td>
</tr>
<tr>
<td>12</td>
<td>3.8</td>
<td>52.0</td>
</tr>
<tr>
<td>13</td>
<td>3.7</td>
<td>54.0</td>
</tr>
<tr>
<td>14</td>
<td>3.6</td>
<td>56.0</td>
</tr>
<tr>
<td>15</td>
<td>3.5</td>
<td>58.0</td>
</tr>
<tr>
<td>16</td>
<td>3.4</td>
<td>60.0</td>
</tr>
<tr>
<td>17</td>
<td>3.3</td>
<td>62.0</td>
</tr>
<tr>
<td>18</td>
<td>3.2</td>
<td>64.0</td>
</tr>
<tr>
<td>19</td>
<td>3.1</td>
<td>66.0</td>
</tr>
<tr>
<td>20</td>
<td>3.0</td>
<td>68.0</td>
</tr>
</tbody>
</table>

**Intervall [s]**

- 46.0, 48.0, 50.0, 52.0, 54.0, 56.0, 58.0, 60.0, 62.0, 64.0, 66.0, 68.0, 70.0

**Categories**

- untrained
- bad
- reasonable
- good
- excellent
- international champion
HIGH-INTENSITY INTERVAL TRAINING VS. REPEATED-SPRINT TRAINING IN TENNIS

JAIME FERNANDEZ-FERNANDEZ, RICO ZIMEK, THIMO WIEWELHOVE, AND ALEXANDER FERRAUTI
Department of Training and Exercise Science; Faculty of Sports Science, Ruhr-University Bochum, Bochum, Germany

Journal of Strength and Conditioning Research
© 2012 National Strength and Conditioning Association

VOLUME 26 | NUMBER 1 | JANUARY 2012 |
Fartlek

1. Teil: 76 m 30 s 2,90 m/s
2. Teil: 176 m 45 s 3,88 m/s
3. Teil: 77 m 30 s 2,57 m/s
4. Teil: 59 m 15 s 4,00 m/s
5. Teil: 165 m 30 s 3,50 m/s
6. Teil: 106 m 30 s 3,50 m/s
7. Teil: 115 m 45 s 2,96 m/s
8-10. Teil: 89 m 15 s 6,67 m/s
11. Teil: 290 m 30 s 2,77 m/s

Dauelauf
Sprint
Sidestep
5 week endurance training

(3x60 min/week)
3 PHYSICAL FITNESS TESTING & TRAINING
15 x 30 m intermittent sprint performance

Continuous running

Fartlek

3 PHYSICAL FITNESS TESTING & TRAINING
4 CHO, CREATINE & CAFFEINE SUPPLEMENTATION
Blood glucose responses and incidence of hypoglycaemia in elite tennis under practice and tournament conditions

A Ferrauti\textsuperscript{1}, B M Pluim\textsuperscript{2}, T Busch\textsuperscript{3} & K Weber\textsuperscript{3}

\textsuperscript{1}Ruhr-University Bochum, Faculty for Sports Sciences, Bochum, Germany. \textsuperscript{2}Royal Netherlands Lawn Tennis Association, Amersfoort, Netherlands. \textsuperscript{3}German Sport University Cologne, Institute of Sports Games, Cologne, Germany

Transition rest-play
NL/RL (n=16)

**glucose [mg/dl]**

-30  -5  0  5  10  15  30

**rest**  **match play**

- 84.2
- 84.8
- 92.8
- 79.3
- 74.3
- 75.7
- 87.3

CHO, CREATINE & CAFFEINE SUPPLEMENTATION

**SPECIAL INSIGHT INTO PHYSIOLOGY OF TENNIS**
Do you frequently complain about hypoglycemia in tennis?

men NL/RL (n=59)

Yes 37 (63%)

No 22 (37%)
incidence of hypoglycemia

(n=59 tournament players)
4 CHO, CREATINE & CAFFEINE SUPPLEMENTATION

Team competition

(n=21 tournament players)

Glucose [mg/dl]

1. Match
2. Match

pre match | post warm-up | post match
---|---|---
rest

pre match | post warm-up | post match
---|---|---

**

Match 1: Pre-match glucose levels are significantly lower than post-match levels, indicating a decrease in glucose levels during the match. Post-warm-up glucose levels are also lower than pre-match levels, indicating a recovery period.

Match 2: Similar trends are observed, with a significant decrease in glucose levels during the match and a recovery period post-warm-up.
Metabolic and ergogenic effects of carbohydrate and caffeine beverages in tennis

A. FERRAUTI, K. WEBER, H. K. STRÜDER
1. Increase of intramuscular phosphocreatine concentration (6-12%).
2. Improvement of phosphocreatine resynthesis in case of intermittent work.
3. Increase of body weight (0.5-1.6 kg after 5-7 days)
   - Water retention
   - Activation of muscle contractil protein synthesis
Creatine + training (1 week loading, 4 weeks/0.05 g/kg/day)

Intermittent Sprint Performance

<table>
<thead>
<tr>
<th></th>
<th>Cr+ (n=9)</th>
<th>Cr- (n=14)</th>
<th>Pl+ (n=10)</th>
<th>Pl- (n=9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 m [s] pre</td>
<td>3.15</td>
<td>3.13</td>
<td>3.11</td>
<td>3.13</td>
</tr>
<tr>
<td>20 m [s] post</td>
<td>3.06 **</td>
<td>3.11</td>
<td>3.10</td>
<td>3.14</td>
</tr>
</tbody>
</table>
Creatine + training (1 week loading, 4 weeks/0,05 g/kg/day)

Serve Velocity

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre (km/h)</th>
<th>Post (km/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cr+</td>
<td>165,0</td>
<td>169,1</td>
</tr>
<tr>
<td>Cr-</td>
<td>166,3</td>
<td>168,9</td>
</tr>
<tr>
<td>Pl-</td>
<td>170,0</td>
<td>169,6</td>
</tr>
</tbody>
</table>

Cr+ (n=10) Cr- (n=12) Pl- (n=9)
ORIGINAL ARTICLE

The effects of creatine supplementation on selected factors of tennis specific training

B M Pluim, A Ferrauti, F Broekhof, M Deutekom, A Gotzmann, H Kuipers, K Weber

TOP 10 Males:
28,7 yrs
193,1 cm
87,3 kg
23,4 BMI

TOP 10 Females:
26,0 yrs
177,9 cm
65,8 kg
20,8 BMI

TOP 10 Males:
27,4 yrs
180,7 cm
72,7 kg
22,1 BMI

TOP 10 Females:
23,0 yrs
167,4 cm
58,0 kg
20,9 BMI

TOP 10 Males:
26,6 yrs
176,4 cm
71,2 kg
22,8 BMI

TOP 10 Females:
23,3 yrs
159,6 cm
51,8 kg
20,3 BMI
<table>
<thead>
<tr>
<th></th>
<th>Badminton</th>
<th>Table Tennis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intermittent Work load</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Adrenergic stimulation</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Catecholamine Release</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Hitting Power demands</td>
<td>+/-</td>
<td>-</td>
</tr>
<tr>
<td>Surface differences</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Endurance Specificity</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Training Drill Demands</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Hypoglycemic risk</td>
<td>+</td>
<td>+/-</td>
</tr>
<tr>
<td>CHO Needs</td>
<td>+</td>
<td>+/-</td>
</tr>
<tr>
<td>Caffeine Effects</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Creatine Benefits</td>
<td>+/-</td>
<td>-</td>
</tr>
</tbody>
</table>
5 TRANSFER TO BADMINTON & TABLE TENNIS

FUN

+++  +++  +++

6th World Congress of Racket Sport Science
SPECIAL INSIGHT INTO PHYSIOLOGY OF TENNIS
SPECIAL INSIGHT INTO PHYSIOLOGY OF TENNIS
Call for papers
German Journal of Exercise and Sport Research
Racket and Batting Sports. A multidisciplinary perspective on globally popular lifetime sports.

This thematic issue will contain – but is explicitly not limited to – outstanding contributions to the 6th World Congress of Racket Sport Science, held in Bangkok in 2018. The issue will include original papers and reviews on performance and health related aspects in Badminton, Baseball, Cricket, Golf, Softball, Squash, Table Tennis and Tennis, as well as new racket and batting sport games. Its goal is to combine research perspectives from science and medicine (e.g. physiology and sports medicine, training and exercise science, biomechanics) with those from the humanities (e.g. sport philosophy, sport history, physical education) and from various social and behavioural academic disciplines (e.g. sport sociology, sport psychology, sport management). Six senior action editors
References


Contact:

Ruhr-University Bochum
Germany

alexander.ferrauti@rub.de
SPECIAL INSIGHTS INTO PHYSIOLOGY OF TENNIS
Alexander Ferrauti

Thank you