universiteit hasselt | FACULTEIT GENEESKUNDE EN LEVENSWETENSCHAPPEN
www.uhasselt.be/glw
postadres: Universiteit Hasselt | Martelarenlaan 42 | BE-3500 Hasselt
bezoekadres: Universiteit Hasselt | Agoralaan, gebouw D | BE-3590 Diepenbeek
T +32(0)11 26 85 36 | F +32(0)11 26 85 99 | E-mail: glw@uhasselt.be

Master's thesis - Part II:

Does the type of exercise test affect exercise capacity measures in soccer players?

Drafted according to the guidelines of 'Medicine & Science in Sports & Exercise':
http://edmgr.ovid.com/msse/

Master's thesis presented for
the achievement of the degree of
Master of Science in
Rehabilitation Sciences and Physiotherapy

by **Pär VANDENBORNE** & **Stef VAN DOOREN**

Under guidance of
Prof. Dr. B. Op 't Eijnde, promoter

Hasselt, 2016

Acknowledgement

First of all, we would like to take this opportunity to thank our promoter Prof. Dr. B. Op ‘t Eijnde for his excellent guidance throughout the first and second part of this thesis. Furthermore, we would like to thank B. Gilis and C. Keytsman for their involvement and support throughout the application of the exercise tests. Measurements of this investigation were administered in the REVAL center of the Hasselt University Biomedical Research Institute, provided with instruments to assess cardiorespiratory fitness (Jaeger, Oxycon) during the maximal treadmill exercise tests.

Finally, we would like to show our gratitude to the coaches and players of F.C. Torpedo Hasselt, K.S. Hasselt and K. Sint-Truiden V.V. for their dedicated participation in our investigation. Without them, this study would not have been possible.

Zoutleeuw (BE) - Genk (BE), 16-06-2015 P.V. - S.V.D.

RESEARCH CONTEXT

Soccer is one of the most popular sports in existence and is performed worldwide on different levels by people of all ages [1]. Soccer performance comprises a combination of genetics, tactical, physical, physiological and psychological factors [8], interacting continuously. During the last decades, these divergent factors were extensively researched with constantly innovating technological resources in order to determine their role of importance in the game. As a result, the game itself and the way it is played has evolved tremendously over the years and will be most likely to continue improving in the future. In particular, the physical aspect of the game was highly affected by these modernizations, primarily in professional soccer.

An important aspect of improving match performance on a physical level is increasing the exercise capacity of the player. In soccer players, maximizing the maximal oxygen consumption (VO_{2max}) is crucial to cover significantly greater distances during a soccer game [5]. In addition, increasing VO_{2max} has been shown to be positively correlated to a higher number of explosive bouts performed during the game [8]. This exercise capacity appears to vary between both field playing position and the level of competition of soccer players [4], [7], [8], [9].

In order to keep track of physical improvements, the aerobic capacity of soccer players can be estimated or measured by field tests or laboratory treadmill tests, respectively [2], [3], [6]. Ergospirometry is used to measure maximal oxygen consumption during maximal graded exercise tests, where players have to sustain a gradually increasing pace until maximal volitional exhaustion is achieved. A player's aerobic capacity, however, can also be determined indirectly through (soccer-specific) field tests by calculating the covered distance. Due to the fact that these are far less time-consuming, costly and more sport-specific, field tests are very popular among soccer teams of all levels of competition and can be performed repeatedly throughout the season.

However, there is still a lot of uncertainty regarding the method of measuring aerobic capacity in soccer players in the most appropriate way. To date, various treadmill protocols are used differing in either starting speed or time-related increase of treadmill speed and/or inclination, as no universal treadmill protocol has yet been developed. Due to this lack of a 'golden standard', there is no guarantee that the data derived from these protocols represent the player's actual exercise capacity. In addition, the use of different treadmill protocols interfere with data comparison between players, as it is uncertain both tests are equally valid and reliable.

This master's study, under supervision of Prof. Dr. B. Op 't Eijnde, is situated within the Cardiorespiratory and Internal Diseases subdomain of Rehabilitation Sciences and Physiotherapy focusing on Exercise Physiology and the ADLON Sports Medical Center. It is a continuation of an ongoing study entitled "Does the nature of the exercise test influence the exercise capacity in soccer players?" that was initiated in 2014.

The current investigation was performed by two students Rehabilitation Sciences and Physiotherapy and was elaborated conform the guidelines of Medicine & Science in Sports & Exercise. In this investigation, both amateur and professional soccer players were recruited in order to determine and compare their exercise capacity using two maximal graded treadmill protocols and a soccer-specific field tests. Given the fact that this is a follow-up study of a previous investigation, the construct of the current study was pre-determined. However, recruitment of the soccer teams was done independently.

Measurements of this investigation were executed in the REVAL Rehabilitation Research Center of the Biomedical Research Institute of Hasselt University, provided with appropriate instruments to assess one's cardiorespiratory fitness (Jaeger, Oxycon). The data-acquisition was performed under supervision of Prof. Dr. B. Op 't Eijnde and C. Keytsman. The field tests, on the other hand, which were performed in a local sports hall approximate to the teams in dispute, were administered by the two students independently. Furthermore, data processing, interpretation and the academic writing process was predominantly performed independently, under guidance of Prof. Dr. B. Op 't Eijnde.

References Research Context

1. Bangsbo, J., *Fitness training for football: a scientific approach.* HO + Storm 1994.
2. Bangsbo, J. and F. Lindquist, *Comparison of various exercise tests with endurance performance during soccer in professional players.* Int J Sports Med, 1992. 13(2): p. 125-32.
3. Drust, B., T. Reilly, and N.T. Cable, *Physiological responses to laboratory-based soccer-specific intermittent and continuous exercise.* J Sports Sci, 2000. 18(11): p. 885-92.
4. Ekblom, B., *Applied physiology of soccer.* Sports Med, 1986. 3(1): p. 50-60.
5. Helgerud, J., et al., *Aerobic endurance training improves soccer performance.* Med Sci Sports Exerc, 2001. 33(11): p. 1925-31.
6. Kemi, O.J., et al., *Soccer specific testing of maximal oxygen uptake.* J Sports Med Phys Fitness, 2003. 43(2): p. 139-44.
7. Mohr, M., P. Krustrup, and J. Bangsbo, *Match performance of high-standard soccer players with special reference to development of fatigue.* J Sports Sci, 2003. 21(7): p. 519-28.
8. Stolen, T., et al., *Physiology of soccer - An update.* Sports Medicine, 2005. 35(6): p. 501-536.
9. Whitehead, E., *Conditioning of sports.* Yorkshire: E P Publishing Co. Ltd, 1975: p. 40-2.

ARTICLE

Does the type of exercise test affect exercise capacity measures in soccer players?

Pär Vandenborne[1], Stef van Dooren[1], Bert Op 't Eijnde[2]

[1] Faculty of Health Medicine and Life Sciences, Master student Rehabilitation Sciences and Physiotherapy, Hasselt University, B- 3590 Diepenbeek

[2] Biomedical Research Institute (BIOMED), Rehabilitation Research Center (REVAL), Faculty of Health Medicine and Life Sciences, Rehabilitation Sciences and Physiotherapy, Hasselt University, B- 3590 Diepenbeek

Corresponding author: Prof. Dr. B. Op 't Eijnde: Hasselt University, Faculty of Health Medicine and Life Sciences, bert.opteijnde@uhasselt.be, +32-11292121

Abstract

Background Overall, various exercise protocols are used to determine the exercise capacity of soccer players. However, to date, it is still unclear what method is the most adequate as no universal protocol has yet been developed. In addition, the correlation between data derived from laboratory tests and soccer-specific field tests remain unclear.

Objectives The aim of this study was to investigate to what extent two maximal graded exercise tests, with short (ST) and long (LT) speed increments of respectively every one and three minutes, correlate with a soccer-specific field test (YYIRTL1). In addition, the impact of the level of competition (amateur vs. professional) the players participate in on the exercise capacity will be studied.

Participants Fifty professional and twenty three amateur male soccer players (N = 73) from Belgium's regional (1^{st}) and national (1^{st}, 2^{nd} and 3^{rd}) divisions were recruited.

Measurements Two maximal graded treadmill tests (Short Term, ST, +1km/h/min vs. Long Term, LT, + 1,8km/h/3min) and the YoYo Intermittent Recovery Test level 1 were applied in order to determine a player's relative maximal oxygen consumption (VO_{2max}), maximal and recuperation heart rate (HR_{max} and HR_{recup}), peak lactate and Borg RPE-score.

Results Data derived from the ST-protocol did not differ significantly compared to the LT-protocol. However, both treadmill protocols showed significantly higher relative VO_{2max} (+7,48% and +4,86%, respectively) in comparison with the YYIRTL1 ($p<0.01$). In addition, professional soccer players scored significantly higher relative VO_{2max} (+5,77%) and Borg RPE (+10,21%) values on the YYIRTL1 ($p<0.01$).

Conclusion The nature of the exercise test (continuous vs. intermittent) has an impact on the exercise capacity of soccer players. However, the type of treadmill protocol (short vs. long) appears to have no significant influence on exercise capacity related parameters in soccer players.

Key words Soccer, VO_{2max}, Treadmill protocol, Soccer-specific field test

1. Introduction

At present, soccer is the most popular sport in the world and is performed on a daily basis by millions of participants with different levels of expertise, both recreationally and professionally. Soccer performance comprises technical, tactical, physical, physiological and psychological factors [18]. Physically, running is the predominant activity, with players covering an average of approximately 8-12km at intensities close to and above the anaerobic threshold (~90% of HR_{max}) during a single soccer match. This activity is performed at an average of 75% of their maximal oxygen uptake (VO_{2max}) [6], [7], [17]. During a soccer game, numerous intermittent explosive bouts of activity are performed including jumping, kicking, tackling, turning, sprinting, changing pace and sustaining forceful contractions to maintain balance and control of the ball against defensive pressure [20]. Sprinting occurs approximately once every 90s and constitutes 1-11% of the total distance covered during a soccer match accumulating muscle and blood lactate [2], [15]. Intermittently, soccer players recover during low-intensity activity to remove lactate from the working muscles. Aerobic metabolism is estimated to contribute approximately 90% of energetic demand [1].

Given the intermittent nature of soccer the physical requirements of the sport impose major demands on both the cardiovascular and metabolic capacities of soccer players [4]. Therefore, in order to maintain a high level of activity during a soccer game, soccer players try to maximize their maximal aerobic and anaerobic exercise capacity during training sessions prior and throughout the season. Several studies report that midfield players run the longest distances during a game and that professional players cover more distance than amateurs indicating differences in aerobic capacity according to field position and level of competition [7], [15], [19].

Traditionally, the golden standard to measure exercise capacity (VO_{2max}) are maximal graded exercise tests [4-6], [9-10], [13]. However, because maximal exercise testing in laboratory settings is considered relatively costly and time-consuming, they are predominantly suitable for professional soccer teams. In addition, they are considered not to be very soccer-specific. As a result, several field tests were developed aiming to estimate exercise capacity. These tests are now abundantly used by teams in nearly every level of competition in order to estimate exercise capacity of the entire team at once, mainly because its application is fairly easy and can be done on the team's own training grounds without the necessity of expensive equipment. Although the validity of certain field tests has been proved in the past, it is not fully clear whether these test correlate with the more objective laboratory tests, and if so, to what extent.

Given the continuous nature of maximal graded exercise tests and many field tests, it is unlikely that these tests reflect the entire intermittent nature of soccer. Consequently, several valid and reliable soccer-specific field tests have been developed to provide a more appropriate way to measure a player's soccer-specific exercise capacity. To date, however, the impact of the applied laboratory and field test protocols on exercise capacity related parameters (e.g. VO_{2max}, time to exhaustion and blood lactate profiles) is unclear. The laboratory tests that are mainly used to investigate the exercise capacity of soccer players can be divided into two types of protocols: the short-term (ST) and long-term (LT) protocols, depending on the time between running speed increments. For a more soccer-specific approach, the Yo-Yo test is the most commonly used field test to evaluate the aerobic capacity of the team.

In keeping with the above line of reasoning, the present project aims to investigate **(a)** to what extent a maximal graded exercise test with short (ST) and long (LT) stages, of respectively one and three minutes, correlates with the YYIRTL1 and **(b)** the lactate response during these maximal graded exercise tests. In addition, **(c)** the significance of the level of competition (e.g. amateur vs. professional) on exercise capacity-related outcome parameters will be investigated.

We hypothesize that **(1)** the VO_{2max}, peak lactate and maximal heart rate values obtained during a soccer specific field test mirror the results obtained during a short (ST) and long term (LT) maximal graded exercise test. **(2)** Furthermore, it is hypothesized that peak lactate values derived from the ST-protocol will be higher in comparison with the LT-protocol. Additionally, **(3)** it is assumed that professional soccer players in general possess higher aerobic capacity in comparison with amateurs.

2. Methods

Participants

Pre-selected teams, based on geographical location, were sent a recruitment letter (*Appendix I*), explaining the context and purpose of the study. When interested, recruiters went on-site to present an informative lecture for further clarification.

Recruited participants were divided into two groups, depending on their level of competition. The first group (N=50) consisted of professional soccer players recruited from Belgium's national first, second and third division, while the second group (N=23) included amateur soccer players participating in Belgium's regional first division. Subject characteristics are shown in *Table 2*. To be included in the study, following selection criteria were set: male soccer players (any level of competition, ≥ 3 training or match sessions a week) with ages ranging between 16-35 years old, who were free of injuries at least two weeks prior of testing. Players suffering from injuries and/or relative and absolute contra-indications for maximal testing (e.g. heart conditions) were excluded for further testing, according to ACSM's Guidelines for Exercise Testing & Prescription (2009). Each participant was provided with detailed information regarding the set-up and aim(s) of the study prior to signing the Informed Written Consent (*Appendix II*). Due to the fact that this project is a follow-up of a pilot study titled "Beïnvloedt de aard van de inspanningstest de inspanningscapaciteit bij voetballers?" (2015), this investigation was previously approved on August 22nd 2014 by the Medical Ethical Committee, of which the form can be found in *Appendix III*. All included participants were free to drop out of the study at any time.

Design

A cross-over study design with repeated measures consisting of three measuring moments, two maximal graded exercise tests and a soccer-specific field test, within a time-span of two weeks was set up. Both laboratory tests (ST. vs. LT-protocol) were performed at the REVAL Rehabilitation Research Center of the Biomedical Research Institute of Hasselt University, with speed increments every one and three minutes, respectively. During the first laboratory testing, the recruited soccer teams were randomly divided into two groups, with each group performing one of two maximal graded treadmill protocols that day. One week after, during the second laboratory testing, both groups switched and performed the other treadmill protocol. Finally, a soccer-specific field test (Yo-Yo Intermittent Recovery Test Level 1) was performed on-site including the entire team. The design is displayed in *Figure 1*.

Laboratory tests

Prior to administering the first exercise test, body composition of the participants was measured using a standardized method. This consisted of measuring the player's stature (stadiometer, Hasselt University, Belgium), body mass (Seca Colorata 760, Hamburg, Germany), fat percentage (sum of four skinfolds, Harpenden Skinfold Caliper, West Sussex, United Kingdom) and age. The player's body mass was measured once more prior to the second laboratory testing in order to rule out excessive weight gain or loss. Measurements were done in a separate room. During this period of time, players were informed one last time regarding the test procedure in order to facilitate a consistent series of testing. Subsequently, players were asked to strap a heart rate monitor (Polar®) around the thorax before starting the standardized warming-up, consisting of ten minutes of jogging at a slow pace (7-8km/h) for the sake of minimizing the chance of injuries. Moreover, this warming-up also served as a habituation session, notably for participants who were less familiar with running on a treadmill, in order to reduce the fall risk. All of the participants, however, seemed to adapt effortlessly.

Within minutes after finishing the warming-up, a face mask (mouth/nose) was carefully and accurately on the participant's face, ready to start the maximal graded exercise test. The test was performed on an electronic treadmill (Technogym, JOG 500, Cesena, Italy) in a secluded room with a constant temperature of 19°C. During the entire test, the participants were supervised and guided by multiple researchers who not only verbally encouraged the players to reach their maximum capacity but also manually increased the treadmill speed and inclination as the test progressed into further stages. These increases in increments and inclination differed between the two test protocols. In the ST-protocol, the initial running speed was set at 4 km/h with speed increments of 1 km/h every minute. Only the first two stages, 4 and 5 km/h, were maintained for two minutes instead of one. On the other hand, in the LT-protocol, initial running speed was set at 5,4 km/h with speed increments of 1,8 km/h every three minutes. In both protocols, a treadmill inclination of 1° was implemented in order to simulate normal outside wind-resistance. When a participant managed to maintain the maximum speed of 18 km/h and would be able to advance, inclination was increased by 2° every minute until maximal volitional exhaustion was reached. Running speed was limited to 18 km/h due to the increased fall risk that might occur when increasing it any further. A detailed description of both treadmill protocols can be found in the *Tables 1.1* and *1.2*.

During the test, ventilation (inhaled/exhaled air) and heart rate were closely monitored using ergospirometry (Jaeger Oxycon, Erich Jaeger GmbH, Hoechberg, Germany) and a heart rate monitor (Polar T31 breast band, Kempele, Finland), respectively. Calibration of the ergospirometry device was repeated prior to each testing session in order to gain a reliable and accurate impression of the gas

volumes (O_2 and CO_2) in the room of testing. The participants' heart rate was registered continuously and carefully marked at any change in speed or inclination. In addition, capillary blood samples from the fingertip were collected at pre-set times every two (ST) of three (LT) minutes in order to keep track of the blood lactate concentration. Lactate analysis was performed instantly using the Accutrend Plus System device (Roche, Indianapolis, United States). Consequently, both cardiorespiratory and metabolic parameters were analyzed in order to determine the anaerobic threshold (lactate concentration, ventilatory threshold, respiratory threshold and RER value), maximal oxygen uptake (VO_{2max}) and maximal heart rate (HR_{max}).

When the participant had reached maximal volitional exhaustion and decided to terminate the test, the mask was removed immediately while the player was asked to stay put for two more minutes while taking deep breaths, in order to gain an impression of the player's speed of recovery. After these two minutes, the recovery heart rate was noted and one final capillary blood sample was collected, representing the peak lactate. Additionally, players were asked to rate their subjectively perceived exertion using the BORG RPE-scale, ranging from 6 (no exertion at all) to 20 (maximal exertion). Finally, they were given the opportunity to cool down by either running or cycling in order to remove the large amounts of lactate accumulated in the muscles.

Table 2.1. Short-term protocol

Time Protocol (minutes)	***Speed (km/h) and Inclination (°)***		
Start	*4 km/h*	*and*	*1°*
2	*5 km/h*	*and*	*1°*
4	*6 km/h*	*and*	*1°*
5	*7 km/h*	*and*	*1°*
6	*8 km/h*	*and*	*1°*
7	*9 km/h*	*and*	*1°*
…	…		
15	*17 km/h*	*and*	*1°*
16	*18 km/h*	*and*	*1°*
17	*18 km/h*	*and*	*3°*
18	*18 km/h*	*and*	*5°*
19	*18 km/h*	*and*	*7°*
…	…		

Table 2.2. Long-term protocol

Time Protocol (minutes)	*Speed (km/h) and Inclination (°)*		
Start	*5,4 km/h*	*and*	*1°*
3	*7,2 km/h*	*and*	*1°*
6	*9 km/h*	*and*	*1°*
9	*10,8 km/h*	*and*	*1°*
12	*12,6 km/h*	*and*	*1°*
15	*14,4 km/h*	*and*	*1°*
18	*16,2 km/h*	*and*	*1°*
21	*18 km/h*	*and*	*1°*
22	*18 km/h*	*and*	*3°*
23	*18 km/h*	*and*	*5°*
24	*18 km/h*	*and*	*7°*
...	*18 km/h*	*and*	*9°*

Field test

The field test was performed one week after the second laboratory test. As a result, the three testing moments took place within a time span of two weeks (see *Figure 1*).

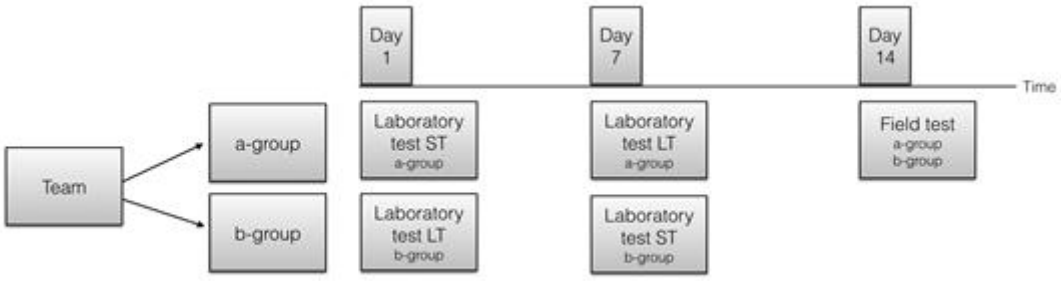


Figure 1. *Study design*

For the soccer-specific field, the Yo-Yo Intermittent Recovery Test Level 1 (YYIRTL1) was picked after extensive research of its validity and reliability in previous studies [4], [10]. Execution of this test was done according to the guidelines of Castagna et al. (2006) [4]. Teams were split into two groups in order to maintain maximal visual supervision of all players during the test, this way smoothening the test procedure. Prior to the test, players were given a heart rate monitor (Polar T31 breast band, Kempele, Finland) to put on along with a watch to register the heart rate during the test.

Meanwhile, they were given information and instructions concerning the test including a short illustration, as some players were not familiar to the test. Hereafter, a standardized warm-up of 10 minutes took place.

During the YYIRTL1, participants had to run back and forth in between cones set at 20m (2x20m) within a gradually decreasing time-interval, following the pre-recorded acoustic signals. After each 40m, a 10s-period of active recovery was provided where players were allowed to walk back and forth in between a 5m-shuttle (2x5m). This period of active recovery in between shuttles, making the field test intermittent in nature, is considered the main difference between this test and other field tests (e.g. Beep test). The test was terminated when a player was unable to maintain the required speed after getting a first warning. The distance covered during the shuttles was recorded for analysis. However, the distance covered during rest was excluded (see *Figure 2*).

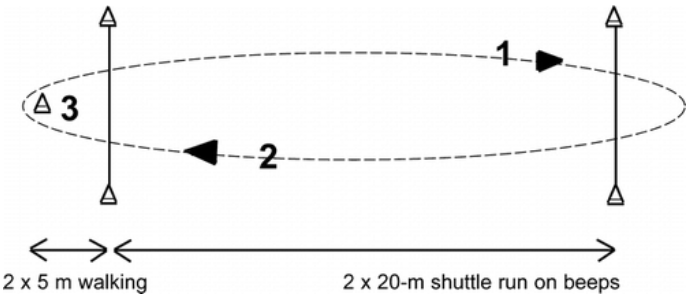


Figure 2. *Schematic representation of the Yo-Yo Intermittent Recovery Test Level 1 (YYIRTL1)*

Statistical analysis

To statistically analyze the obtained data from the experiment, IBM SPSS statistics 23 (SPSS Inc., Chicago, USA) was used. Shapiro-Wilk and Levene's test were applied to verify the normality and homoscedasticity, respectively. This was done for the entire sample in conjunction with the amateur and professional groups separately. Furthermore, (paired) t-tests and mixed-design ANOVA with repeated measures were performed in order to analyze the data derived from the maximal exercise tests. In addition, Pearson correlations were applied to investigate relations between parameters from the different exercise tests. Subsequently, the coefficient of determination (R^2) was calculated to portray the strength of the correlations. When the conditions concerning normality were not met, Kruskall-Wallis and Mann Whitney analyses were performed. All of the collected data will be presented as a mean ± standard deviations (mean±SD's) and will be considered statistically significant when $p<0.05$. A prospective power analysis and sample size estimation was performed to see (a) how large the sample is needed to enable accurate and reliable statistical analysis, and (b) how likely our statistical test will be to detect effects of a given size in a particular situation (Source: Statsoft). As a result, it was suggested that this study needed approximately 55 participants, translating into three to four soccer teams.

3. Results

The obtained results, with the exception of the subject characteristics, were analyzed in four distinctive ways. First of all, the test results of both groups were analyzed as a whole (N=73) and a comparison was made between outcome parameters of both laboratory tests and the field test. Additionally, the results were split according to level of competition (professional vs. amateur players) and analyzed accordingly. Finally, a comparison between both groups was made in order to investigate potential discrepancies related to level of competition.

Biometry

Age, stature, body mass, BMI and fat percentage did not differ between amateur (N=23) and professional (N=50) soccer players. Anthropometrical subject characteristics are shown in *Table 2*.

Table 2. Subject characteristics

	Total (n=73)	*Pro (n=50)*	*Amateur (n=23)*	*p-level*
Age (years)	*20,9 ± 3,3*	20,6 ± 3,3	21,7 ± 3,0	0,282
Height (cm)	*177,7 ± 6,6*	178,3 ± 6,0	176,4 ± 7,6	0,432
Weight (kg)	*71,8 ± 7,5*	72,2 ± 6,8	70,7 ± 8,8	0,931
BMI (kg/m²)	*22,7 ± 1,7*	22,7 ± 1,4	22,7 ± 2,3	0,175
Body fat (%)	*12,1 ± 2,7*	11,8 ± 2,2	12,7 ± 3,4	0,18

Values are mean ± SD's; BMI: Body mass index.

Test-related exercise capacity

Short-term (ST) and long-term (LT) treadmill data did not differ when taken as a whole. However, both ST ($p < 0.01$)- and LT ($p < 0.01$) treadmill protocols showed significant higher relative VO_{2max} values (+7,48% and +4,86%, respectively) in comparison with the YYIRTL1. Furthermore, no significant differences were found between either the ST- or LT treadmill protocol and the YYIRTL1 (see *Table 3* and *Appendix 4*).

The coefficient of determination between different outcome parameters was calculated. A strong coefficient of determination was found for the maximal and recuperation heart rate ($R^2_{ST\text{-}LT} = 0.60$; $R^2_{ST\text{-}LT} = 0.62$). Furthermore, mild coefficients of determination were calculated for VO_{2max} and Borg RPE ($R^2_{ST\text{-}LT} = 0.32$; $R^2_{ST\text{-}LT} = 0.24$) between both treadmill tests. Similar results were found for maximal heart rate values ($R^2_{ST\text{-}YIRT} = 0.35$; $R^2_{LT\text{-}YIRT} = 0.34$) concerning both treadmill protocols in relation to the field test. Low R^2-values were found in peak lactate ($R^2_{ST\text{-}LT} = 0.02$), VO_{2max} ($R^2_{ST\text{-}YIRT} = 0.14$; $R^2_{LT\text{-}YIRT} = 0.13$) and Borg RPE ($R^2_{ST\text{-}YIRT} = 0.14$; $R^2_{LT\text{-}YIRT} = 0.10$). The results are shown in *Table 3*.

Table 3. Physiological variables of the different exercise tests

	Short-term	*Long-term*	*YYIRTL1*
VO_2max	*58,05 ± 5,61 * □ ⁝*	*56,63 ± 5,21 * ⁝*	*54,01 ± 3,80*
HRmax	*194,27 ± 9,10 ▸ •*	*194,34 ± 8,02 •*	*192,54 ± 9,56*
Borg RPE	*16,37 ± 1,78 □ ⁝*	*16,66 ± 1,53 ⁝*	*16,97 ± 1,69*
La peak	*12,18 ± 3,40 •*	*11,76 ± 2,75*	*Not Applied*
HRrecup	*133,99 ± 14,03 ▸*	*132,23 ± 13,34*	*Not Applied*

Data represent physiological values obtained during a Short-term (ST, 1-min exercise steps, + 1km/h) and Long-term (LT, 3-min exercise steps, + 1,8km/u) maximal graded exercise tests and the YoYo intermittent recovery test (YYIRTL1) and are expressed as means ± SD's.
VO_2max = Maximal oxygen consumption, HRmax = Maximal heart rate, Borg RPE-scale = Scale for subjectively experienced fatigue, La Peak = Peak lactate, HRrecup = Recuperation heart rate 2min. after termination, COD = coefficient of determination.
** Significant difference (p<0,05) related to YYIRTL1, ▸ Strong COD related to LT-protocol(R^2), □ Mild COD related to LT-protocol(R^2), • Mild COD related to the YYIRTL1 (R^2), • Low COD related to LT-protocol (R^2), ⁝Low COD related to the YYIRTL1 (R^2).*

Level-related exercise capacity

Professional

In the group of professional soccer players, no significant differences were found between the ST- and LT treadmill protocol. This was not the case when comparing the ST-protocol with the YYIRTL1, where significant differences were found in relative VO_{2max} ($p<0.01$), maximal heart rate ($p<0.05$) and Borg RPE ($p<0.01$). Both VO_{2max} and maximal heart rate values were significantly higher (+4,82% and +2,5 beats/min) on the ST-protocol, while the Borg RPE-score was significantly lower (-5,32%) compared to the YYIRTL1. Furthermore, significant differences were found in relative VO_{2max} ($p<0.05$) and Borg RPE ($p<0.01$) of respectively +2,55% and -4,52% between the LT-protocol in comparison with the YYIRTL1.

A strong coefficient of determination was found for the maximal heart rate (R^2_{ST-LT} = 0.60) between both treadmill protocols. Moderate R^2-values were determined for maximal heart rate ($R^2_{ST-YIRT}$ = 0.49; $R^2_{LT-YIRT}$ = 0.45), recuperation heart rate (R^2_{ST-LT} = 0.42) and Borg RPE (R^2_{ST-LT} = 0.21) while only low values were found for relative VO_{2max} (R^2_{ST-LT} = 0.19; $R^2_{ST-YIRT}$ = 0.08; $R^2_{LT-YIRT}$ = 0.05) and peak lactate (R^2_{ST-LT} = 0.002).

Amateur

When analyzing the group of amateur soccer players, no significant differences in outcome parameters were reported between the two treadmill protocols. However, the relative VO_{2max} obtained from the YYIRTL1 differed significantly from the relative VO_{2max} measured during the ST- and LT-protocol ($p<0.01$) with -13.53% and -10,10%, respectively. Furthermore, no other significant differences were found.

In contrary to the professionals, moderate coefficients of correlation were found for relative VO_{2max} ($R^2_{ST-LT} = 0.56$; $R^2_{ST-YIRT} = 0.46$; $R^2_{LT-YIRT} = 0.46$). Additionally, maximal heart rate, recuperation heart rate and Borg RPE ($R^2_{ST-LT} = 0.59$; $R^2_{ST-LT} = 0.35$; $R^2_{ST-LT} = 033$, respectively) showed moderate R^2-values when comparing both treadmill protocols. Similar to the group of professionals, peak lactate showed a very low coefficient of determination ($R^2_{ST-LT} = 0.08$).

Professional vs. amateur

When comparing the professional group of soccer players with the amateurs, no significant differences were found between either the ST- or LT-protocol. In contrary, statistically significant differences were demonstrated between both groups concerning the relative VO_{2max} ($p<0.01$) and Borg RPE ($p<0.01$) concerning the YYIRTL1, where the professionals scored respectively 5,77% and 10,21% higher. Results are illustrated in *Table 4* and *Appendix V*. Only weak correlations of determination were derived from the Pearson correlations applied on both amateur and professional groups.

Table 4. Physiological variables of different levels

		Professionals	*Amateurs*
VO_2max	*Short-term*	*57,61 ± 5,23* • ⁝	*58,99 ± 6,37* □ ◦ ▲
	Long-term	*56,36 ± 4,92* ⁝	*57,21 ± 5,85* ◦ ▲
	YYIRT1	*54,96 ± 3,08* *	*51,96 ± 4,45* ▲
HRmax	*Short-term*	*194,82 ± 8,81* ▸ ♦	*193,09 ± 9,92* □ ▲
	Long-term	*194,62 ± 8,11* ♦	*193,74 ± 7,98* ▲
	YYIRT1	*192,38 ± 9,02*	*192,95 ± 11,05°* ▲
Borg RPE	*Short-term*	*16,56 ± 1,79* □	*15,96 ± 1,72* □ ▲
	Long-term	*16,70 ± 1,56*	*16,57 ± 1,50* ▲
	YYIRT1	*17,49 ± 1,57* *	*15,87 ± 1,49* ▲
La Peak	*Short-term*	*12,49 ± 3,28* •	*11,52 ± 3,62* • ▲
	Long-term	*12,05 ± 2,75*	*11,14 ± 2,70* ▲
HR recup	*Short-term*	*134,6 ± 13,47* □	*132,65 ± 15,41* □ ▲
	Long-term	*133,72 ± 13,70*	*129,00 ± 12,21* ▲

** Significant difference from the professionals in relation to the amateurs*
° Only 20 of 23 soccer players were included due to registration errors of the heart rate.`
Data represent physiological values obtained during a Short-term (ST, 1-min exercise steps, + 1km/h) and Long-term (LT, 3-min exercise steps, + 1,8km/u) maximal graded exercise tests and the YoYo intermittent recovery test (YYIRTL1) and are expressed as means ± SD's.
VO_2max = Maximal oxygen consumption, HRmax = Maximal heart rate, Borg RPE-scale = Scale for subjectively experienced fatigue, La Peak = Peak lactate, HRrecup = Recuperation heart rate 2min. after termination, COD = Coefficient of determination. (R^2)

- Within professionals;

▸ *Strong COD related to LT-protocol,* □ *Mild COD related to LT-protocol,* ♦ *Mild COD related to the YYIRTL1,*

• *Low COD related to LT-protocol,* ⁝ *Low COD related to the YYIRTL1.*

- Within amateurs;

□ *Mild COD related to LT-protocol,* ◦ *Mild COD related to the YYIRTL1,* ◎ *Low COD related to LT-protocol.*

- Between professionals and amateurs;

▲ *Low COD related to the professional group.*

4. Discussion

Worldwide, all kinds of exercise tests are used by professional soccer teams in order to determine the exercise capacity of their players. This is mainly the case because no 'golden standard' has yet been developed. Consequently, to date, it is still unclear which protocol gives the best representation of a players' aerobic capacity. Through comparison with a soccer-specific field test, this study strives to investigate this matter. While no significant differences were found between both treadmill protocols themselves, the aerobic capacity did differ in comparison with the soccer-specific field test.

This follow-up study, in combination with its (Dutch) predecessor, is the first of its kind comparing multiple continuous treadmill protocols in conjunction to a soccer-specific field test. Yet, some comparisons with previous studies can be made. For the entire sample of professional and amateur soccer players combined, no significant differences were found between outcome parameters concerning the short-term (ST) and long-term (LT) treadmill protocol, with speed increments every one and three minutes respectively. Even though the peak lactate was expected to be higher after the ST-protocol, no significant differences were found. These results were in accordance with Pierce et al., (1999), who reported similar non-significant results regarding the same outcome measures [16]. On the contrary, Machado et al. (2012) reported significant higher peak lactate values related to the ST-protocol in comparison with the LT-protocol, objecting the current findings [11]. Although no significances were found between the treadmill protocols itself, both protocols showed significant higher relative VO_{2max} compared to the YYIRTL1. These results are in conformity with Metaxas et al. (2005) and Castagna et al. (2006), plausibly indicating an underestimation of the estimated VO_{2max} derived from the total distance covered during the test [4], [14]. Nevertheless, the absence of significantly different maximal heart rates between either the ST- or LT-protocol compared to the YYIRTL1 might imply maximal effort and a limiting cardiovascular factor on both tests, either continuous or intermittent in nature.

When analyzing the results from the group of professional soccer players separately, no significant differences were found between the ST- and LT treadmill protocol. Correspondingly, similar results were derived when evaluating the group of amateur soccer players where no significances were found between both protocols. Unfortunately, up to this point there are no studies who have yet evaluated the impact of the level of competition on different treadmill protocols.

On the other hand, when the treadmill protocols were opposed to the YYIRTL1, significant results were found within each group according to level of competition. When comparing the results of the ST-protocol with the YYIRTL1 in the group of professional soccer players, significant differences were found in relative VO_{2max}, HR_{max} and Borg RPE. In the amateur group, solely the relative VO_{2max} differed

significantly between both tests. Thus, as mentioned earlier, it appears that the VO_{2max} derived from the YYIRTL1 propose an underestimation of the actual measured values during the lab tests, without regard to the level of competition the players participate in. It is unclear why the maximal heart rate of the professional group was significantly lower during YYIRTL1 compared to the ST-protocol. Furthermore, it appears to be that the YYIRTL1 was considered significantly more exhausting, according to the Borg RPE-score, than the ST-protocol. This phenomenon might be attributed to the fact that during the field test the players are limited by themselves rather than the equipment. Therefore, when players subjectively experienced maximal exhaustion, there was no motivational factor of a running treadmill but instead were limited by their own (lack of) perseverance by a greater share. Consequently, although the field test was experienced as more exhausting, their maximal heart rate was never actually reached. On the other hand, a more rapid and higher accumulation of blood lactate might also be the underlying cause of this paradox. Up until now, there are no studies who have investigated the effect of the nature of the exercise test on the subjectively experienced exhaustion, including its underlying causes. Along with the differing results mentioned above, significant differences were found in the professional group concerning relative VO_{2max} and Borg RPE between the LT-protocol in comparison with the YYIRTL1. Similar to the comparison made earlier between ST-protocol vs. YYIRTL1, the amateur group only differed in relative VO_{2max}.

Finally, a between-group comparison was made in order to compare differences between soccer level. No statistically significant differences were found between both groups regarding either the ST- or LT-protocol. We hypothesized that the professional group would have a higher VO_{2max} than the amateur group. Surprisingly, this was not the case. These remarkable results can possibly be attributed to the fact that the professional group was tested prior to the preparation of the new season while the amateur group was tested at the start of the season, this way giving them more time to improve their physical fitness. These fluctuations in physical fitness throughout the season have already been studied in the past [8], [12]. On the other hand, the group of professionals showed higher, although non-significant, peak lactate values, possibly indicating a higher tolerance for lactate accumulation. Furthermore, there have been several studies trying to prove an existing difference in relative VO_{2max} through maximal exercise testing between professional and amateur players, but the results, as it is also the case in this current study, remain inconclusive [21]. However, when comparing the results of both groups on the YYIRTL1, the group of professional soccer players appeared to achieve significantly higher relative VO_{2max} values than the amateur group. Hence, while both groups seemed to have corresponding results on the continuous laboratory tests, a clear distinction in maximal oxygen consumption was revealed during the soccer-specific field test. This might be an

indication that the nature of the exercise test, continuous vs. intermittent, possibly interacts with the level of competition the players participate in.

An important strength of this investigation was its study design. The cross-over design, where all three tests were performed within a time-span of two weeks, permitted the players to function as their own control group while being able to attribute the results to the intervention itself instead of the training period players endured on the side. This way, a potential source of bias was minimized. It would have been optimal to conduct all three tests at the same day in order to minimize training effects, but this was practically impossible due to fatigue and lack of time. It is believed that these potential interferences were minimized due to the cross-over design. The maximal treadmill exercise tests were conducted in a standardized environment. Each player endured the same standardized warm-up, this way acclimatizing to the laboratory environment and adapting to the treadmill.

However, there were also limitations. First, it would have been very interesting to have measured the players' peak lactate after the YYIRTL1. That way, it could have been compared with peak lactate values obtained after treadmill testing in order to gain an impression of possible correlations or discrepancies between the two. Practically, this appeared to be impossible with only two observers measuring over ten participants at the same time. Additionally, the number of amateur players (N=23) was disproportionate to the number of professional soccer players (N=50) included in this study. Finally, as mentioned earlier, the time of testing of both groups was slightly different, possibly affecting the outcome. The professionals were tested prior to the preparation of the new season, while the amateurs were tested a month afterwards, at the start of the new season. However, because a cross-over design was applied, no significant effects on the results are expected. Furthermore, it might be important to note that female soccer players were not included in this study due to the lack of existing literature regarding female test performances and an increased chance of unreliable test results as a result of hormonal fluctuations throughout different testing moments. However, future studies might want to take this into account.

In summary, we conclude that the nature of the exercise test affects exercise capacity measurements of soccer players, considering the significant differences found in VO_{2max} between the continuous lab tests and intermittent soccer-specific field test. This was applicable for both professional and amateur soccer players. However, this did not apply to the comparison of both laboratory tests where no significances were found at any level, this way rejecting our initial hypothesis of significantly differing peak lactate. Furthermore, the professionals showed significantly higher VO_{2max} on the YYIRTL1 than the amateurs, implying an interaction between the impact of the soccer-specific nature of the test and level of competition on the players' exercise capacity.

Recommendations for further research include a higher number of participants, inclusion of female soccer players and the collection of blood lactate during and after the YYIRTL1. Furthermore, a distinction between different field positions can be made.

5. Reference List

1. Bangsbo, J., *Fitness training for football: a scientific approach.* HO + Storm 1994.
2. Bangsbo, J., L. Norregaard, and F. Thorso, *Activity profile of competition soccer.* Can J Sport Sci, 1991. 16(2): p. 110-6.
3. Castagna, C., S. D'Ottavio, and G. Abt, *Activity profile of young soccer players during actual match play.* J Strength Cond Res, 2003. 17(4): p. 775-80.
4. Castagna, C., et al., *Aerobic fitness and yo-yo continuous and intermittent tests performances in soccer players: a correlation study.* J Strength Cond Res, 2006. 20(2): p. 320-5.
5. Chamari, K., et al., *Endurance training and testing with the ball in young elite soccer players.* Br J Sports Med, 2005. 39(1): p. 24-8.
6. Dittrich, N., et al., *Validity of Carminatti's test to determine physiological indices of aerobic power and capacity in soccer and futsal players.* J Strength Cond Res, 2011. 25(11): p. 3099-106.
7. Ekblom, B., *Applied physiology of soccer.* Sports Med, 1986. 3(1): p. 50-60.
8. Kalapotharakos, V.I., Ziogas, G. & Tokmakidis, S.V. *Seasonal aerobic performance variations in elite soccer players*. Journal of Strength and Conditioning Research, 25(6): 1502-1507, 2011 June.
9. Kemi, O.J., et al., *Soccer specific testing of maximal oxygen uptake.* J Sports Med Phys Fitness, 2003. 43(2): p. 139-44.
10. Krustrup, P., et al., *The Yo-Yo IR2 test: physiological response, reliability, and application to elite soccer.* Med Sci Sports Exerc, 2006. 38(9): p. 1666-73.
11. Machado, F.A., et al., *Effect of stage duration on maximal heart rate and post-exercise blood lactate concentration during incremental treadmill tests*. Journal of Science and Medicine in Sport, 16: 276-280, 2012 Aug.
12. McMillan, K., et al., *Lactate threshold responses to a season of professional British youth soccer.* Br J Sports Med, 2005. 39(7): p. 432-6.
13. Metaxas, T., et al., *Seasonal variation of aerobic performance in soccer players according to positional role.* Journal of Sports Medicine and Physical Fitness, 2006. 46(4): p. 520-525
14. Metaxas, T.I., Koutlianos, N.A., Kouidi, E.J. & Deligiannis, A.P. *Comparative study of field and laboratory tests for the evaluation of aerobic capacity in soccer players*. Journal of Strength and Conditioning Research, 19(1): 79-84, 2005 Feb.
15. Mohr, M., P. Krustrup, and J. Bangsbo, *Match performance of high-standard soccer players with special reference to development of fatigue.* J Sports Sci, 2003. 21(7): p. 519-28
16. Pierce S.J., Hahn A.G., Davie A. et al. *Prolonged incremental tests do not necessarily compromise VO2max in well-trained athletes.* J Sci Med Sport, 2: 356–363, 1999.
17. Santos-Silva, P.R., et al., *Reproducibility of maximum aerobic power (VO2max) among soccer players using a modified heck protocol.* Clinics (Sao Paulo), 2007. 62(4): p. 391-6.
18. Stolen, T., et al., *Physiology of soccer - An update.* Sports Medicine, 2005. 35(6): p. 501-536
19. Whitehead, E., *Conditioning of sports.* Yorkshire: E P Publishing Co. Ltd, 1975: p. 40-2.
20. Wisloff, U., J. Helgerud, and J. Hoff, *Strength and endurance of elite soccer players.* Med Sci Sports Exerc, 1998. 30(3): p. 462-7.
21. Ziogas, G.G., Patras, K.N., Stergiou, N. & Georgoulis, A.D. *Velocity at lactate threshold and running economy must also be considered along with maximal oxygen uptake when testing elite soccer players during preseason*. J Strength Cond Res, 25(2): 414-419, 2011 Feb.

APPENDICES

Appendix I. Recruitment Letter

OPLEIDING REVALIDATIEWETENSCHAPPEN & KINESITHERAPIE
REHABILITATION SCIENCES & PHYSIOTHERAPIE
FACULTEIT GENEESKUNDE EN LEVENSWETENSCHAPPEN UNIVERSITEIT HASSELT
FACULTY OF MEDICINE AND LIFE SCIENCES HASSELT UNIVERSITY
AGORALAAN GEBOUW D, B-3590 DIEPENBEEK
BELGIUM

universiteit hasselt

Betreft: deelname onderzoek inspanningstesten bij voetballers

Beste,

In het onderzoekscentrum REVAL en het ADLON Sportmedisch Adviescentrum van de Universiteit Hasselt (opleiding Revalidatiewetenschappen & Kinesitherapie) is momenteel een nieuwe studie met als titel *"Beïnvloedt de aard van de inspanningstest de inspanningscapaciteit bij voetballers?"* reeds opgestart. Concreet willen we onderzoeken welk type van inspanningstest het best de diverse aspecten (basisconditie, trainingsdrempels, verzuringsprofiel) van fysieke conditie bij voetballers meet. Dit onderzoek willen we uitvoeren bij voetballers van hoog niveau. De voetbalspelers van uw team komen hiervoor in aanmerking.
De inspanningstesten vinden plaats in het bovengenoemde onderzoekscentrum onder leiding van Prof. dr. Bert Op 't Eijnde. Er zullen twee meetmomenten plaatsvinden binnen een periode van maximaal 2 weken en ieder meetmoment zal ongeveer een 45' in beslag nemen. In functie van een goede timing voor beide partijen zullen de onderzoeken uitgevoerd worden na het seizoen 2014-2015 en voor/tijdens de voorbereiding van het seizoen 2015-2016. Idealiter dus in de periode van begin Juli.

Deelname aan het onderzoek is geheel gratis en er zal een adequate terugkoppeling van resultaten gebeuren. Dit houdt ondermeer in dat we de resultaten zullen aanbieden en verder verduidelijken alsook zal er wetenschappelijk advies voor training en wedstrijden gegeven worden. Deze resultaten bieden zeker en vast een meerwaarde voor zowel spelers als begeleiding in functie van het nieuwe seizoen.

Indien u er graag meer over wil horen mag u ons vrijblijvend contacteren.

Met vriendelijke groeten,

Studenten Revalidatiewetenschappen en Kinesitherapie:
van Dooren Stef
0478/ 69 89 01
stef.Vandooren@student.UHasselt.be

Vandenborne Pär
0472/ 22 03 29
par.vandenborne@student.UHasselt.be

O.l.v.
Prof. Dr. Op 't Eijnde
ADLON - Sportmedisch adviescentrum
REVAL - Rehabilitation Research Center
Universiteit Hasselt.

Appendix II. Informed Written Consent

PATIËNTENINFORMATIE

Titel van de studie:	Beïnvloedt de aard van de inspanningstest de inspanningscapaciteit?
Opdrachtgever:	Prof. Dr. Bert Op't Eijnde
	Faculteit geneeskunde en levenswetenschappen
	Universiteit Hasselt
Onderzoeksinstelling	REVAL – Rehabilitation Research Center
	Agoralaan, gebouw A
	B-3590 Diepenbeek
Comité voor Medische Ethiek:	Comité Medische Ethiek
	Faculteit geneeskunde en levenswetenschappen
	Universiteit Hasselt
	Campus Diepenbeek
	Agoralaan, gebouw D
	3590 Diepenbeek
Lokale artsen-onderzoekers: *Prof. Dr. Bert Op 't Eijnde & Prof. Dr. Dominique Hansen*	

U wordt uitgenodigd om vrijwillig deel te nemen aan een experimentele studie over het meten van de inspanningscapaciteit van voetballers. Alvorens deelname aan deze studie moet u hiermee schriftelijk instemmen. Om een correct beeld te geven over het verloop van het onderzoek is het van belang onderstaande informatie goed te begrijpen. Indien deze informatiebrochure informatie bevat die u niet begrijpt, zijn we uiteraard graag bereid om deze te toe te lichten. U zult een kopie van deze brochure en uw ondertekend formulier ontvangen om te bewaren. Hiernaast zal ons onderzoeksteam eveneens een kopie van dit ondertekend toestemmingsformulier bewaren. In dit informatie- en toestemmingsformulier worden het doel, de onderzoeken, de voordelen, risico's en ongemakken gepaard gaande met de studie beschreven. Ook de voor u beschikbare alternatieven en het recht om op elk ogenblik de studie te verlaten, zijn hieronder beschreven.

<u>Als u aan deze klinische studie deelneemt, dient u het volgende te weten</u>:

- ➢ Deze klinische studie wordt opgestart na evaluatie door één of meerdere ethische comité(s).
- ➢ Uw deelname is vrijwillig; er kan op geen enkele manier sprake zijn van dwang. Voor deelname is uw ondertekende toestemming nodig. Ook nadat u hebt getekend, kan u de onderzoekers laten weten dat u uw deelname wilt stopzetten. De beslissing om al dan niet (verder) deel te nemen zal geen enkele negatieve invloed hebben op de kwaliteit van de zorgen noch op de relatie met de onderzoekers.
- ➢ De gegevens die in het kader van uw deelname worden verzameld, zijn vertrouwelijk. Bij de publicatie van de resultaten is uw anonimiteit verzekerd.
- ➢ Er worden u geen kosten aangerekend voor specifieke behandelingen, bezoeken / consultaties, onderzoeken in het kader van deze studie.
- ➢ Er is een verzekering afgesloten voor het geval dat u schade zou oplopen in het kader van uw deelname aan deze klinische studie.
- ➢ Indien u extra informatie wenst, kan u altijd contact opnemen met de arts-onderzoeker of een medewerker van zijn of haar team.

Doel en beschrijving van de studie

Dit is een experimenteel-wetenschappelijk onderzoek waaraan naar verwachting ongeveer 60 Belgische voetballers zullen deelnemen, bestaande uit zowel elite- als amateur voetballers.

Het doel van de studie kan opgedeeld worden in vier onderdelen. Allereerst willen we onderzoeken in welke mate de aard van een inspanningstest de inspanningscapaciteit van een voetballer meet. Hiervoor gaan we twee laboratorium protocollen met elkaar vergelijken, namelijk maximale inspanningstests met korte vs. lange inspanningstrappen. Concreet betekent dit dat er in het korte protocol de snelheid van de loopband elke minuut verhoogt, terwijl dit in het lange protocol om de drie minuten zal gebeuren. Vervolgens onderzoeken we in welke mate deze laboratoriumtests en een voor voetbalgevalideerde veldtest gerelateerd zijn. Tot slot wordt nagegaan of het niveau van de voetbalspeler (amateur of elite) en de positie op het voetbalveld (verdediger, middenvelder, aanvaller) hierin een rol speelt.

Na rekrutering worden geïnteresseerde voetballers cardiologisch gescreend door het onderzoeksteam en al dan niet opgenomen in de voorliggende studie. Hierna volgen de proefpersonen drie meetsessies: het korte- en lange protocol op de loopband en een veldtest.

De eerste- en tweede meetsessies worden uitgevoerd in een gekruist onderzoeksdesign met een tussenpauze van maximaal twee weken. Dit wil zeggen dat de voetballers willekeurig worden ingedeeld in een van de twee loopband protocollen voor het uitvoeren van de eerste inspanningstest en vervolgens binnen een periode van twee weken ook de tweede inspanningstest uitvoeren.

De derde meetsessie is een voetbalspecifieke veldtest, namelijk de Yo-Yo veldtest. Deze veldtest zal plaatsvinden in een hiervoor geschikte sportzaal in de buurt van uw voetbalclub.

Metingen in het kader van de studie

Indien u instemt tot deelname aan de studie zullen de volgende tests en metingen worden uitgevoerd:

Meten van de lichaamssamenstelling:

Deze testen worden tweemaal afgenomen voor de afname van de laboratoriumtests. Hierbij wordt het gewicht (weegschaal), de lengte (lengtemeter) en het vetpercentage (som van 4 huidplooien) bepaald met hiervoor geschikte apparatuur.

Meten van de inspanningscapaciteit in laboratoriumcontext

Deze test wordt uitgevoerd op een loopband die manueel wordt aangepast in snelheid of hellingsgraad door de onderzoekers. De proefpersonen worden telkens op hetzelfde moment van de dag getest om invloed van het dagritme uit te schakelen. Proefpersonen dienen 30 minuten voor aanvang van elke meetsessie aanwezig te zijn. Binnen deze tijdsperiode krijgen zij de tijd om zich om te kleden en wordt de planning en bijkomende informatie toegelicht. Voorafgaand aan elke meetsessie wordt het gewicht, de lengte, de leeftijd en het vetpercentage (zie hierboven) van de proefpersonen bepaald. Na deze metingen wordt er een hartslagmeter aangebracht op de borst, waarna een warming up is voorzien. Deze warming up van tien minuten op de loopband vindt plaats in een aparte ruimte. Drie tot vijf minuten na het beëindigen van de warming up , start het een- of drie minuut protocol op de loopband. Binnen deze tijdspanne wordt er een mond/neusmasker nauwaansluitend bevestigd op het aangezicht van de proefpersoon. Door middel van dit masker zal de in- en uitgeademde lucht worden geanalyseerd. Deze gegevens geven betrouwbare informatie in functie van de maximale inspanningscapaciteit. Tijdens de test wordt de hartslagfrequentie van de proefpersoon constant gemeten door middel van de aangebrachte hartslagmeter. Op vastgelegde tijdstippen, afhankelijk van het gebruikte protocol, zullen er enkele druppels bloed uit de vingertop van de proefpersoon afgenomen worden om de mate van verzuring te bepalen.

Het ‘korte’ inspanningsprotocol start aan een snelheid van vier km/h en een basisinclinatie van één graad. Na twee minuten wordt de snelheid verhoogd tot vijf en zes km/u. Hierna wordt de snelheid elke minuut verhoogd met één km/u tot een maximale snelheid van 18 km/u. Indien een proefpersoon bij 18 km/u de test nog niet vrijwillig stopzet wordt elke vervolgminuut de inclinatie verhoogd met twee graden tot uitputting.

Het ‘lange’ inspanningsprotocol start aan een loopsnelheid van 5,4 km/u en een basisinclinatie van één graad. Tot aan een maximale snelheid van 18 km/u wordt de loopsnelheid verhoogd met een 1,8 km/u om de drie minuten. Indien een proefpersoon bij 18 km/u de test nog niet vrijwillig stopzet wordt elke vervolgminuut de inclinatie verhoogd met twee graden tot uitputting.

De metingen vinden allen plaats in een afgesloten kamer, voorzien van de benodigde apparatuur. Tenslotte is er een cooling down voorzien van tien minuten na het uitvoeren van de inspanningstest in dezelfde ruimte waar de warming up plaats vond.

Meten van de inspanningscapaciteit door middel van een veldtest

Proefpersonen worden tien minuten voor aanvang van de veldtest verwacht in de sportzaal. Binnen deze tijdsperiode kan de voetballer zich omkleden, wordt er een hartslagmeter rond de borst aangebracht en bloed afgenomen ter bepaling van de verzuring in het bloed. Hierna volgt een gestandaardiseerde warming up van tien minuten, waarna de veldtest start.

De gekozen veldtest is de Yo-Yo Intermittent Recovery Test Level 1. Hierbij moet de voetballer 2x20 meter heen en weer al lopend afleggen binnen een gradueel stijgend tijdsinterval. Deze tijdsintervallen worden aangegeven met een auditief signaal. Na 40 meter is er een herstelperiode van 10s waarin de voetballer 2x5 meter al wandelend aflegt. Vervolgens wordt dit proces herhaaldelijk uitgevoerd totdat het niet meer mogelijk is om binnen het gegeven tijdsinterval de afstand af te leggen. De voetballer krijgt één waarschuwing als dit niet binnen de gegeven tijd behaald wordt en zal bij een tweede opmerking de test moeten beëindigen. Twee minuten na het uitvoeren van deze veldtest vindt er opnieuw een bloedafname plaats voor het bepalen van de lactaatconcentratie

Opdrachtgever en locatie van de studie

De studie zal worden uitgevoerd onder de verantwoordelijkheid van Prof. Dr. Bert Op ’t Eijnde (Faculteit Geneeskunde & Levenswetenschappen, Universiteit Hasselt).

Locatie:
REVAL – Rehabilitation Research Center
Agoralaan, gebouw A
B-3590 Diepenbeek.

Duur van de klinische studie

Indien u aanvaardt aan deze studie deel te nemen, zal u tweemaal naar het onderzoekscentrum moeten komen voor het uitvoeren van de inspanningstesten en het meten van de lichaamssamenstelling binnen een periode van twee weken. Ook zal er een moment voorzien worden voor het uitvoeren van de veldtest in de periode van een week voor de uitvoering van beide laboratoriumtesten.

Vrijwillige deelname

Deelname aan het onderzoek is geheel vrijwillig. Voor het bevestigen tot deelname, graag het aangehechte toestemmingsformulier te ondertekenen. U hebt het recht om uw deelname op elk ogenblik stop te zetten, zelfs nadat u het toestemmingsformulier ondertekend heeft. U hoeft geen reden te geven voor het intrekken van uw toestemming tot deelname.

Het onderzoeksteam kan u zonder uw toestemming uit het onderzoek terugtrekken en bijgevolg uw deelname stopzetten in de volgende gevallen:

- U houdt zich niet aan de instructies voor deelname aan de studie.
- U kan door ziekte of blessure een meetmoment niet bijwonen.
- Het plots ontstaan van absolute- of relatieve (contra-) indicaties

Risico's en ongemakken

Het onderzoek wordt zodanig uitgevoerd dat er een minimale kans op risico's bestaat. Hiernaast kunnen deelnemers mogelijke ongemakken ondervinden:

- Om de lactaatconcentratie te bepalen is het noodzakelijk enkele druppels bloed van de proefpersoon te nemen. Dit gebeurt via een prikje in de vingertop. Mogelijk ervaart u hiervan een lichte pijnsensatie.
- Tijdens de inspanningstest wordt een mond/neusmasker nauw aansluitend bevestigd op het aangezicht van de proefpersoon. De proefpersoon ervaart hierdoor mogelijk een benauwend gevoel.
- De inspanningstesten gebeuren na voorafgaandelijke gunstige cardiologische controle. Ze zijn allen van maximale aard waarbij in het geval van de laboratoriumtesten de snelheid op de loopband waarden kan bereiken die ver boven de normale training- of wedstrijdintensiteit liggen. Dit brengt mogelijk een kans op vallen of blessure met zich mee. Hiernaast kan spierstijfheid na elke inspanningstest voorkomen. De uitgevoerde opwarming en cooling down zullen dit evenwel aanzienlijk beperken.
- Voorafgaand elke laboratorium inspanningstest worden de lengte en het gewicht van de proefpersoon bepaald. Ook wordt het vetpercentage gemeten door middel van huidplooimetingen. Deze metingen brengen geen risico's of ongemakken met zich mee.
- Voor aanvang van de inspanningstesten wordt een hartslagmeter rond de thorax, twee centimeter onder de tepels, aangebracht zodat de hartfrequentie gemeten wordt. Deze meting brengen geen risico's of ongemakken met zich mee.

Veiligheid/maatregelen

Door het toepassen van een warming up en cooling down reduceren we het risico op spierblessures/-pijn. Het valrisico wordt verkleind door het geven van een gewenningssessie. Een andere veiligheidsmaatregel rondom het lopen op de loopband, is het geven van instructies omtrent de noodstop. De voetballers worden voorafgaand de inspanningstests, cardiologisch gescreend.

Voordelen

Indien u aan deze studie deelneemt, kan de bepaling van uw inspanningscapaciteit nuttig zijn voor u als sporter voor het bepalen van trainingsintensiteiten alsook voor het opstellen van specifieke individuele trainingsprogramma's. Indien er een goede relatie kan aangetoond worden tussen de inspanningsparameters van de veldtest en de laboratoriumtesten wijst dit er op dat de veldtest valide instrument is en dus ook geïntegreerd kunnen worden in trainingssessies van uw voetbalteam.

De resultaten van uw eigen inspanningstest zullen u worden bezorgd en worden toegelicht. U kan ze gebruikten ter verbetering van uw eigen fysieke conditie. Voor deelname aan deze studie is er geen vergoeding voorzien.

Verzekering

Indien u of uw rechthebbenden (familie) schade ondervindt die verband houdt met deze onderzoeksstudie, zal deze schade door de opdrachtgever van deze studie vergoed worden overeenkomstig de wet inzake experimenten op de menselijke persoon van 7 mei 2004. De opdrachtgever heeft een burgerlijke aansprakelijkheidsverzekering afgesloten die de risico's en de schade, die zouden voorvloeien uit deze studie, dekken. U of uw rechthebbenden kunnen de verzekeraar rechtstreeks in België dagvaarden.

Bescherming van de persoonlijke levenssfeer

Uw identiteit en deelname aan deze studie worden strikt vertrouwelijk behandeld. U zult niet bij naam of op een andere herkenbare wijze geïdentificeerd worden in dossiers, resultaten of publicaties in verband met de studie.

Overeenkomstig de richtlijnen van goede klinische praktijk zal uw medische voorgeschiedenis, voor zover dit verband houdt met de studie, ingezien worden door het onderzoeksteam. Uw identiteit blijft geheim aangezien informatie over u enkel aan de hand van een uniek patiëntnummer (dus gecodeerd) zal worden aangeduid.

Mogelijk gebruikt de opdrachtgever de informatie over u voor andere onderzoeksdoeleinden of in het kader van de gezondheidszorg met betrekking tot vervolgstudies in kader van dit onderzoeksdomein. Enkel de gecodeerde informatie over u zal voor dit doel worden gebruikt. De persoonlijke informatie wordt mogelijk vrijgegeven aan regelgevende overheden, aan de commissie voor ethiek en aan andere organisaties die samenwerken met de opdrachtgever. Dit bereikt ook andere vestigingen van de opdrachtgever in dit land en in andere landen waar de normen inzake beheer van persoonlijke gegevens wellicht verschillend of minder strikt zijn. De opdrachtgever zal dezelfde normen inzake gegevensbescherming toepassen binnen het wettelijk kader van de betrokken landen.

De informatie zal elektronisch (d.w.z. in de computer) of handmatig verwerkt en geanalyseerd worden om de resultaten van deze studie te bepalen. U hebt het recht aan de onderzoeker te vragen welke gegevens worden verzameld in het kader van de studie en wat de bedoeling ervan is. U hebt ook het recht om aan de onderzoeker te vragen inzage in uw persoonlijke informatie te verlenen en er eventueel de nodige verbeteringen in te laten aanbrengen. De bescherming van de persoonlijke gegevens is wettelijk bepaald door de wet van 8 december 1992 betreffende de bescherming van de persoonlijke levenssfeer.

Wanneer u aan dit onderzoek deelneemt, betekent dit dat u ook toestemming geeft voor het gebruik van uw gecodeerde medische gegevens voor de hierboven beschreven doelen en het overmaken ervan aan bovenvermelde personen en/of instanties.

Kennisgeving van nieuwe informatie

Soms komt er in de loop van een onderzoeksproject nieuwe informatie aan het licht over de bestudeerde onderzoeksmethode. Indien dit het geval is, zal u op de hoogte gebracht worden van nieuwe informatie die uw bereidheid om aan deze studie verder deel te nemen, kan beïnvloeden.

In dat geval zal gevraagd worden een nieuw informatie- en toestemmingsformulier te ondertekenen. Mocht u naar aanleiding van de nieuwe informatie besluiten met het onderzoek te willen stoppen, dan zal de onderzoeksarts ervoor zorgen dat u op de beste manier verder wordt behandeld.

Indien u aan deze studie deelneemt, vragen wij u het volgende:

- ➢ Ten volle mee te werken voor een correct verloop van de studie.
- ➢ Geen informatie over uw gezondheidstoestand, de geneesmiddelen die u gebruikt of de symptomen die u ervaart te verzwijgen.
- ➢ Niet deel te nemen aan een andere klinische studie met een experimentele behandeling - ongeacht of het een studiegeneesmiddel, medisch hulpmiddel of een procedure betreft- tijdens uw deelname aan de huidige studie.

Commissie voor ethiek

Deze studie is beoordeeld door een onafhankelijke commissie voor ethiek, nl. de commissie Ethiek van de Universiteit Hasselt*,* die een gunstig advies heeft gegeven op *22/08/2014.*

Contactpersonen in geval van vragen in verband met de studie

Indien er vragen zijn over het onderzoek of de rechten als studiedeelnemer, nu- tijdens of na uw deelname, dan kan u contact opnemen met:

Pär Vandenborne - Revalidatiewetenschappen en kinesitherapie
0472/ 22 03 29

par.vandenborne@student.uhasselt.be

TOESTEMMINGSFORMULIER

universiteit hasselt
KNOWLEDGE IN ACTION

Beïnvloedt de aard van de inspanningstest de inspanningscapaciteit?

Deel enkel bestemd voor de patiënt(e) of de wettelijke vertegenwoordig(st)er:

Hierbij bevestig ik, ondergetekende (naam & voornaam) _____dat ik over de studie ben ingelicht en een kopie van de "Patiënteninformatie" en het "Toestemmingsformulier" ontvangen heb. Ik heb de informatie gelezen en begrepen. Bovendien werd mij voldoende tijd gegeven om de informatie te overwegen en om vragen te stellen, waarop ik bevredigende antwoorden gekregen heb.

– Ik heb begrepen dat ik mijn deelname aan deze studie op elk ogenblik mag stopzetten nadat ik mijn arts hierover heb ingelicht, zonder dat dit mij enig nadeel kan berokkenen.

– Ik geef toestemming aan de verantwoordelijken van de opdrachtgever *(naam invullen)* en aan regulerende overheden om inzage te hebben in mijn patiëntendossier. Mijn medische gegevens zullen strikt vertrouwelijk behandeld worden. Ik ben mij bewust van het doel waarvoor deze gegevens verzameld, verwerkt en gebruikt worden in het kader van deze studie.

– Ik ga akkoord met de verzameling, de verwerking en het gebruik van deze medische gegevens, zoals beschreven in het informatieblad voor de patiënt. Ik ga eveneens akkoord met de overdracht en de verwerking van deze gegevens in andere landen dan België.

– Ik stem geheel vrijwillig toe om deel te nemen aan deze studie en om mee te werken aan alle gevraagde onderzoeken. Ik ben bereid informatie te verstrekken i.v.m. mijn medische geschiedenis, mijn geneesmiddelengebruik en eventuele deelname aan andere studies.

Datum: _____

Handtekening patiënt(e) (of wettelijk vertegenwoordig(st)er):_____

Deel enkel bestemd voor het onderzoeksteam

Ik, ondergetekende, _____, bevestig hierbij dat ik, _____ (naam van de patiënt(e) voluit) of zijn wettelijke gegevens vertegenwoordig(st)er) heb ingelicht en dat hij (zij) zijn (haar) toestemming heeft gegeven om deel te nemen aan de studie.

Datum: _____

Handtekening: _____

Appendix III. Approval Medical Ethical Committee

CORRESPONDENTIEADRES
Campus Virga Jesse
Stadsomvaart 11
3500 Hasselt

JESSA ZIEKENHUIS

Ethische Toetsingscommissie

ADVIESFORMULIER

- ■ studieprotocol
- □ amendement protocol
- □ medical need program

VOORZITTER
dr. Koen Magerman

SECRETARIAAT
Katrien Jaemers
katrien.jaemers@jessazh.be

CONTACT
ethische.toetsingscommissie@jessazh.be

ONS KENMERK
14.64/reva14.08

Hasselt, 22 augustus 2014

Titel protocol: Beïnvloedt de aard van de inspanningstest ook de inspanningscapaciteit bij voetballers?

Acroniem:
Firma: /
Belgisch registratien°:
Onderzoeker(s): Dominique Hansen
Bert Op 't Eijnde

Geachte collega,

Op 22/08/2014 maakte de Ethische Toetsingscommissie opmerkingen in verband met het ingediende studiedossier.
Hierbij bevestigen wij dat we uw **aangepaste** studieaanvraag ontvingen:

- ■ informatie- en toestemmingsformulier, versie oktober 2014

De gewijzigde documenten voldoen aan de gestelde opmerkingen en zullen aan het studiedossier toegevoegd worden.
De Ethische Toetsingscommissie geeft hierbij haar **definitieve goedkeuring** voor de start van het onderzoek.

De Ethische Toetsingscommissie is georganiseerd en handelt volgens de richtlijnen van GCP/ICH.

In bijlage vindt u de ledenlijst van de Ethische Toetsingscommissie.

Met vriendelijke groeten,

Ter goedkeuring,

Dr. Koen Magerman
Voorzitter Ethische Toetsingscommissie
Jessa Ziekenhuis

17 oktober 2014

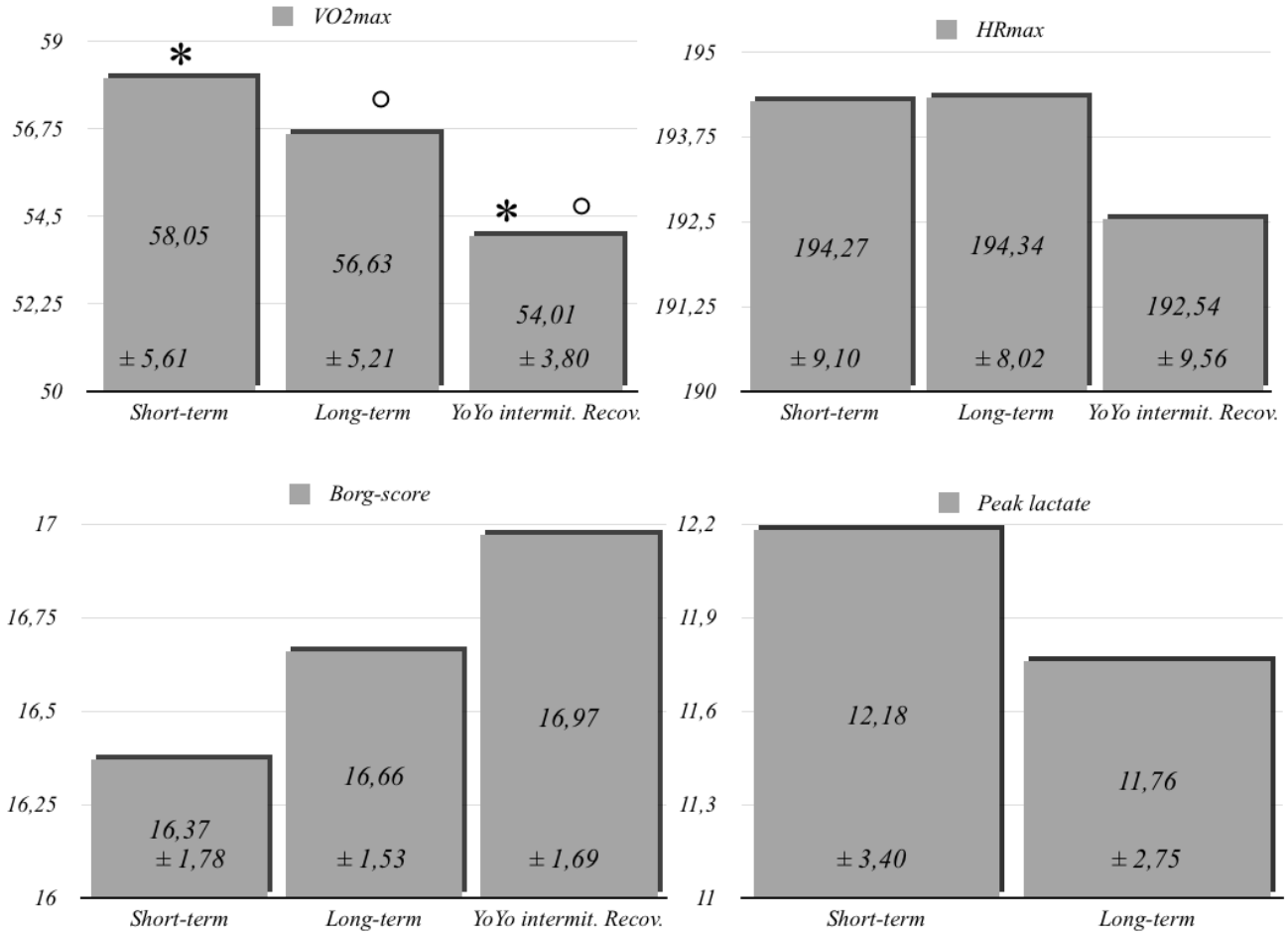
Jessa Ziekenhuis

Ledenlijst Ethische Toetsingscommissie 2014

Dr. Koen Magerman, voorzitter – klinisch bioloog
Dr. Johan Vanwalleghem, ondervoorzitter – nefroloog
Dr. Brigitte Maes, secretaris – klinisch biologe
Mevr. Mieke Bieghs – apotheek
Dr. Marcel De Ruyter – klinisch bioloog
Mevr. Chris Desmet – zorgmanager, verpleegkundige
Mevr. Lies De Waele – apotheek
Mevr. Katrien Jaemers – management assistant
Dhr. Pros Vanhelmont – jurist
Dr. Herman Kuppers – huisarts
Dr. Bjorn Stessel – anesthesist
Dr. Nikolaos Mortzos – endocrinoloog
Dr. Wendy Werckx – pediater
Mevr. Nathalie Cardinaels - psychologe

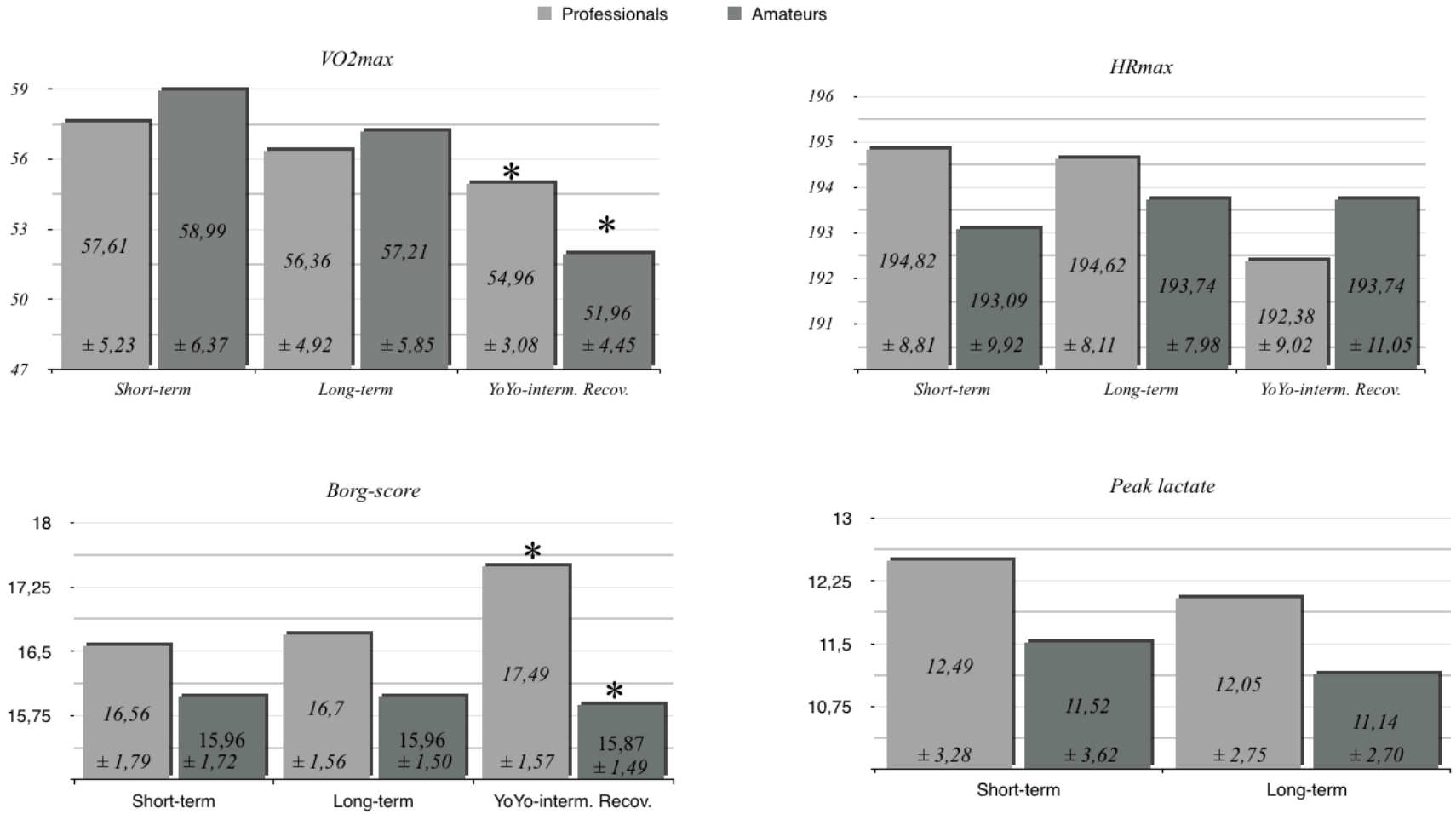
De vzw Jessa Ziekenhuis is een fusie tussen het Virga Jesseziekenhuis en het Salvator-St-Ursulaziekenhuis
Maatschappelijke zetel: Salvatorstraat 20, 3500 Hasselt

Appendix IV. Physiological variables of the different exercise tests



Data represent physiological values obtained during a Short-term (ST, 1-min exercise steps, + 1km/h) and Long-term (LT, 3-min exercise steps, + 1,8km/u) maximal graded exercise tests and the YoYo intermittent recovery test (YYIRTL1) and are expressed as means ± SD's. +p<0,05° compared to YYIRTL1. Peak lactate values were only derived from both laboratory tests.*

Appendix V. Physiological variables of different soccer levels



Comparison between professional (light grey) and amateur (dark grey) soccer players.
Data represent physiological values obtained during a Short-term (ST, 1-min exercise steps, + 1km/h) and Long-term (LT, 3-min exercise steps, + 1,8km/u) maximal graded exercise tests and the YoYo intermittent recovery test (YYIRTL1) and are expressed as means ± SD's. +p<0,05 compared to YYIRTL1.*

Auteursrechtelijke overeenkomst

Ik/wij verlenen het wereldwijde auteursrecht voor de ingediende eindverhandeling:
Does the type of exercise test affect exercise capacity measures in soccer players?

Richting: **master in de revalidatiewetenschappen en de kinesitherapie-revalidatiewetenschappen en kinesitherapie bij musculoskeletale aandoeningen**
Jaar: **2016**

in alle mogelijke mediaformaten, - bestaande en in de toekomst te ontwikkelen - , aan de Universiteit Hasselt.

Niet tegenstaand deze toekenning van het auteursrecht aan de Universiteit Hasselt behoud ik als auteur het recht om de eindverhandeling, - in zijn geheel of gedeeltelijk -, vrij te reproduceren, (her)publiceren of distribueren zonder de toelating te moeten verkrijgen van de Universiteit Hasselt.

Ik bevestig dat de eindverhandeling mijn origineel werk is, en dat ik het recht heb om de rechten te verlenen die in deze overeenkomst worden beschreven. Ik verklaar tevens dat de eindverhandeling, naar mijn weten, het auteursrecht van anderen niet overtreedt.

Ik verklaar tevens dat ik voor het materiaal in de eindverhandeling dat beschermd wordt door het auteursrecht, de nodige toelatingen heb verkregen zodat ik deze ook aan de Universiteit Hasselt kan overdragen en dat dit duidelijk in de tekst en inhoud van de eindverhandeling werd genotificeerd.

Universiteit Hasselt zal mij als auteur(s) van de eindverhandeling identificeren en zal geen wijzigingen aanbrengen aan de eindverhandeling, uitgezonderd deze toegelaten door deze overeenkomst.

Voor akkoord,

Vandenborne, Pär **van Dooren, Stef**