

SETTORE



TECNICO



# L'Optimal Training-Load nel CALCIO: Evidenze Scientifiche

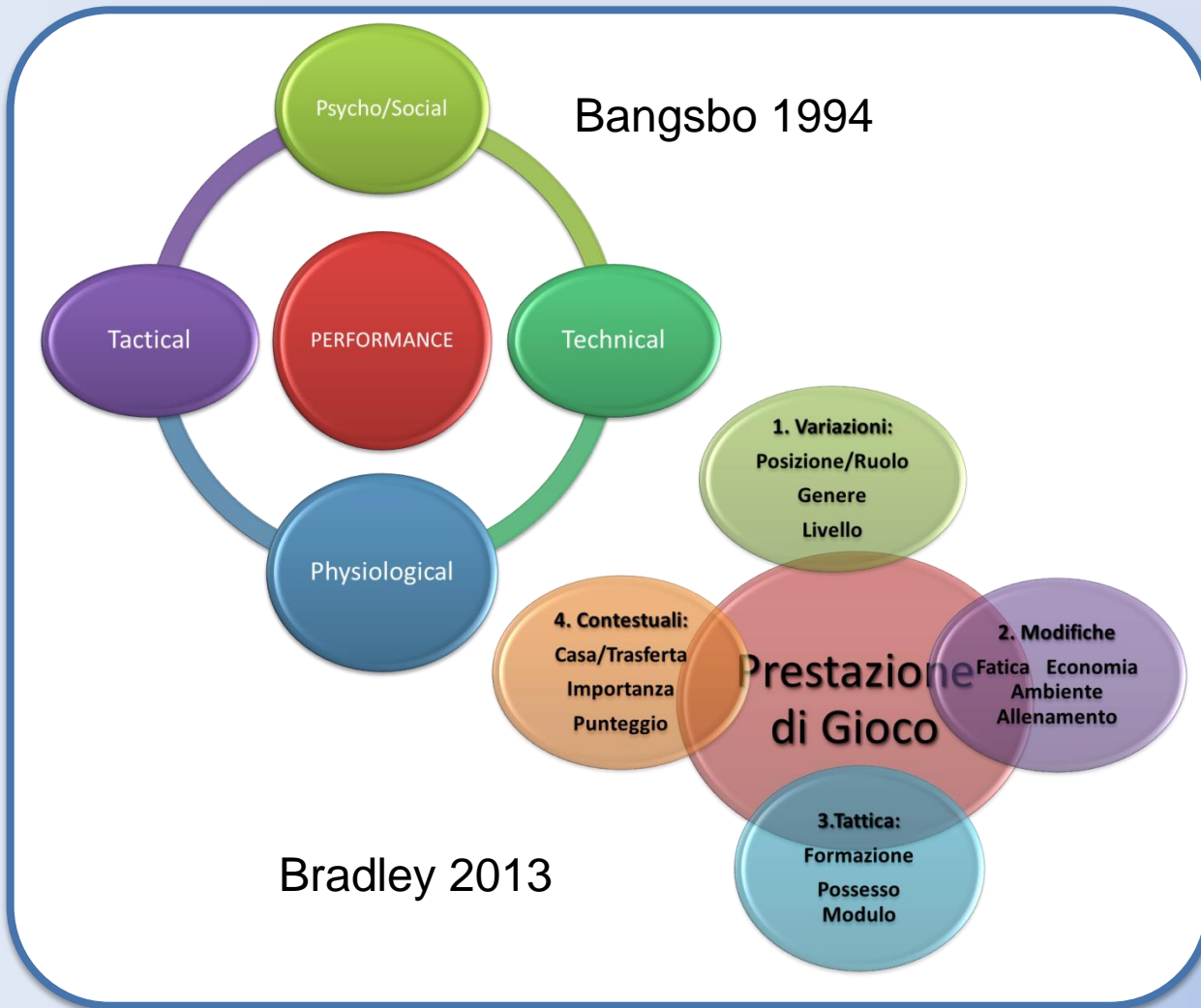
**Carlo Castagna**

**Settore Tecnico FIGC**

**Laboratorio di Metodologia  
e Biomeccanica Applicata al Calcio,  
Coverciano (Firenze)**



# Prestazione Calcistica



# Prestazione Calcistica



Impellizzeri and Marcora 2009

## Theoretical Framework : Football

Football  
Performance

Ranking

Relevant  
Constructs

Technical

Tactical

Physical

Causal Construct  
Indicators

Match  
Hi-Intensity

Causal Variables

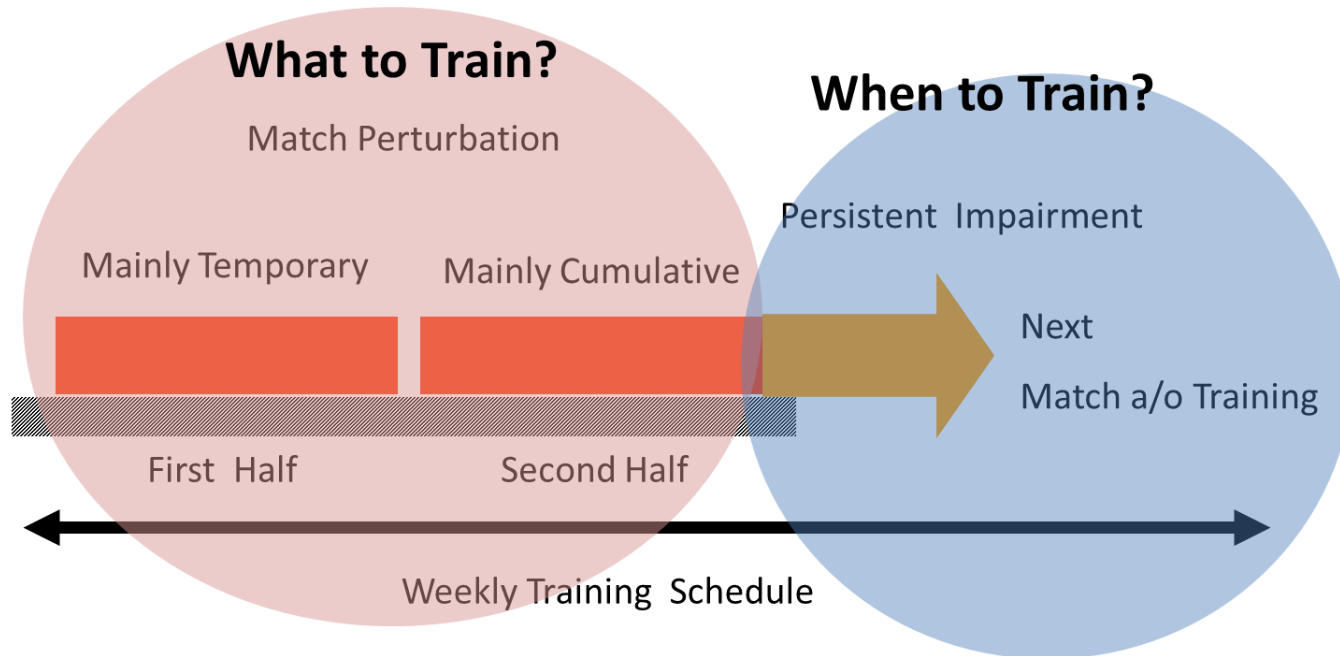
Criterion  
Performance



# Allenamento-Funzionale



## Evidence Based Training Intervention Logic



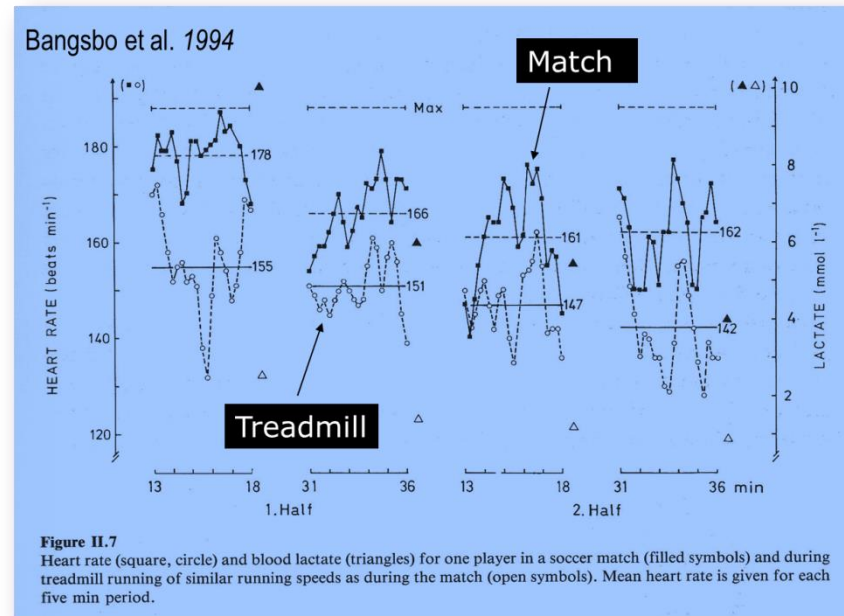
## Richieste:

- $VO_2 \rightarrow 70-80\% VO_{2max}$
- $HR \rightarrow 80-90\% HR_{max}$
- 150-250 Short Hi/Int

## Effetti:

- Phos-Creatine  $\rightarrow$  Glycolisis
- $\downarrow 40-90\%$  [Glycogen]
- $\uparrow$  FFA  $\downarrow$  pH
- $\uparrow$  Glu  $\uparrow$  IMP

Bangsbo et al. 2007



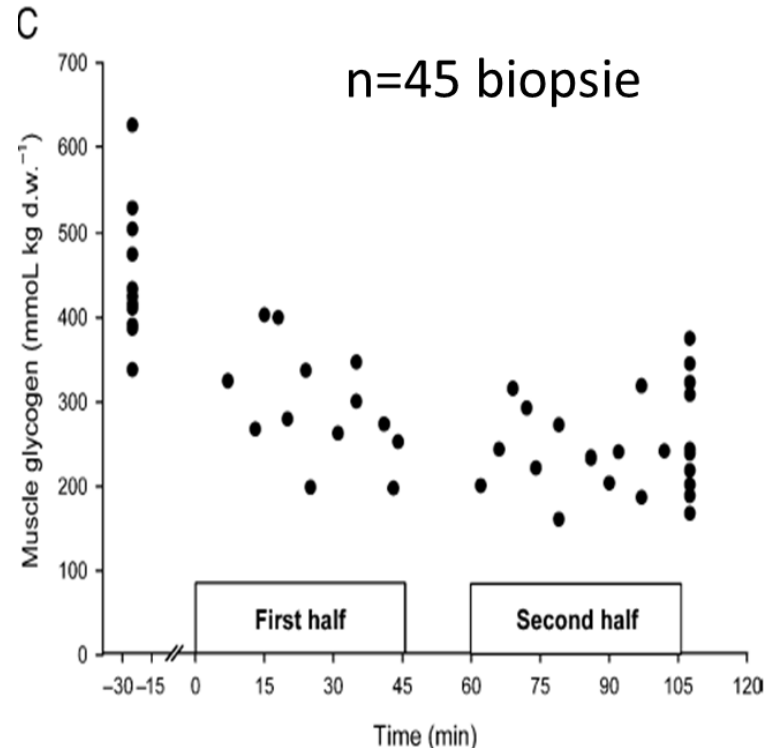
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Bangsbo et al. 2007



# Post-Partita



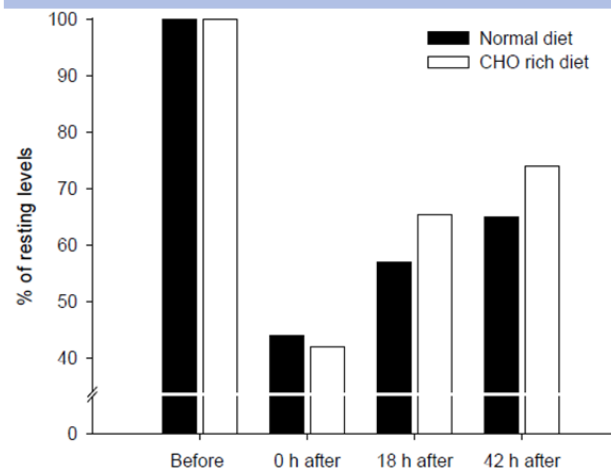
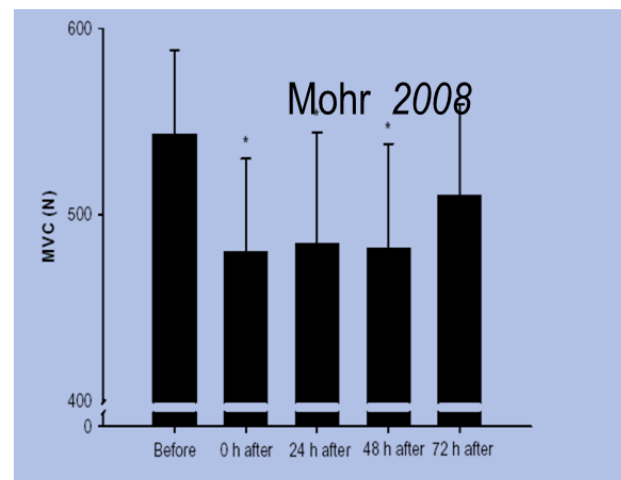
## Decrementi:

- Maximal Strength (MVC)
- Endurance (Yo-Yo IR1)
- Repeated Jumping (CMJ)

## Ripristino:

- [Gly] 24-72h
- MVC 72h
- CMJ 72h

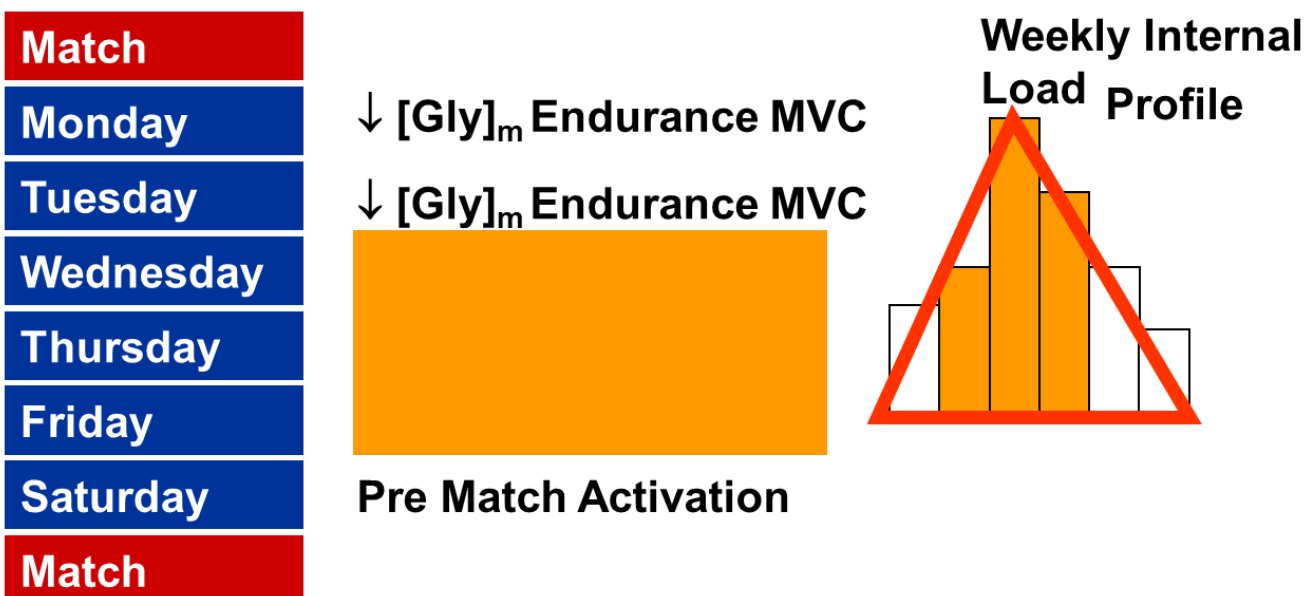
Stølen et al. 2005, Mohr 2008



# Micro-Ciclo Competitivo



## Interventi Post-Match





# Allenamento



**Carico= Volume · Intensità**

Matvedejev 1960; Harre 1972, Banister 1975

**Performance= Fitness-Fatigue**

Banister 1975

Future Aims

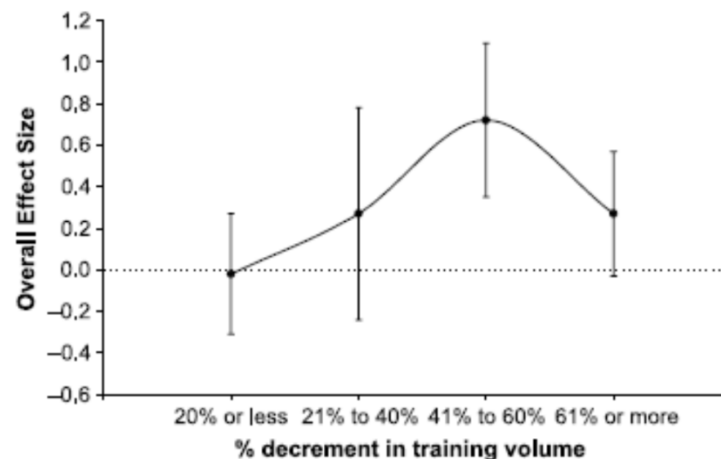
**Personalized Training**

**Improvisation Training**



## Enfasi Metodologica

- Decremento Volume
- Mantenimento Intensità
- Max Performance Gara



Bosquet et al 2007

# Fitness

# - Fatigue

---

# = PERFORMANCE

Banister 1975

**Fitness**  
**- Fatigue**

- Forza
- Agilità
- Funzionalità Aerobica
- RSA
- Speed Endurance

---

**=PERFORMANCE**

Banister 1975

## **Fitness** **- Fatigue**

- Forza
- Agilità
- Funzionalità Aerobica
- RSA
- Speed Endurance
- Over-reaching
- Over-Training
- Tapering
- Detraining

---

**=PERFORMANCE**

Banister 1975

## Fitness - Fatigue

- Forza
- Agilità
- Funzionalità Aerobica
- RSA
- Speed Endurance
- Over-reaching
- Over-Training
- Tapering
- Detraining

**= PERFORMANCE**

- Andamento Gara

Banister 1975

# Controllo Allenamento



## How Much is Enough?

- Cross Sectional Studies
- Longitudinal Studies
- Training Studies

Impellizzeri et al 2006; Bravo et al 2007

Team Studies



## Verifica Miglioramenti

- Longitudinali
- Nella Propria Squadra
- Oggettivando Dosi

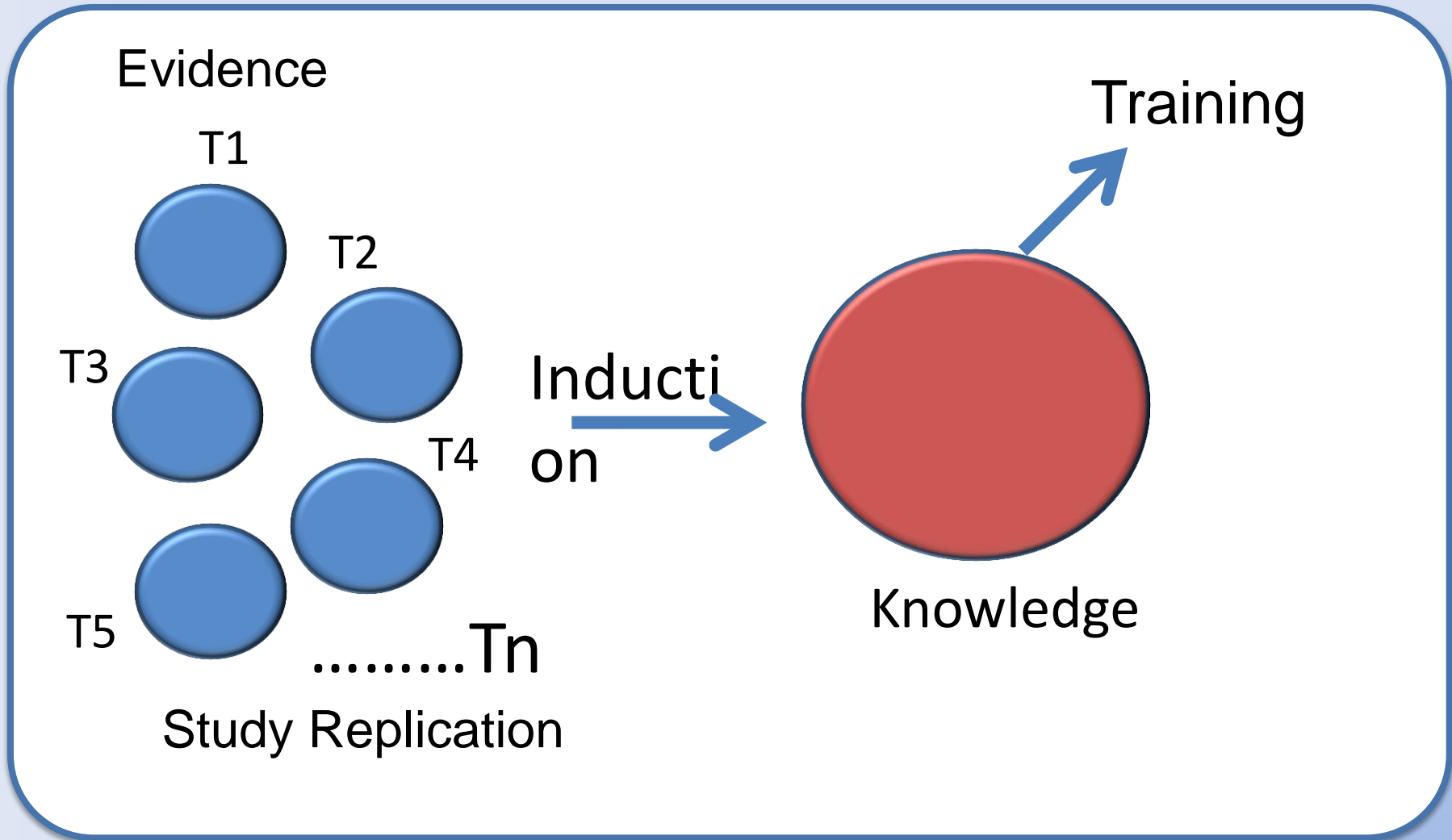
Frequenza Cardiaca

TRIMPi

Session-RPE



# Team-Studies Philosophy



## EFFECT OF TRAINING INTENSITY DISTRIBUTION ON AEROBIC FITNESS VARIABLES IN ELITE SOCCER PLAYERS: A CASE STUDY

CARLO CASTAGNA,<sup>1</sup> FRANCO M. IMPELLIZZERI,<sup>2</sup> ANIS CHAOUACHI,<sup>3</sup> CLAUDIO BORDON<sup>4</sup> AND VINCENZO MANZI<sup>1</sup>

<sup>1</sup>School of Sport and Exercise Sciences, Team-Sports Department, Faculty of Medicine and Surgery, University of Rome Tor Vergata, Rome, Italy; <sup>2</sup>Department of Research and Development, Schülthess Klinik, Zürich, Switzerland; <sup>3</sup>Research laboratory: Sports Performance Optimization, National Center of Medicine and Science in Sports (CNMSS), Tunis, Tunisia; and <sup>4</sup>Palermo Football Club, Palermo, Italy

## PRESEASON VARIATIONS IN AEROBIC FITNESS AND PERFORMANCE IN ELITE-STANDARD SOCCER PLAYERS: A TEAM STUDY

CARLO CASTAGNA,<sup>1</sup> FRANCO M. IMPELLIZZERI,<sup>2</sup> ANIS CHAOUACHI,<sup>3</sup> AND VINCENZO MANZI<sup>1</sup>

<sup>1</sup>Football Training and Biomechanics Laboratory, Italian Football Association (FIGC), Technical Department, Coverciano (Florence), Italy; <sup>2</sup>Neuromuscular Research Laboratory, Schülthess Clinic, Zurich, Switzerland; and <sup>3</sup>Tunisian Research Laboratory "Sport Performance Optimization," National Center of Medicine and Science in Sports (CNMSS), Tunis, Tunisia

## INDIVIDUAL TRAINING-LOAD AND AEROBIC-FITNESS VARIABLES IN PREMIERSHIP SOCCER PLAYERS DURING THE PRECOMPETITIVE SEASON

VINCENZO MANZI,<sup>1</sup> ANTONIO BOVENZI,<sup>2</sup> MARIA FRANCO IMPELLIZZERI,<sup>3</sup> IVAN CARMINATI,<sup>4</sup> AND CARLO CASTAGNA<sup>1,5</sup>

<sup>1</sup>Football Training and Biomechanics Lab, Italian Football Association (FIGC), Technical Department, Coverciano (Florence), Italy; <sup>2</sup>University of Florence, Florence, Italy; <sup>3</sup>Neuromuscular Research Laboratory, Schülthess Clinic, Zurich, Switzerland; <sup>4</sup>Manchester City Football Club, Manchester, United Kingdom; and <sup>5</sup>Marche Regional School of Sport, Italian Olympic Committee (CONI), Ancona, Italy

## Take Home Messages

- Validazione FC
- Validazione TRIMPi
- Intensità Efficace >90% FCmax
- Dose Efficace >500 au Aerobic Fitness
- Dose Efficace >400 au sub-max Aerobic Fitness
- Dose Mantenimento
- Dose Sviluppo 7-10% Carico

# Training Specificity



## COMPARING THE PHYSICAL DEMANDS OF FRIENDLY MATCHES AND SMALL-SIDED GAMES IN SEMIPROFESSIONAL SOCCER PLAYERS

DAVID CASAMICHANA,<sup>1</sup> JULEN CASTELLANO,<sup>1</sup> AND CARLO CASTAGNA<sup>2,3</sup>

<sup>1</sup>Department of Physical Education and Sport, Faculty of Physical Activity and Sport Sciences, University of the Basque Country (UPV-EHU), Vitoria-Gasteiz, Spain; <sup>2</sup>Biomechanics Laboratory, Italian Football Association (FIGC), Technical Department, Coverciano, Italy; and <sup>3</sup>Regional School of Sport of Marche, Italian Olympic Committee (CONI), Ancona, Italy

### Friendly Matches vs SSG

- SSG 3v3, 5v5, 7v7  $\Delta = 210 \text{ m}^2$
- FM  $\Delta = 300 \text{ m}^2$

### Effects

- Sprints 10-40m FM > SSG
- Sprints >40m FM > SSG
- RHIA FM > SSG

### Take Home Messages

- Specificità Scopo Dipendente
- Filosofia di Gioco
- Tipologia Giocatori



# Match Evidence



FIFA®

## Transitions

- All teams used rapid counter-attacks as part of their game
- Thirty-four of the 171 goals scored at the World Cup came from quick transition play or counter-attacks (38 from set pieces)
- Counter-attacking tactics were once a tool in a team's armoury, but now some teams base their entire play around such tactics

# Optimal Loading



- Carico Interno
- Carico Esterno
- Personalized Training
- Improvisation Training
- Session-RPE



# Carico Esterno vs Interno



## RELATIONSHIP BETWEEN INDICATORS OF TRAINING LOAD IN SOCCER PLAYERS

DAVID CASAMICHANA,<sup>1</sup> JULEN CASTELLANO,<sup>1</sup> JULIO CALLEJA-GONZALEZ,<sup>1</sup> JAIME SAN ROMÁN,<sup>1</sup> AND CARLO CASTAGNA<sup>2</sup>

<sup>1</sup>Faculty of Physical Activity and Sport Sciences, University of the Basque Country (EHU/UPV), Vitoria-Gasteiz, Spain; and <sup>2</sup>Football Training and Biomechanics Laboratory, Italian Football Federation (FIGC), Technical Department, Coverciano (Florence), Italy

### ABSTRACT

Casamichana, D, Castellano, J, Calleja-Gonzalez, J, San Román, J, and Castagna, C. Relationship between indicators of training load in soccer players. *J Strength Cond Res* 27(2): 369–374, 2013—This study examined the relationship between work load indicators used to quantify full training sessions in soccer. The participants were 28 semiprofessional male soccer players age  $22.9 \pm 4.2$  years, height  $177 \pm 5$  cm, body mass  $73.6 \pm 4.4$  kg. Players' physical and physiological work load was monitored over 44 training sessions using global positioning system devices (10 Hz) and heart rate, respectively. After each training session, players' training perceived-exertion (rating of perceived exertion [RPE]) was assessed using the Borg CR-10 scale. Players' internal training load was assessed using the session-RPE and the Edwards methods. Total distance, distances covered at arbitrary selected high-intensity speed zones ( $\geq 18$  and  $21 \text{ km}\cdot\text{h}^{-1}$ ), but frequency at speed  $>18$  and  $21 \text{ km}\cdot\text{h}^{-1}$ , and work:rest ratio during training drills were considered as signs of physical work load. Furthermore, player load assumed as reflection of total center-of-mass acceleration was considered as representative of players' external load. Very-large association of player load with Edwards and session-RPE methods was found. Total distance covered was large to very large associated with Player Load, Session-RPE, and Edwards methods. The findings of this study provided evidence for the safe use of session-RPE, Edwards methods, and Players Load as valid indicators of training responses in soccer.

**KEY WORDS** association football, training control, session-RPE, heart rate, GPS technology

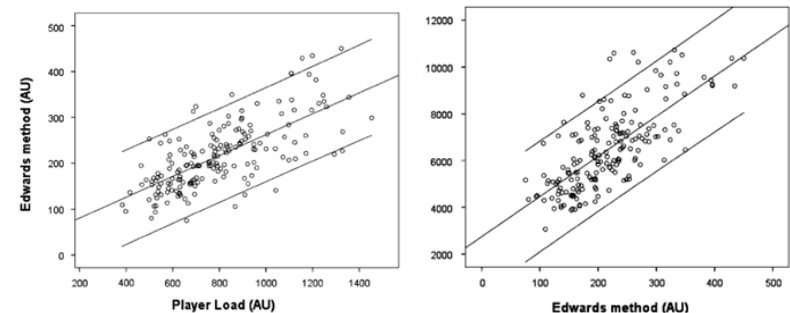
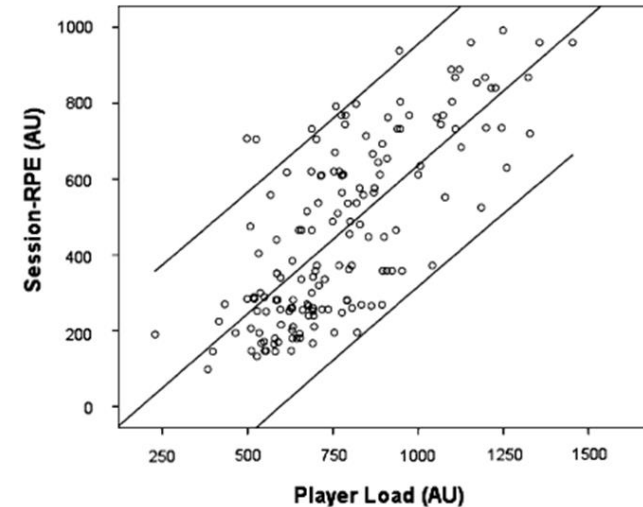
### INTRODUCTION

To develop physical fitness and team skills, an extensive use of group training (i.e., specific training) drills is considered in soccer (13). Specific training in soccer assumes the form of small-sided games using different number of players, pitch dimensions, and game rules to promote the requested adaptations (21). Team-skill training load (TL) quantification is of importance when the objective is to evaluate magnitude compliance between planned and performed training drills. This enables TL to be modulated according to seasonal training aims. This assumes value as efficient training prescription is work load dependent (29).

In soccer, the individual training response (internal load) to a given imposed training program (external load) may result in being different among players, and consequently, training individualization may result problematic (12). Therefore, the development of valid methods for TL assessment is paramount in soccer because extreme training responses may result in training maladaptations and injuries (17,18).

With the aim to profile the internal load, a number of methods have been proposed using effort perception or heart-rate (HR) responses to training (3). Recently, the session-rating of perceived exertion method (sRPE) has been the object of studies that examined its validity assuming as construct HR methods (24), which has been correlated with other internal and external TL (8).

Despite the practical interest provided by these studies, a conclusive response as per sRPE method criterion validity is yet to be reported in soccer. Indeed, HR methods were based on theoretical construct and consequently cannot be considered as TL gold-standard criteria.



# Carico Esterno vs Interno

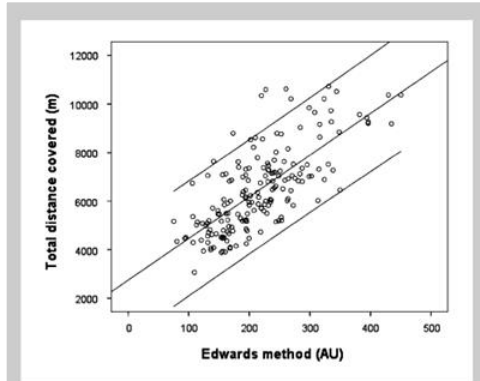


Figure 1. Relationship between the Edwards indicator and the total distance covered for the 210 recordings made ( $r = 0.72$ ;  $p < 0.01$ ). "AU" is arbitrary unit.

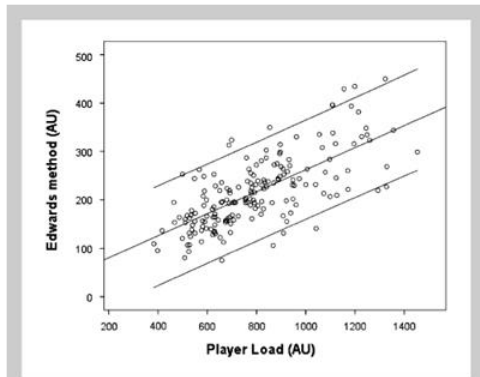


Figure 2. Relationship between player load (determined by accelerometry) and the training load indicator obtained via the Edwards method for the 210 recordings made ( $r = 0.70$ ;  $p < 0.01$ ). "AU" is arbitrary unit.

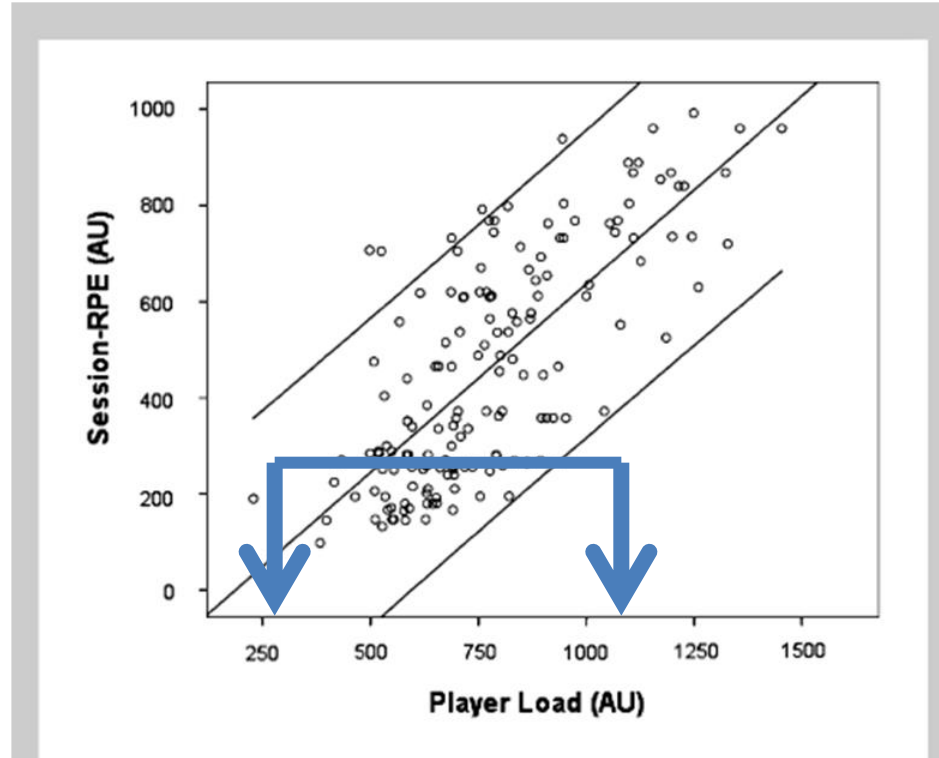


Figure 4. Relationship between player load (determined by accelerometry) and the session-rating of perceived exertion indicator for the 210 recordings made ( $r = 0.74$ ;  $p < 0.01$ ). "AU" is arbitrary unit.

# Optimal Loading



## AEROBIC FITNESS ECOLOGICAL VALIDITY IN ELITE SOCCER PLAYERS: A METABOLIC POWER APPROACH

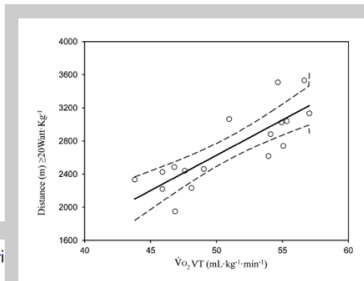
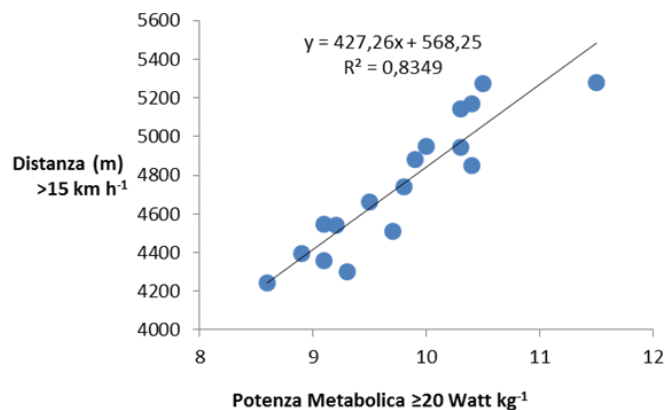
VINCENZO MANZI,<sup>1</sup> FRANCO IMPELLIZZERI,<sup>2</sup> AND CARLO CASTAGNA<sup>1</sup>

<sup>1</sup>Technical Department, Football Training and Biomechanics Laboratory, Italian Football Association (FIGC), Florence, Italy; and <sup>2</sup>Neuromuscular Research Laboratory, Schulthess Clinic, Zurich, Switzerland

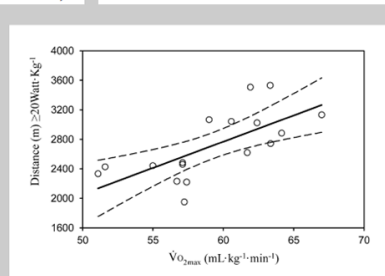
**TABLE 2.** Correlation matrix of the resulting associations among aerobic fitness and the metabolic power categories considered.\*

Variables (W·kg <sup>-1</sup> )	$\dot{V}O_2\text{max}$	$\dot{V}O_2\text{VT}$	% $\dot{V}O_2\text{VT}$	Maximal Aerobic Speed	$V_{L4}$
>20	0.68† (0.30–0.88)	0.83‡ (0.58–0.94)	0.62† (0.20–0.85)	0.72§ (0.36–0.89)	0.73‡ (0.58–0.94)
>35	0.63† (0.22–0.85)	0.79‡ (0.50–0.92)	0.64† (0.23–0.86)	0.64† (0.23–0.86)	0.67† (0.50–0.92)
>55	0.55§ (0.10–0.81)	0.72† (0.37–0.89)	0.65† (0.24–0.86)	0.52§ (0.05–0.80)	0.56§ (0.37–0.89)

\*Data are reported as coefficient of correlation and 95% confidence intervals.  
 † $p < 0.01$ .  
 ‡ $p < 0.001$ .  
 § $p < 0.05$ .



**Figure 2.** Scatter plot of the resulting relationship between distance covered at metabolic power  $\geq 20$   $\text{W}\cdot\text{kg}^{-1}$  and  $\dot{V}O_2\text{VT}$ ;  $r = 0.83$  (95% confidence interval, 0.58–0.94);  $p < 0.0001$ .



**Figure 1.** Scatter plot of the resulting relationship between distance covered at metabolic power  $\geq 20$   $\text{W}\cdot\text{kg}^{-1}$  and  $\dot{V}O_{2\text{max}}$ ;  $r = 0.68$  (95% confidence interval, 0.30–0.88);  $p = 0.0024$ .





## Il Carico Interno ed Esterno nel controllo del 3v3: Studio di un caso.

Carlo Castagna, Vincenzo Manzi 2013

### RISULTATI

- Distanza  $721 \pm 60$  metri
- PM  $11.2 \pm 1.1$  Watt·kg<sup>-1</sup>
- VO<sub>2</sub>  $47.2 \pm 8.1$  ml·kg<sup>-1</sup>·min<sup>-1</sup> (80±10%)
- Stima VO<sub>2</sub>  $33 \pm 3$  ml·kg<sup>-1</sup>·min<sup>-1</sup> (56±7.4%)
- Lattato  $3.7 \pm 2.4$  mmol·l<sup>-1</sup>



Medicine & Science  
IN  
Sports & Exercise

The Official Journal of the American College of Sports Medicine  
[www.acsm-msex.org](http://www.acsm-msex.org)

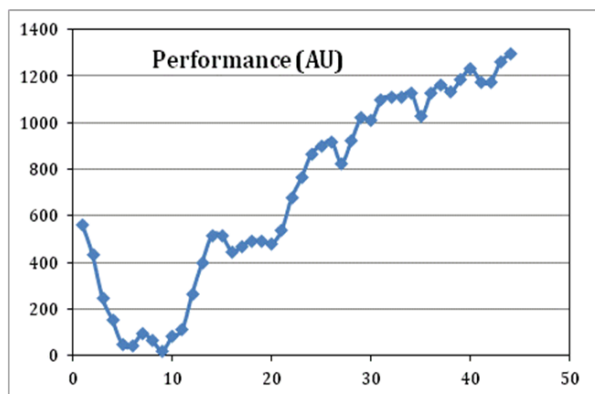
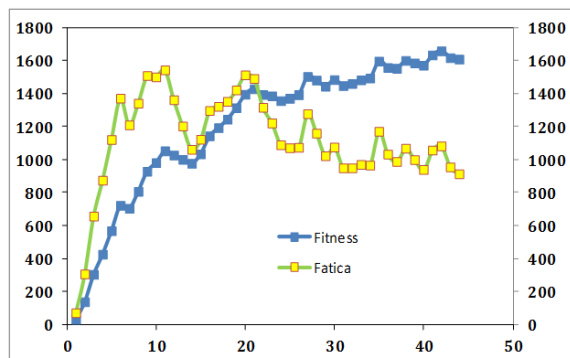
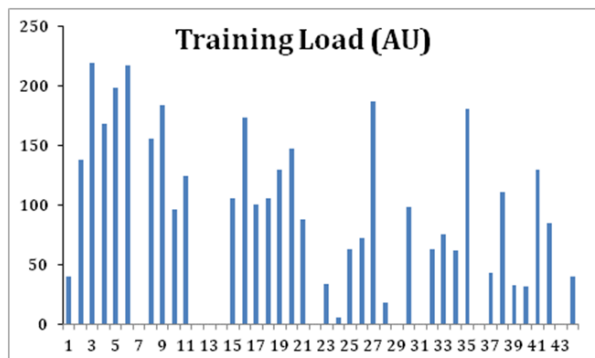
*... Published ahead of Print*

## Measured and Estimated Energy Cost of Constant and Shuttle Running in Soccer Players

Tom Gerardus Antonia Stevens<sup>1</sup>, Cornelis Johannes de Ruiter<sup>1</sup>, David van Maurik<sup>1</sup>, Chris Joannes Wilhelmus van Lierop<sup>1</sup>, Geert Jozef Peter Savelsbergh<sup>1,2</sup>, and Peter Jan Beek<sup>1,3</sup>

**Conclusion** Shuttle running raised the player's energy cost of running compared to constant running at the same average speed. While for constant running actual energy cost was significantly overestimated by di Prampero's approach using LPM data as input, actual energy cost of shuttle running was significantly underestimated.

# Personalized Training



## Best-fit parameter values:

Parameter	Value	Units
$p(0)$	1760	m
$k_1$	0,546	m/AU
$k_2$	0,694	m/AU
$\tau_1$	26	days
$\tau_2$	13	days

Manzi and Castagna., (2013) unPublished

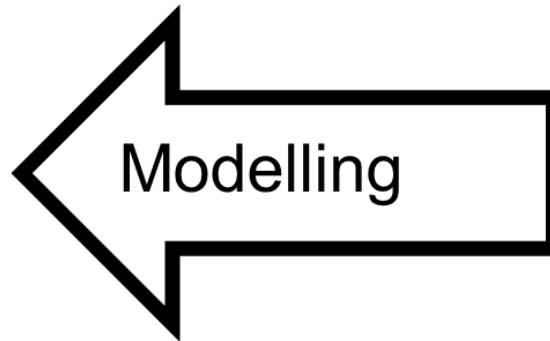
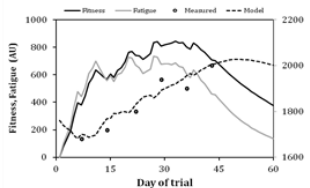
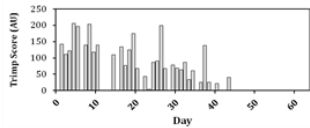
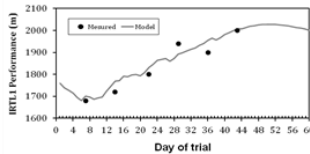
# Personalized Training



Castagna, Giovannelli, Manzi 2014

**Causal Variables**

**Criterion Performance**



**Yo-Yo IR1**

**Yo-Yo IE2**

**Yo-Yo IR2**

**S-SSG**

**Super Small-Sided Games**

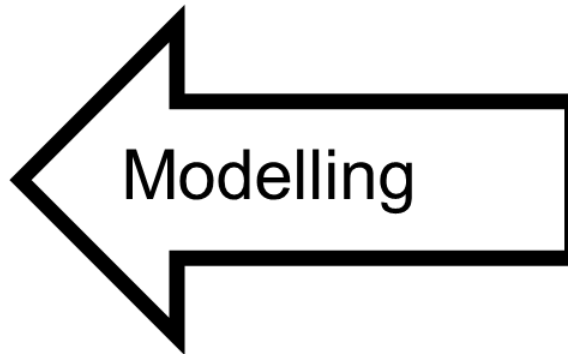
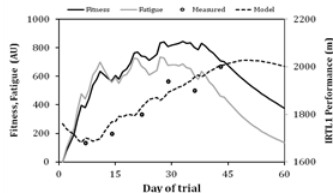
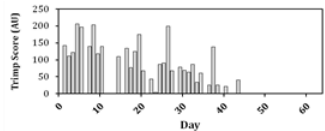
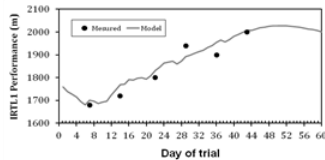
# Personalized Training



Castagna, Giovannelli, Manzi 2014

**Causal Variables**

**Criterion Performance**



**5v5**

**3v3**

**2v2**

**S-SSG**

**$\delta=300\text{m}^2 \text{Plyr}^{-1}$**

# Personalized Training



5vs5

$\delta=300\text{m}^2$

86x 35m



Variable	ICC	TEM CV%
<b>HR (b/min)</b>	0.74 (0,50-0,87)	3 (2,3-4,1)
<b>RPE</b>	0.33 (-0,06 0,63)	10 (7,8-14)
<b>HI (m)</b>	0.84 (0,68-0,93)	17 (12,9-23,7)
<b>MPHI (m)</b>	0.79 (0,59-0,90)	11 (8,5-15,3)
<b>AHI (m)</b>	0.46 (0,09-0,71)	19 (14,84-27,46)
<b>DecHI (m)</b>	0.41 (0,04-0,69)	32.3 (25,12-48,12)
<b>AMP (w/kg)</b>	0.59 (0,28-0,79)	7 (5,58-9,99)
<b>TD (m)</b>	0.65 (0,36-0,83)	6 (4,96-8,85)

# Improvisation Training



## Scala di Börg CR10

TRAINING	RPE	ANCORA	%FCMAX	LATTATO
Riposo	0	ASSENTE	30	1,0
	0,3			
Rigenerazione	0,5	ESTREMAMENTE LIEVE	75	1,2
	0,7	APPENA PERCEPIBILE		
Riscaldamento @ Jogging	1	MOLTO LIEVE	80	1,5
	1,5			
	2	LIEVE	84	1,7
Soglia Aerobica—Lattato	2,5	LEGGERO		
	3	MODERATO	88	2,5
	4			3,5
OBLA	5	FORTE	93	4,5
	6	INTENSO		5,1
	7	MOLTO FORTE	97	6,0
vVO <sub>2</sub> max	8		98	8,8
Speed Endurance -RSA	9		100	8,9
All-out	10	ESTREMAMENTE FORTE	100	9,0
Esaurimento — Gara	11	"MASSIMO"		
	§			
	#	MASSIMO IN ASSOLUTO	MASSIMO PENSABILE	

# Improvisation Training



## Scala di Börg CR10 x Session-RPE

Days	RPE-T	RPE-M	% $\Delta$
<b>1</b>	2.7	2.6	4
<b>2</b>	7.5	7.3	3
<b>3</b>	3.5	3.7	-6
<b>4</b>	4.0	3.6	10
<b>5</b>	3.5	3.4	4

Castagna 2013





## Qualità Globale del Recupero (QGR10)

QGR10	
VALORE	ANCORA
0	NON HO RECUPERATO AFFATTO
0,3	
0,5	RECUPERO MOLTO MOLTO SCARSO
0,7	
1	RECUPERO MOLTO SCARSO
1,5	
2	RECUPERO SCARSO
2,5	
3	RECUPERO MODERATO
4	
5	RECUPERO BUONO
6	
7	RECUPERO MOLTO BUONO
8	
9	
10	RECUPERO COMPLETO

«Quale è il tuo stato di recupero questa mattina? Usa questa scala per graduarla...»

Castagna Manzi 2013

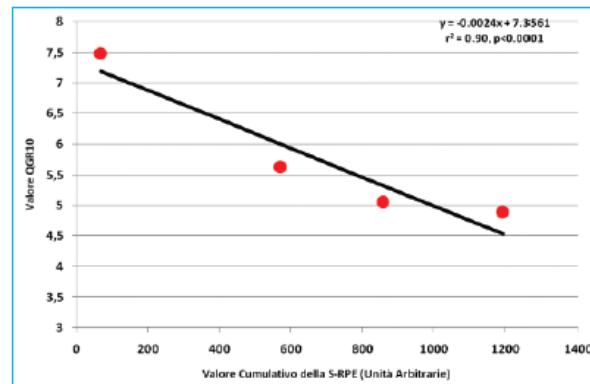


FIGURA 3. Associazione tra i valori del QGR10 e quelli delle corrispondenti S-RPE cumulative (4 raffronti), nel corso del raduno atletico (n=78).

# Improvisation Training



TReS	
0	RIPOSO ASSOLUTO
0,3	
0,5	ESERCIZI di RIGENERAZIONE
0,7	
1	ALLENAMENTO a INTENSITÀ MOLTO BASSA
1,5	
2	ALLENAMENTO BASSA INTENSITÀ
2,5	
3	ALLENAMENTO A INTENSITÀ MODERATA
4	
5	ALLENAMENTO A ALTA INTENSITÀ
6	
7	ALLENAMENTO A INTENSITÀ MOLTO ALTA
8	
9	
10	PRONTO PER LA COMPETIZIONE

## TReS 10

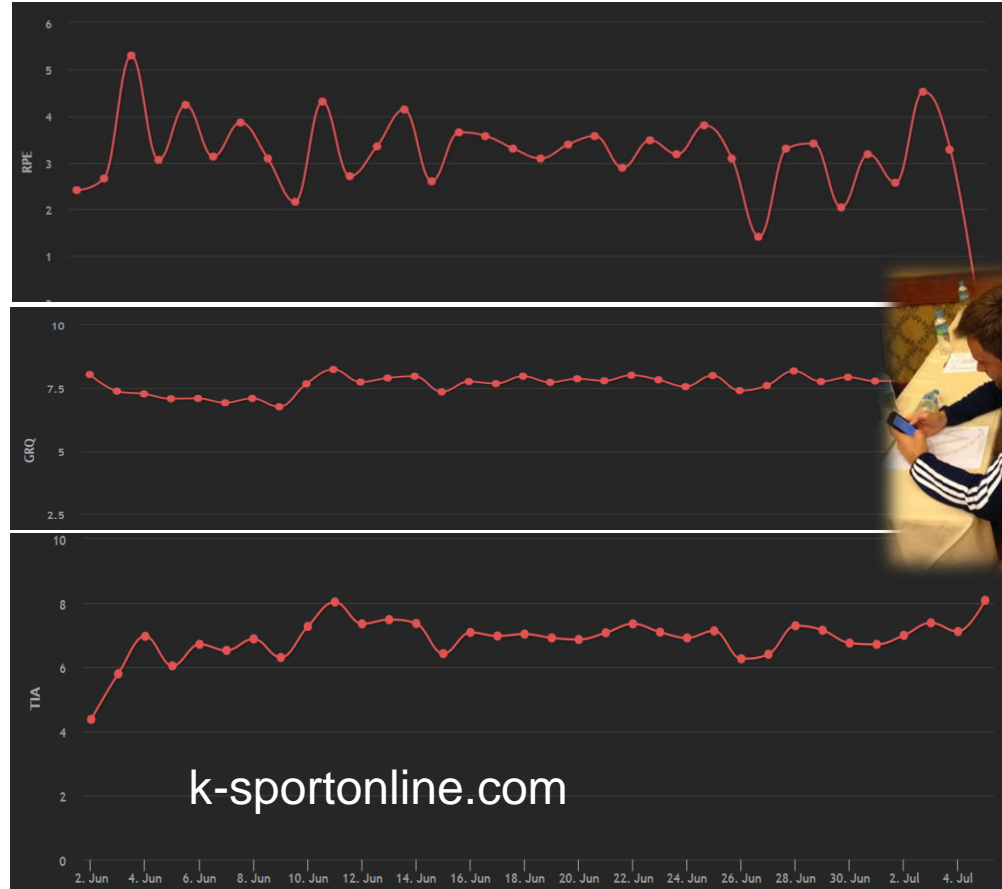




FIFA WORLD CUP  
Brasil



# Optimal Loading: Morning Check



k-sportonline.com

# Optimal-Load nel Calcio: Evidenze



**GRAZIE PER  
L'ATTENZIONE**

