

Swarup Mukherjee

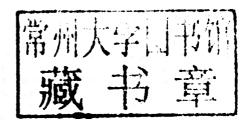
Repeated high-intensity running in youth professional soccer players

Assessment and evaluation of the indicators



Repeated high-intensity running in youth professional soccer players

Assessment and evaluation of the indicators



VDM Verlag Dr. Müller

Swarup Mukherjee

Repeated high-intensity running in youth professional soccer players

Impressum/Imprint (nur für Deutschland/ only for Germany)

Bibliografische Information der Deutschen Nationalbibliothek: Die Deutsche Nationalbibliothek verzeichnet diese Publikation in der Deutschen Nationalbibliografie; detaillierte bibliografische Daten sind im Internet über http://dnb.d-nb.de abrufbar.

Alle in diesem Buch genannten Marken und Produktnamen unterliegen warenzeichen-, markenoder patentrechtlichem Schutz bzw. sind Warenzeichen oder eingetragene Warenzeichen der jeweiligen Inhaber. Die Wiedergabe von Marken, Produktnamen, Gebrauchsnamen, Handelsnamen, Warenbezeichnungen u.s.w. in diesem Werk berechtigt auch ohne besondere

Kennzeichnung nicht zu der Annahme, dass solche Namen im Sinne der Warenzeichen- und Markenschutzgesetzgebung als frei zu betrachten wären und daher von jedermann benutzt werden dürften.

Coverbild: www.ingimage.com

Verlag: VDM Verlag Dr. Müller Aktiengesellschaft & Co. KG Dudweiler Landstr. 99, 66123 Saarbrücken, Deutschland Telefon +49 681 9100-698, Telefax +49 681 9100-988

Email: info@vdm-verlag.de

Herstellung in Deutschland: Schaltungsdienst Lange o.H.G., Berlin Books on Demand GmbH, Norderstedt Reha GmbH, Saarbrücken Amazon Distribution GmbH, Leipzig

ISBN: 978-3-639-26951-2

Imprint (only for USA, GB)

Bibliographic information published by the Deutsche Nationalbibliothek: The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data are available in the Internet at http://dnb.d-nb.de.

Any brand names and product names mentioned in this book are subject to trademark, brand or patent protection and are trademarks or registered trademarks of their respective holders. The use of brand names, product names, common names, trade names, product descriptions etc. even without a particular marking in this works is in no way to be construed to mean that such names may be regarded as unrestricted in respect of trademark and brand protection legislation and could thus be used by anyone.

Cover image: www.ingimage.com

Publisher: VDM Verlag Dr. Müller Aktiengesellschaft & Co. KG Dudweiler Landstr. 99, 66123 Saarbrücken, Germany Phone +49 681 9100-698, Fax +49 681 9100-988

Email: info@vdm-publishing.com

Printed in the U.S.A.

Printed in the U.K. by (see last page)

ISBN: 978-3-639-26951-2

Copyright © 2010 by the author and VDM Verlag Dr. Müller Aktiengesellschaft & Co. KG and licensors

All rights reserved. Saarbrücken 2010

TABLE OF CONTENTS

CHAPTER 1: INTRODUCTION

1.1 Soccer: an intermittent high-intensity sport	13
1.2 High-intensity running	13
1.3 Motion characteristics of soccer: intermittent and acyclical	15
1.4 Energetics in soccer	15
1.5 Laboratory and field tests of repeated high-intensity running	16
1.6 Functional bases of repeated high-intensity running- a lack of consensus	17
1.7 Analysis of match play work intensity	20
1.8 Body fat and soccer performance	21
1.9 Fatigue in soccer and the role of oxidative stress	22
1.9.1 Oxidative stress	23
1.9.2 The antioxidant defence	23
1.9.3 High-intensity exercise and oxidative stress	24
1.9.4 Oxidative stress in soccer players: paucity of studies	25
1.10 Aims and objectives	25
1.11 Repeated high-intensity running capability: a challenge for research	26
1.12 Significance of the proposed study	27
1.12.1 Assessing repeated high-intensity running capability: a longitudinal and integrated approach	27
1.12.2 Exploring the influence of percentage body fat on repeated high-intensity running capability	28
1.12.3 Exploring the role of oxidative stress as a possible limiting factor in soccer	28
1.13 Hypotheses	29
1.14 Assumptions, limitations and delimitations	29
1.15 Definition of terms	31

CHAPTER 2: REVIEW OF THE THEORETICAL AND RESEARCH LITERATURE

2.1 Activity profile of soccer	34
2.1.1 Total distance covered in soccer matches	35
2.1.2 Motion categories in soccer	38
2.1.3 High-intensity running capability: the discriminatory and valid measure of soccer performance	40
2.1.4 High-intensity running capability-positional differences	42
2.1.5 Motion characteristics of high-intensity running in soccer	43
2.1.6 Repeated high-intensity running capability-the decisive performance quality	43
Summary	44
2.2 Physiology of soccer: with reference to performance of repeated high-intensity exercise	45
2.2.1 The phosphagen system	46
2.2.2 The anaerobic glycolytic system	47
2.2.3 The aerobic system	50
Summary	53
2.2.4 Allometric scaling of aerobic capacity	54
2.2.4.1 Positional differences in the physical characteristics of soccer players	55
2.2.4.2 Proportionality of peak $\dot{V}O_2$ to body mass	56
Summary	58
2.3 Field tests in soccer	59
2.3.1 Tests simulating overall game pattern	59
2.3.1.1 The Bangsbo Test	59
2.3.1.2 The Loughborough Intermittent Shuttle Test (LIST)	61
2.3.1.3 Ekblom's Field Test Circuit	64
Summary	66
2.3.2 Tests assessing repeated sprint running ability	66
2.3.2.1 Sprint distance and recovery duration	68
2 3 2 2 Number of sprint repetitions	70

2.3.2.3 Nature of recovery	71
2.3.2.4 Reliability and validity	74
2.3.3 Tests assessing intermittent high-intensity running capability	
: the YoYo tests	76
2.3.4 Tests estimating aerobic capacity	79
Summary	80
2.4 Laboratory tests in soccer	81
2.4.1 Tests on the motorised treadmill	81
2.4.2 Tests on the non-motorised treadmill	84
2.4.3 Tests on the bicycle ergometer	89
Summary	92
2.5 Match play analysis	93
2.5.1 Motion characteristics analysis techniques	94
2.5.2 Assessment of match play work intensity	94
2.5.2.1 Heart-rate estimation	94
2.5.2.2 Time-motion analysis	98
2.5.2.3 Estimation of oxygen uptake	98
2.5.2.4 Estimation of blood lactate	99
Summary	101
2.6 Fatigue in soccer- with special reference to oxidative stress	101
2.6.1 Fatigue during a soccer game	101
2.6.2 Implications of fatigue in soccer	103
2.6.3 Factors underlying fatigue in soccer	103
2.6.4 Oxidative stress- a possible cause of fatigue	105
2.6.5 The antioxidant defence	107
2.6.6 Estimation of urinary total antioxidant capacity	108
2.6.7 Physical exercise and oxidative stress	109
2.6.8 Oxidative stress in soccer	110
Summary	111
2.7 Body composition in soccer- with reference to percentage body fat	111
2.7.1 Body composition in soccer-paucity of studies	112

2.7.2 Effect of body fat on high-intensity running capability	114
2.7.3 Technological advances in body composition assessment- applicability in soccer	116
Summary	117
2.8 General summary and recommendations following review of the extant	
theoretical and research literature	118
CHAPTER 3: METHODS	
3.1 Ethical approval and informed consent	122
3.2 Participants	122
3.3 Experimental overview of the study	123
3.4 The training programme	125
3.5 Test locations	126
3.6 Familiarisation sessions	126
3.7 Standardisation of the test procedures	129
3.8 Test protocols and equipment	130
3.8.1 Anthropometric data	130
3.8.1.1 Age, stature and body mass	130
3.8.1.2 Body fat estimation	131
3.8.2 Laboratory test for the estimation of peak $\dot{V}O_2$	132
3.8.3 Laboratory test for assessment of repeated sprint ability	135
3.8.4 Laboratory test for assessment of intermittent high-intensity running capability	140
3.8.5 Lactate analysis by finger-prick blood sample method	142
3.8.6 Urine analysis for urinary total antioxidant capacity	143
3.8.7 Field-based test to assess running repeated sprint ability	147
3.8.8 Field-based test to assess intermittent high-intensity running capability: The YoYo Intermittent Recovery Test Level 2	150
3.9 Match play analysis	152
3.10 Statistical analysis of data	154
3.11 Estimation of the required sample size for the study	155
3.12 Allometric scaling of aerobic capacity	156

CHAPTER 4: RESEARCH STUDIES

4.1 Phase-1:	Assessment of repeated high-intensity running capability
in youth	professional soccer players during the pre-season
(Januar	v-February)

60
63
65
66
66
67
68
68
71
178
179
187
198
204
207
210
212
214
214
215
215
215

4.2.3.4 Measures of match play work intensity	217
4.2.3.5 Relationship between measures of repeated high-intensity running capability, match performance and measures of % BF, peak VO ₂ and uTAC	217
4.2.4 Discussion	224
4.2.4.1 Anthropometric characteristics	225
4.2.4.2 Peak $\dot{V}O_2$	228
4.2.4.3 Intermittent high-intensity running capability	231
4.2.4.4 Repeated sprint ability	232
4.2.4.5 Match play analysis	233
Summary	235
4.3 Phase-3: Assessment of repeated high-intensity running capability in youth professional soccer players during the end mid-season (August-September)	
Abstract	236
4.3.1 Introduction	238
4.3.2 Methods	238
4.3.3 Results	239
4.3.3.1 Anthropometric characteristics	239
4.3.3.2 Laboratory-based tests	239
4.3.3.3 Field-based tests	240
4.3.3.4 Measures of match play work intensity	241
4.3.3.5 Relationship between measures of repeated high-intensity running capability, match performance and measures of $\%$ BF, peak \red{VO}_2 and $uTAC$	241
4.3.4 Discussion	247
4.3.4.1 Anthropometric characteristics	248
$4.3.4.2$ Peak $\dot{V}O_2$	250
4.3.4.3 Intermittent high-intensity running capability	251
4.3.4.4 Repeated sprint ability	252
4.3.4.5 Match play analysis	253
Summary	254

328

REPEATED HIGH-INTENSITY RUNNING CAPABILITY AND THE	
ADDITIONAL MEASURES	
5.1 Introduction	256
5.2 Overview of the longitudinal data analysis	259
5.3 Results	260
5.3.1 Indicators of repeated high-intensity running capability	260
5.3.2 Additional measures	264
5.4 Discussion	268
Summary	276
CHAPTER 6: CONCLUSION AND DIRECTIONS FOR FUTURE RESEA	RCH
6.1 Adding to the knowledge and information base	277
6.2 Implication of the results: from the testing arena to the performance arena 6.3 Assessing repeated high-intensity running capability	279
in soccer players:choice of indicators	281
6.4 Directions for further research	283
REFERENCES	286
APPENDICES	
A: Activity profile of soccer determined by various analysis techniques	314
B: Summary of pilot data	315
C: Participant declaration sheet for medical and injury history	317
D: Diet record sheet	319
E: Instructions to the participants	320
F: The team training program during the soccer season	322
G: Minimum sample size required for desired power in multivariate approach to repeated measures	326
H: Outline of steps to conduct doubly multivariate repeated measures ANOVA	327
I. Selected output tables for doubly multivariate reneated measures	

CHAPTER 5: LONGITUDINAL ANALYSIS OF THE INDICATORS OF

ANOVA

List of Tables

Table 1.1: Criteria for running intensity in soccer	14
Table 2.1: Distance (km) covered by male outfield soccer players during a match	36
Table 2.2: Percentage distance covered at high-intensity in soccer matches	40
Table 2.3: Blood lactate concentration (mmol.L ⁻¹) with sample taken from fingertip or an arm vein during or after soccer matches	49
Table 2.4: Allometric scaling of maximal oxygen uptake and running economy in three subjects of different body mass	57
Table 2.5: Field-based test protocols for repeated sprint ability (RSA)	67
Table 2.6: Repeated sprint protocols on bicycle ergometer	90
Table 2.7: Methods used for analysis of motion characteristics in soccer	95
Table 2.8: Anthropometric characteristics of elite mature football players in different codes	113
Table 2.9: Anthropometric and sprint performance profiles of elite players in two football codes	115
Table 2.10: Knowledge gaps identified from the literature review and their proposed solutions	119
Table 4.11: Performance measures of RSA on the NMT	168
Table 4.12: Match analysis data for work intensity using HR monitoring	169
Table 4.13: Correlation matrix of the anthropometric measures, repeated high-intensity running capability measures and the match play analysis data	172
Table 4.14: Anthropometric characteristics of the participants and elite Asian soccer players	179
Table 4.15: Pre-season % BF in elite soccer players	180
Table 4.16: Anthropometric characteristics of the participants and elite Youth soccer players	180
Table 4.17: Peak VO2 of the participants and other elite Asian soccer players	188
Table 4.18: Correlation between peak $\dot{V}O_2$ and performance in the YoYo IRT L2: comparison between studies	191
Table 4.19: Work-intensity during soccer games	196
Table 4.20: Maximal aerobic capacity and work-intensity in match-1	197
Table 4.21: Performance measures of PSA on the NMT	21/

Table 4.22: Match analysis data for work intensity using HR monitoring	217
Table 4.23: Correlation matrix of the anthropometric measures, repeated high-intensity running capability measures and the match play analysis data	218
Table 4.31: Performance measures of RSA on the NMT	240
Table 4.32: Match analysis data for work intensity using HR monitoring	241
Table 4.33: Correlation matrix of the anthropometric measures, repeated high-intensity running capability measures and the match play analysis data	242
Table 5.1: Indicators of repeated high-intensity running: descriptive data	260
Table 5.2: Additional measures: descriptive data	264
Table 5.3: Match results in the League	275

List of Figures

Figure 2.1: Playing positions in soccer	37
Figure 2.2: Distance (km) covered in a competitive soccer game for different positions	38
Figure 2.3: Motion categories based on running speed in soccer	39
Figure 2.4: Movement pattern in soccer (% of total playing time)	39
Figure 2.5: Bangsbo soccer field test circuit	60
Figure 2.6: Bangsbo soccer field test protocol	61
Figure 2.7: Schematic representation of the Loughborough Intermittent Shuttle Test	62
Figure 2.8: Ekblom's Field Test Circuit for football players	65
Figure 2.9: Schematic layout of the YoYo Intermittent Endurance Test	76
Figure 2.10: Schematic layout of the YoYo Intermittent Recovery Test	77
Figure 3.1: Experimental overview of the study	123
Figure 3.2: Schematic representation of the protocol for estimation of peak $\text{\r{V}}\text{O}_2$	134
Figure 3.3: Schematic representation of the non-motorised sprint treadmill system	136
Figure 3.4: Schematic representation of laboratory test protocol for intermittent high-intensity running capability	141
Figure 3.5: Sample 96 well plate format	147
Figure 3.6: Schematic illustration of the electronic timing gates	148
Figure 3.7: Schematic illustration of the running repeated sprint ability (rRSA) test area	149
Figure 3.8: Schematic layout of the YoYo intermittent Recovery Test in the present study	151
Figure 3.9: Schematic illustration of team-system heart rate monitoring unit	152
Figure 4.11 (a): Illustration of HR during a soccer match for one of the players	169
Figure 4.11 (b): HR-VO ₂ relationship in one of the players obtained during treadmill running	170
Figure 4.12 (a): HR-VO ₂ relationship during continuous and intermittent exercise. Playing position - defender	170
Figure 4.12 (b): HR-VO ₂ relationship during continuous and intermittent exercise. Playing position - midfielder	17

Figure 4.12 (c): HR-VO ₂ relationship during continuous and intermittent exercise. Playing position – forward	171
Figure 4.13: Relationship between peak $\dot{V}O_2$ and AHR as percentage of individual HRmax in match-1	174
Figure 4.14: Relationship between peak $\dot{V}O_2$ and AHR as percentage of individual HRmax in match-2	174
Figure 4.15: Relationship between peak $\dot{V}O_2$ and performance in the laboratory-based test of intermittent high-intensity running	175
Figure 4.16: Correlation between the YoYo IRT Level 2 and the laboratory-based test of intermittent high-intensity running	176
Figure 4.17: Correlation between performance in the laboratory-based test of intermittent high-intensity running and the high-intensity work (HR > 90 % of individual HRmax) performed during match-1	177
Figure 4.18: Correlation between performance in the YoYo IRT Level 2 and the high-intensity work (HR > 90 % of individual HRmax) performed during match-1	177
Figure 4.19: High-intensity exercise performed in match-1 and 2: intra-individual differences	202
Figure 4.21: Relationship between % BF and performance in the laboratory -based intermittent high-intensity running test	219
Figure 4.22: Relationship between % BF and performance in the YoYo IRT L 2 $$	220
Figure 4.23: Relationship between % BF and performance in the field-based RSA test	220
Figure 4.24: Relationship between peak $\rm \mathring{V}O_2$ and AHR as percentage of individual HRmax in match-1	221
Figure 4.25: Relationship between peak ${\rm \r{V}O_2}$ and AHR as percentage of individual HRmax in match-2	222
Figure 4.26: Correlation between the YoYo IRT L 2 and the laboratory -based test of intermittent high-intensity running	222
Figure 4.27: Correlation between performance in the laboratory-based test of intermittent high-intensity running and the high-intensity work (HR $>$ 90 % of individual HRmax) performed during match-2	223
Figure 4.28: Correlation between performance in the YoYo IRT Level 2 and the high-intensity work (HR $>$ 90 % of individual HRmax) performed during match-2	224
Figure 4.29: High-intensity exercise performed in match-1 and 2: Intra-individual differences	234

Figure 4.31:	Relationship between % BF and performance in the laboratory-based intermittent high-intensity running test	243
Figure 4.32:	Relationship between $\%$ BF and performance in the YoYo IRT L 2	243
Figure 4.33:	Relationship between % BF and performance in the field-based RSA test	244
Figure 4.34:	Relationship between peak $\dot{V}O_2$ and match play AHR as percentage of individual HRmax during match play	245
Figure 4.35:	Correlation between performance in YoYo IRT L 2 and the laboratory-based test of intermittent high-intensity running	245
Figure 4.36:	Correlation between performance in the laboratory-based test of intermittent high-intensity running and the high-intensity work (HR $>$ 90 % of individual HRmax) performed during match play	246
Figure 4.37:	Correlation between performance in the YoYo IRT L 2 and the high-intensity work (HR $>$ 90 % of individual HRmax) performed during match play	247
(Change in the repeated high-intensity running capability measured as listance covered in the laboratory-based test of intermittent high- intensity running ability through different phases of the soccer season	261
	Change in the repeated high-intensity running capability measured as distance covered in the YoYo Intermittent Recovery Test Level 2 through different phases of the soccer season	262
(Change in the average mean power as a measure of RSA measured on the non-motorised treadmill through different phases of the soccer season	263
-	Change in total sprint time as a field-based measure of RSA through the soccer season	263
-	a): Change in the allometrically scaled peak $\dot{V}O_2$ of the participants through the soccer season	265
Figure 5.5 (b): Change in peak VO2 of the participants through the soccer season	265
0	Change in the percentage body fat of the participants through the season	266
Figure 5.7:	Change in the uTAC of the participants through the soccer season	266
_	Change in the average match play work intensity through the soccer season	267
	Change in the high-intensity exercise performed during match play in different phases of measurement	268

TABLE OF CONTENTS

CHAPT	ER 1:	INTR	ODU	CTION

1.1 Soccer: an intermittent high-intensity sport			
1.2 High-intensity running			
1.3 Motion characteristics of soccer: intermittent and acyclical			
1.4 Energetics in soccer	15		
1.5 Laboratory and field tests of repeated high-intensity running	16		
1.6 Functional bases of repeated high-intensity running- a lack of consensus			
1.7 Analysis of match play work intensity	20		
1.8 Body fat and soccer performance	21		
1.9 Fatigue in soccer and the role of oxidative stress			
1.9.1 Oxidative stress	23		
1.9.2 The antioxidant defence	23		
1.9.3 High-intensity exercise and oxidative stress	24		
1.9.4 Oxidative stress in soccer players: paucity of studies	25		
1.10 Aims and objectives	25		
1.11 Repeated high-intensity running capability: a challenge for research			
1.12 Significance of the proposed study			
1.12.1 Assessing repeated high-intensity running capability: a longitudinal and integrated approach	27		
1.12.2 Exploring the influence of percentage body fat on repeated high-intensity running capability	28		
1.12.3 Exploring the role of oxidative stress as a possible limiting factor in soccer	28		
1.13 Hypotheses			
1.14 Assumptions, limitations and delimitations			
1.15 Definition of terms			