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An Application of Incremental Running Test Results to Train Professional Soccer Players

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Key words: *soccer, heart rate, lactate threshold, intermittent exercise, individualization.*

Abstract

Background: *The aim of this study was to lay out an incremental running test to determine anaerobic threshold and its usefulness as a predictability factor of the physiological load on professional soccer players during soccer training activities.*

Material/Methods: *Subjects performed multi-stage incremental running test at three time points throughout the soccer season on a synthetic soccer pitch to determine the lactate threshold. The initial speed was set at 2.8 m/s and increased by 0.4 m/s after each stage until termination. HR was recorded at 5-second intervals by the Polar heart rate monitor (Polar Electro, FIN) at the end of each 3.30 – 5 min running stage. A capillary blood sample was taken from the fingertip during 1 minute rest between stages. Blood lactate concentration from each sample was assigned to the corresponding values of the heart rate and the running speed. Beaver method was used to determine the lactate threshold (LT) and the corresponding values of HR (HR/LT) and the running speed (V/LT). According to V/LT and HR/LT players were assigned to running and training groups for optimal individualization of the training process. Players performed some training activities like running or small-sided games in those groups.*

Results: *The velocity at LT in the first test was 3.61 ± 0.22 m/s and increased during the preparation period (Test 2 – 3.79 ± 0.21 m/s). A further increment was observed during the soccer season. HR/LT was 173.90 ± 7 bpm in the first test and decreased after preseason preparations to 168.58 ± 6.78 bpm. During the soccer season no significant changes were observed.*

Conclusions: *In this study we have observed that aerobic fitness increased during the preparation period and a further increment was observed after the competitive season. The present study shows V/LT and HR/LT as useful indicators for programming and monitoring training loads.*

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Introduction

It is widely known that soccer is a high-intensity acyclic activity which requires a combination of aerobic capacity with anaerobic elements. During a soccer match, when the best players usually cover a distance of 10–12 km, average work intensity is close to the lactate threshold (LT) which corresponds to 80–90% of HRmax [1,2]. Aerobic capacity is an important feature for the evaluation of performance in soccer players [3,4]. Physical conditioning and aerobic capacity, in particular, depend on important elements such as maximal oxygen consumption (VO_2max) and lactate threshold (LT) [5]. Both of these indicators accurately determine the level of physical fitness. However, LT defined as the highest workload, oxygen consumption or heart frequency in dynamic work using large muscle groups, at which production and elimination of lactate balances [6] seems to be a much more sensitive indicator of the physiological load than VO_2max [7]. Well-programmed and effective high intensity training improves VO_2max, running economy and reduces the blood lactate accumulation during submaximal running [8]. The positive impact of HIT (high-intensity training) on match performance was proved as well. In endurance sports, LT might be a better indicator of aerobic endurance performance than VO_2max. LT might also change without alterations in VO_2max and a higher LT means, theoretically, that a player could maintain higher average intensity in an activity without accumulation of blood lactate [1].

The aim of this study was to lay out an incremental running test to determine the anaerobic threshold and its usefulness as a predictability factor of physiological load on professional soccer players during soccer training activities.

Material and methods

19 professional soccer players completed 3 incremental running tests on a synthetic soccer pitch. The first test (Test 1) took place at the beginning of the preparation period, the second test (Test 2) was completed at the beginning of the soccer season and the third one (Test 3) at the end of the season. The intensity of training sessions two days before each test was limited.

Tab. 1 Physical characteristics of players (n = 19)

	Age [years]	Mass [kg]	Height [cm]
Mean	24.42	79.44	184.05
SD	3.34	6.67	7.41

The protocol of the test, based on Jastrzębski [9], included 3:30 – 5 minute running stages separated by a 1-minute rest during which a capillary blood sample was taken from the fingertip. The initial speed was set at 2.8 m/s and increased of 0.4 m/s after each stage. There were 4 reference points situated along the 300 m circuit and players followed an acoustic signal to maintain the determined running speed. Additionally, subjects were verbally instructed when they have to be at the reference point. A scheme of the test is presented in Figure 1.

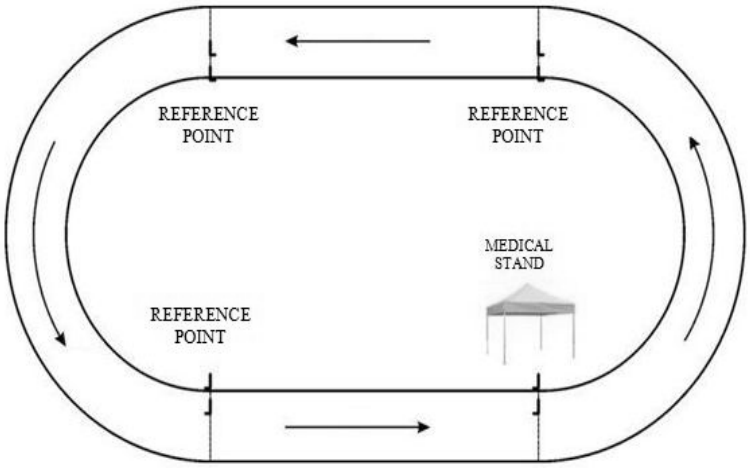

Fig. 1. Scheme of the incremental running test

Heart rate was recorded using a short-wave telemetry device (Polar Electro OY, Finland). HR at the end of each stage was considered as a corresponding value to the running speed and the blood lactate concentration. Figure 2 presents a record of HR during the incremental running test. Blood samples were analyzed for lactate concentrations in a laboratory using EPOLL 200 spectrophotometer. The Beaver method [10] was used to determine the lactate threshold. After the test the players were assigned to 6 running and training groups/teams for optimal individualization of the training process. Some training activities like running or small sided games were performed in those groups.

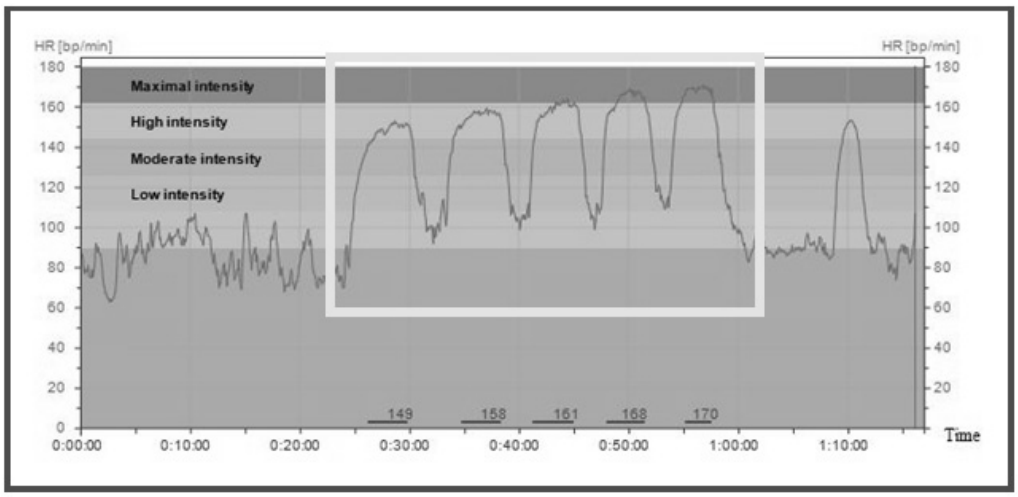

Fig. 2. Record of HR during the incremental running test

Results are presented as mean ± SD. All data sets were assessed with an assumption of normality using Shapiro-Wilk's test for normality of statistical distribution. The Levene test was used to check the homogeneity of variances. A repeated measures analysis of variance (ANOVA) was used for dependent variables (V/LT and HR/LT). The post-hoc Tukey test of honest significant difference (HSD) was applied to identify existing differences. The statistical significance was set at $p < 0.01$. All statistical analyses were carried out using STATISTICA 8.0.

Results

The lowest values (3.63 ± 0.22 m/s) of running speed at the lactate threshold were noted in Test 1, at the beginning of pre-season preparations. In the second test V/LT was higher (3.79 ± 0.21 m/s) and finally increased to 3.91 ± 0.24 at the end of the soccer season. A significant difference was observed between Test 1 and Test 3. HR/LT in the Test 1 was 173.90 ± 7 bpm and decreased after preparation period (Test 2 – 168.58 ± 6.78 bpm). HR/LT did not change significantly during the season. Mean and standard deviation data for V/LT and HR/LT are displayed in Table 2.

Tab. 2. Running speed and heart rate relative to lactate threshold intensity (mean ± SD; * significant differences at p < 0.01)

	Test 1	Test 2	Test 3
Running speed/LT [m/s]	3.63 ± 0.22	3.79 ± 0.21	3.91 ± 0.24*1-3
HR/LT [bpm]	173.90 ± 7.00	168.58 ± 6.78	170.37 ± 7.45

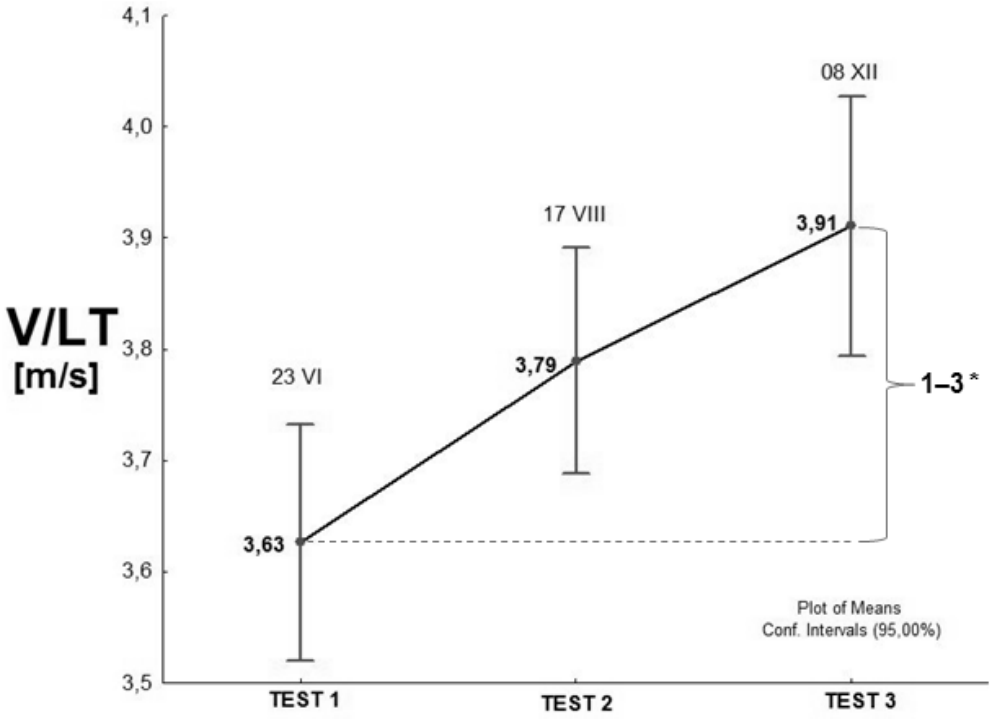

Fig. 3. Changes of running speed at LT (V/LT) during a soccer season *(*significant differences at p < 0.01)*

In this study we decided to lay out some examples of training sessions during which values of V/LT and HR/LT might be used. Training sessions using V/LT indicator included running activities. Players assigned to the same group ran together with the same speed. Heart rate monitors were used during the run to check if the running velocity corresponds with the assumed speed (Fig. 4). Two examples of high intensity training sessions are presented in this study as well. The first one (Fig. 5) shows 4 x 5 minutes of run at V/LT separated with 3 min of active rest (stretching). To confirm the correctness of a training load, blood samples were taken from randomly chosen subjects after runs and blood lactate concentration was determined. The HIT running training session is usually performed twice a week in the preparation period and once a week in the

competitive season. Figure 6 shows a HR record of the training session which includes two series of small-sided games (four-a-side, in an area of approximately 40 x 30 m, 4 x 1 minute separated with 2 minutes of active rest and 3 x 2 minutes separated with 2.5 minute of active rest). The main assumption was that during each game the players have to reach the intensity corresponding to the lactate threshold or higher, i.e. 80–90% of HRmax. Results of HR responses to this effort were set in the table (Tab. 3) where marked values mean that the intensity was below the lactate treshhold (HR_{game} < HR/LT) so the players did not work as directed in those games. A clear exposition of performed small-sided games allows players to evaluate their commitment. The frequency of this type of training sessions is usually twice a week in the pre-season period and once a week during the soccer season.

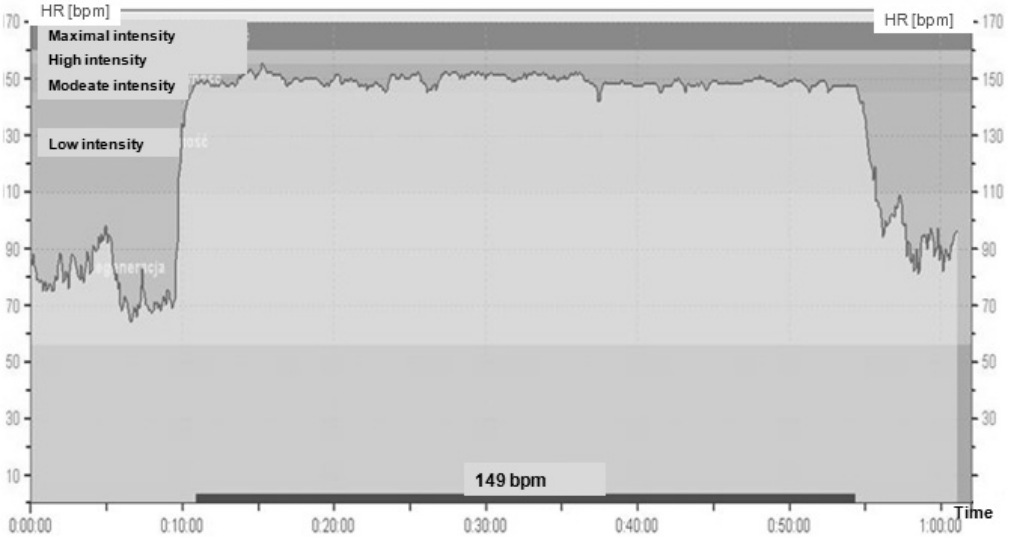

Fig. 4. Record of HR during 45 minutes of aerobic running at HR/LT – 10 bpm

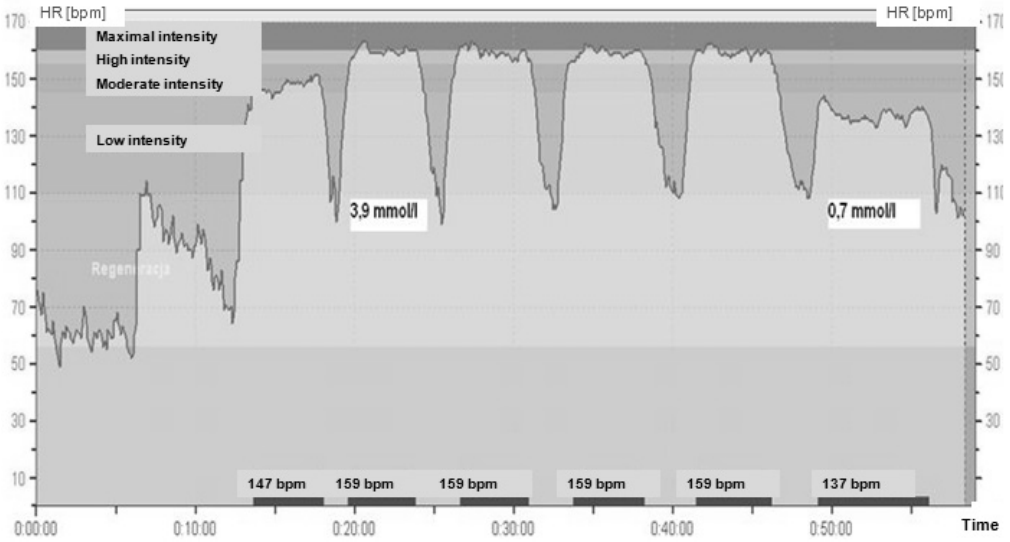

Fig. 5. Record of HR during 4 x 5 minutes of run at V/LT

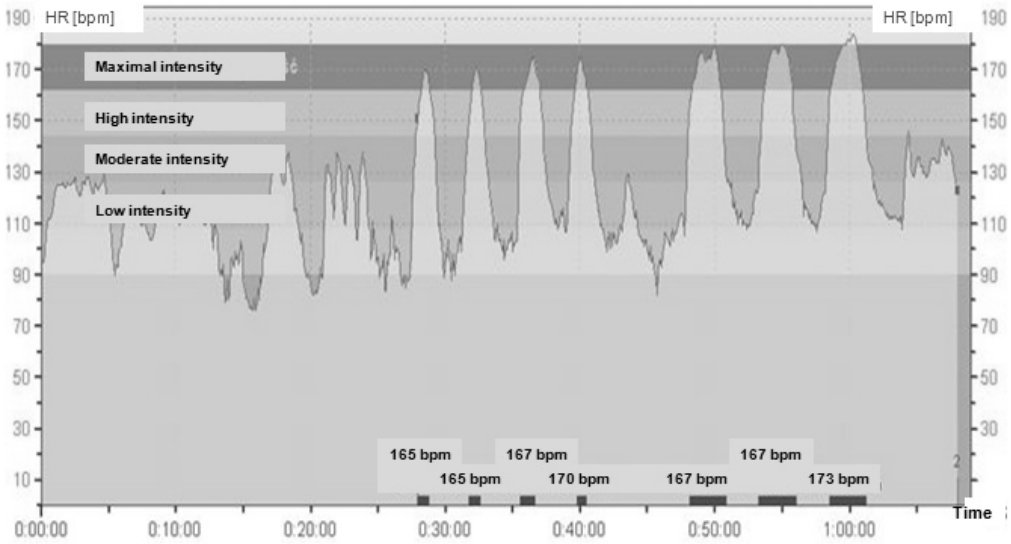

Fig. 6. Record of HR during a small sided games training session

Tabl. 3 HR values [bpm] during each small sided game (* - HR values below LT)

Player	HR/LT	Game 1	Game 2	Game 3	Game 4	Game 5	Game 6	Game 7
1	**168**	179	182	181	**164***	169	171	171
2	**178**	178	186	186	178	**174***	180	185
3	**159**	**155***	160	168	**157***	**156***	161	168
4	**167**	**156***	169	171	**156***	169	**166***	175
5	**158**	**155***	160	164	158	160	169	162

Discussion

Test 1 was performed immediately after 3 weeks' summer break, which was probably the reason for a low level of running speed at the lactate threshold. After 7 weeks of preparations V/LT increased with a coexistent decrease in the heart rate at LT. Interestingly, during the competitive season a further increment was observed. McMillan et al. [11] in their study checked running velocity at blood lactate concentration of 4 mmol/l at six different points of the season using a flat treadmill. At the beginning of the preparation period running velocity at LT (4mmol/l) was 3.78 m/s what is 0.15 m/s more than in the current study. The increment of running speed at LT at the early weeks of the competitive playing season was also greater in McMillan's study (0.3 m/s vs. 0.16 m/s) [11]. But there was no further increment observed during the competitive season in contrast to our findings. Di Michelle et al. [12] found differences between physiological responses to an incremental running test on a treadmill and synthetic turf. Running speed at blood lactate concentration of 4 mmol/l measured on a treadmill was significantly higher than on synthetic grass. Helgerud et al. [1] determined the running speed at the lactate threshold of junior elite soccer players before and after the pre-season preparations using treadmill at 3° inclination. V/LT in this research at the beginning of preparations was definitely lower (3.09 m/s) in comparison to the current study but during 8 weeks of preparations significantly increased to the level comparable with our results (3.75 vs. 3.79 m/s).

Knowledge of the players' level of physical fitness is an indispensable component of programming an effective training process. The lactate threshold is regarded as one of the most practical indicators of soccer players' physical fitness. Values of HR and running speed relative to LT allow soccer coaches to individualize physical loads and control the correctness of training performance [13]. The intensity of the soccer training depends on the part of the season. During the preparation period training includes many components directed at improving physical fitness. When the soccer season starts, coaches usually try to avoid performing high intensity training sessions more than twice a week.

A large number of studies [1,2,3,8,14] proved that high intensity training (HIT) is very effective in soccer players and improves their aerobic capacity and match performance. In this study some examples of results of high intensity training sessions are presented.

During the competitive season Ferrari Bravo et al. [13] completed 8-week running training where subjects preformed 4 x 4 minutes of run separated with 3 minutes of rest at 90–95% HRmax twice a week. His subelite players significantly improved their VO_2max (6.6%) and VO_2 at the respiratory compensation point (3.7%). Junior elite players in Helgerud's et al. [1] study undertook similar training during the pre-season period. Positive physical adaptations were observed after 8 weeks of this training. VO_2max (10.8%), V/LT (21.6%), VO_2/LT (15.9%) and running economy (6.7%) increased significantly. Moreover, important performance changes where noted. The total distance covered during a match increased by about 20%, and the number of sprints by about 100%. Impellizzeri et al. conducted the same training for 12 weeks (4 weeks in pre-season and 8 weeks in the season) and very similar adaptations were found including 22.8% increment of high intensity activity during the match. Using indicators such as HR/LT and V/LT allows performing such an intensive training in a proper way.

Some researchers [8,15] claim that high-intensity training through typical football exercises is the most effective form of improving physical fitness of soccer players. Because of their similarity to the game, specific loads such as small-sided games provide adaptations typical of this sport. In the study of Impellizzeri et al. [16] 14 junior elite soccer players twice a week performed small sided games 4 x 4 minutes at 90–95% HRmax separated with 3 minutes of rest for 12 weeks (4 in pre-season and 8 in season). After this training players improved their VO_2max (7.1%), V/LT (9.7%) and VO_2/LT (10.8%). Additionally, the total distance and high intensity activity during the match increased significantly as well. Hill-Haas et al. [14] observed after 7 weeks of using small-sided games training protocol (3 – 6 x 6 – 13 min, 1 – 2 min rest, 2 x week, above 80% HRmax) a 17% improvement in the yo-yo intermittent recovery (YYIR) soccer specific test performance. In specific high intensity training technical, tactical and coordination skills are trained in similar conditions to match performance. When carrying out fitness training with the ball, it is fundamental to make sure that players exercise at the desired intensity [8]. An assumption that players with higher V/LT should play against each other seems to be advisable.

Conclusion

In this study we observed that aerobic fitness increased during the preparations period and a further increment was observed after the competitive season. The present study lays out V/LT and HR/LT as useful indicators for programming and monitoring physical loads particularly when high intensity training with or without the ball is performed.

References

1. Helgerud J, Engen LC, Wisloff U, et al. Aerobic endurance training improves soccer performance. *Med Sci Sports Exercise* 2001;11:1925–31.
2. McMillan K, Helgerud J, Wisloff U. Physilogical adaptations to soccer specific endurance training in professional youth soccer players. *Br J Sports Med* 2005;39:273–277.
3. Reilly T. Energetics of high-intensity exercise (soccer) with particular reference to fatigue. *J Sports Sci* 1997;15:257–263.

4. Reilly T, Secher N. Physiology of sports: An overview. In: Reilly T, Secher N, Snell P, Williams C, editors. *Physiology of Sport.* London: E & FN Spon; 1990:465–485.
5. Metaxas TI, Koutlianos NA, Koudi EJ, Deligiannis AP. Comparative study of field and laboratory tests for the evaluation of aerobic capacity in soccer players. *J Strength Cond Res* 2005;19(1):79–84.
6. Helgerud J, Ingjer JF, Stromme SB. Sex differences in performance-matched marathon runners. *Eur J Appl Physiol* 1990;61:433–439.
7. Helgerud J. Maximal oxygen uptake, anaerobic threshold and running performance in woman and men with similar performances levels in marathons. *Eur J Appl Physiol* 1994;68:155–161.
8. Iaia FM, Rampinini E, Bangsbo J. High intensity training in football. *Int J Sport Physiol Perform*, 2009;4:291–306.
9. Jastrzębski Z. Zakres obciążeń treningowych w piłce nożnej i ręcznej a ich wpływ na rozwój sportowy zawodników [Scope of training loads in handball and soccer and their influence on sports development of competitors]. Gdańsk AWFiS; 2004 [in Polish].
10. Beaver WL, Wasserman K, Whipp BJ. Improved detection of lactate threshold during exercise using a log-log transformation. *J Appl Physiol* 1985;59:1936–40.
11. McMillan K, Helgerud J, Grant SJ, et al. Lactate threshold responses to a season of professional British youth soccer. *Br J Sport Med* 2005;39:432–436.
12. Di Michele R, Di Renzo AM, Ammazzalorso S, Merni F. Comparison of physiological responses to an incremental running test on treadmill, natural grass and synthetic turf in young soccer players. *J Strength Cond Res* 2009;23(3):939–945.
13. Eniseler N. Heart rate and blood lactate concentrations as predictors of physiological load on elite soccer players during various soccer training activities. *J Strength Cond Res* 2005;19(4):799–804.
14. Ferrari Bravo D, Impellizzeri FM, Rampinini E, Castagna C, Bishop D, Wisloff U. Sprints vs. interval training in football. *Int J Sport Med* 2008;29(8):668–674.
15. Hill-Haas S, Coutts AJ, Dawson BT, Rowsell GJ. Generic versus small-sided game training in soccer. *Int J Sport Med* 2009;30(9):636.
16. Impellizzeri F, Marcora S, Castagna C, Reilly T, Sassi A, Iaia FM, Rampinini E. Physiological and performance effects of generic versus specific aerobic training in soccer players. *Int J Sport Med* 2006;27(6):483 – 492.