THE COMPARE OF OXYGEN UPTAKE KINETICS OF YOUNG SOCCER PLAYERS ACCORDING TO PLAY POSITIONS

[1]Hamit CİHAN, [2]Erdal ARI, [3]İbrahim CAN, [4]Bahadır DEMİR
[1]Karadeniz Technical University Physical Education and Sports School, Turkey.
[2]Ordu University Physical Education and Sports School, Turkey.
[3]Gümüşhane University Physical Education and Sports School, Turkey.
[4]Physical Education Teacher, Ministry of the National Education, Turkey.

Abstract

The purpose of this study was to compare oxygen uptake kinetics, ventilatory threshold of young soccer players according to playing position and to determine relationship between oxygen uptake kinetics and ventilatory threshold of young soccer players. Twenty-three young soccer players joined to study voluntarily (n=23; age: 19.8±0.4 years, body height: 179.4±7.2 cm., body mass: 74.2±7.4 kg., VO_2max: 59.7±8 ml/kg/min.). The players were categorized according to playing positions. The VO_2max, ventilatory threshold were determined by incremental treadmill test. Then, treadmill test at running velocity determined VO_2max was performed and oxygen uptake kinetics were identified by mono-exponentinal model. The time to achieve 95% of VO_2max, spending time at VO_2max were accepted as oxygen uptake kinetics. The correlation among time to achieve 95% of VO_2max, spending time at VO_2max and ventilatory threshold values of young soccer were determined by correlation anlyze and differences according to playing positions were identified by one-way analysis of variance. It was determined significiant negative correlation between time to achieve 95% of VO_2max and spending time at VO_2max ($r=-0.526$, $p<0.05$). The no significiant difference among playing positions was found without time to achieve 95% of VO_2max. The centerbacks had higher time to achieve 95% of VO_2max values than goalkeepers ($p<0.05$) but no significiant difference among other playing positions was found ($p>0.05$). Consequently, it could be said that reaching to steady-state level early during exercise could shorten time to achieve 95% of VO_2max and increase spending time at VO_2max.
Key Words: Oxygen uptake kinetics, soccer, play position.

GENÇ FUTBOL OYUNCULARININ OKSİJEN TÜKETİMİ KİNETİKLERİNİN MEVKİLERİNE GÖRE KARŞILAŞTIRILMASI

Özet

Bu çalışmanın amacı genç futbol oyuncularının oksijen tüketimi kinetikleri ile solunum eşiği değerleri arasındaki ilişkiyi belirlemek ve oyuncuların mevkilerine göre oksijen tüketimi kinetikleri ve solunum eşiği değerlerini karşılaştırmaktır. 23 genç futbol oyuncusu gönüllü olarak çalışmaya katılmıştır (n = 23, yaş: 19.8±0.4 yıl, boy uzunluğu: 179.4±7.2 cm., vücut ağırlığı: 74.2±7.4 kg., VO_2max: 59.7±8 ml/kg/dk.). Maksimum oksijen tüketimi (VO_2max) ve solunum eşiği değerleri, koşu bandında uygulanan ve koşu hızı giderek artan test protokolüyle belirlenmiştir. Daha sonra VO_2max değerine tekabül eden koşu hızında test uygulanmıştır ve oksijen tüketim kinetiği değerleri mono-exponentinal model yardımıyla belirlenmiştir. VO_2max değerinin % 95'ine ulaşılan süre ve VO_2max değerinde geçirilen süre, oksijen tüketimi kinetikleri olarak kabul edilmiştir. VO_2max değerinin % 95'ine ulaşılan süre, VO_2max değerinde geçirilen süre ve solunum eşiği değerleri arasındaki ilişkiler korelasyon analiziyle, mevkilere göre farklılıklar ise tek yönlü varyans analiziyle belirlenmiştir. VO_2max değerinin % 95'ine ulaşılan süre ile VO_2max değerinde geçirilen süre arasında negatif yönlü ve anlamlı bir ilişki tespit edilmiştir ($r=-0.526$, $p<0.05$). VO_2max değerinin % 95'ine ulaşılan süre hariç olmak üzere diğer değerler bakımından oyuncuların mevkileri arasında anlamlı farklılık görülmemiştir. VO_2max değerinin % 95'ine ulaşılan süre bakımından stoper oyuncularının kalecilerden daha yüksek değerlere sahip olduğu ($p < 0.05$), diğer mevkiler arasında ise herhangi bir farklılık olmadığı belirlenmiştir. Sonuç olarak egzersizde steady-state seviyesine kısa zamanda ulaşmanın VO_2max değerinin % 95'ine ulaşılan süreyi kısaltabileceği ve VO_2max değerinde geçirilen süreyi arttırabileceği ifade edilebilir.
Anahtar Kelimeler: Oksijen tüketim kinetikleri, futbol, mevki.

Introduction

The capacity of oxygen using during exercise was important for performance. Maximum oxygen uptake (VO_2max) was the highest oxygen amount utilized by body during exercise (Bassett and Howley, 2000). VO_2max is a important parameter effecting aerobic performance of athletes. At initial of incremental exercise, oxygen uptake (VO_2) increases linearly until steady-state level is achieved. VO_2 rises mono-exponentially to reach steady-state level within 2-3 minutes after onset of constant moderate exercise (Carter et al., 2000). The oxygen deficit exists at part between initial of incremental exercise and steady-state level. The amount of oxygen deficit effects reach time to steady state level. Time constant parameter (τ) is estimated by exponential function during period of reach to steady-state level (Burnley and Jones, 2007) The τ parameter is equal to 63 % of final VO_2 response determined by monoexponential function (Jones and Poole, 2005) The τ parameter determines amount of oxygen deficit. It means that a smaller value of τ parameter diminishes reach time to steady state level and is required to anaerobic energy systems. The fatigue will be delayed since it is smally required to support of anaerobic energy systems (Burnley and Jones, 2007).

Soccer is a intermittent sport branch required high level of aerobic fitness parameters. The avarage VO_2max values of elite soccer players was determined between 56.8 and 67.6 ml/kg/min (Al-Hazzaa et al., 2001; Árnason et al., 2004; Bangsbo and Lindquist, 1992; Bangsbo et al., 1991; Casajús, 2001; Davis et al., 1992; Rhodes et al., 1986; Strudwick et al., 2002; Wisloeff et al., 1998). Also, it was determined that increase of VO_2max and running economy (5 ml/kg/min and 7 %, respectively) improved match performance of soccer players (Chamari et al., 2005; Helgerud et al., 2001). The energy costs of activities performed at soccer game such as dribbling with ball are similar to energy costs of laboratory treadmill tests performed with inclination for determining VO_2max (Kemi et al., 2003). The soccer players having high values of aerobic capacity performs soccer activities with less energy cost and delays fatigue at exercise as VO_2 of muscles is high.

Although many studies were performed regarding activity profiles and covered distance values during soccer game of young soccer players, no study was performed regarding VO_2 kinetics of young soccer players according to playing position. The investigating of VO_2 kinetics of young soccer players according to play position will be useful for developing performances of players, planning of trainings and determining of physiological requirements of play positions. Therefore, aim of this study was to compare VO_2kinetics and ventilatory threshold (Vt) values of young soccer players according to playing position, to determine relationship between VO_2 kinetics and Vt values of young soccer players and to test the hypothesis that VO_2 kinetics and Vt values of young soccer players will diferentiate according to playing positions.

Method

Research Group

Twenty-three young soccer players playing young team category of professional soccer team placing Turkish Super League participated to this study voluntarily (n=23; age: 19.8±0.4 years; body height: 179.4±7.2 cm; body mass: 74.2±7.4 kg; VO_2max: 59.7±8 ml/kg/min). Twenty-three young soccer players were divided to six playing position categories as goalkeepers (n=3; age: 19.7±0.5 years; body height: 186.3±1.5 cm; body mass: 83.1±2.8 kg; VO_2max: 52.3±1.2 ml/kg/min), fullbacks (n=4; age: 19.8±0.5 years; body height: 176.8±2.8 cm; body mass: 67.9±4.7 kg; VO_2max: 62.3±0.5 ml/kg/min), centerbacks (n=4; age: 19.8±0.5 years; body height: 185.5±7.9 cm; body mass: 79.3±9.9 kg; VO_2max: 59.3±5.6 ml/kg/min), midfielders (n=4; age: 19.8±0.5 years; body height: 176.8±2.8 cm; body mass: 67.9±4.7 kg; VO_2max: 69.3±8.8 ml/kg/min), wingers (n=4; age: 19.8±0.5 years; body height: 169.8±1.7 cm; body mass: 68.0±1.2 kg; VO_2max: 58.3±3.4 ml/kg/min), forwards (n=4; age: 20 years; body height: 182.3±2.6 cm; body mass: 74.4±0.7 kg; VO_2max: 55±11.2 ml/kg/min). The study was applied according to the Helsinki Declaration and objective and possible risks of study were explained to all participants. Also, it was said that all participants could leave from study at any time.

Collection of Datas

The research was performed at pre-season period of young soccer team. The young soccer team had pre-season preparatory camp. The VO_2max and Vt values of young soccer players were measured by incremental treadmill test. All players were informed about test protocol. Maximum effort was exhibited by players during test protocol. The incremental treadmill test was performed for determining VO_2max and Vt values of young soccer players. The initial velocity of incremental velocity test was 10 km/h. Then velocity was increased by 1 km/h at every 3 minutes until exhaustion. The test was finished when players exhausted and didn't continue test due to fatigue. VO_2 values during incremental test were measured as breath-by breath by telemetric system (Cosmed K4b^2, Rome, Italy). Average values of expired gas at every 5 seconds were determined during incremental test. Before incremental test, calibration of oxygen analyzer system was done according to instructions of device calibration. The criterias of VO_2max determination were plateau in VO_2 despite constant increase of running velocity and heart rate value passing 90% of maximal heart rate predicted previously (Taylor et al., 1955). The running velocity of VO_2max (vVO_2max) was determined by identify the lowest running velocity VO_2max occured (Billat and Koralsztein, 1996). Also Vt was determined by incremental treadmill test.

After 3 days from incremental test, players performed treadmill test at 100% of vVO_2max (100% vVO_2max test) until exhaustion. Before 100% vVO_2max test, players performed warm-up for 15 minutes at 60% of vVO_2max and stretching exercises for 5 minutes. 100% vVO_2max test was initialized and players were encouraged for maintaining test until exhaustion. VO_2 value was measured by gas

analyzer during test. VO_2 plateau was observed at 95% of VO_2max. Therefore time to achieve 95% of VO_2max (ta-95%VO_2max) was time to achieve VO_2max (ta-VO_2max). The ta-95%VO_2max and spending time at VO_2max (t-VO_2max) values of players were computed as below:

$$VO_2\ (t) = VO_{2baseline} + A \times (1 - e^{-(t / \tau)}) \text{ (Mono-exponential function)} \quad (1)$$

At this mono-exponential function, VO_2 (t) is oxygen uptake value of time t, $VO_{2baseline}$ is oxygen uptake value measured after warm-up period, A is amplitude at oxygen uptake value (VO_2max - $VO_{2baseline}$) and τ is time constant (Barstow and Mole, 1991).

The formula of mono-exponentinal function (equation 1) was regulated as below:

$$VO_2\ (t) = VO_{2baseline} + A \times (1 - e^{-(t / \tau)}) \quad (1)$$

For determination of t (time);

$$t = -\tau \times \ln[1 - (VO_2\ (t) - VO_{2baseline}) / A] \quad (2)$$

The ta-95%VO_2max value was equaled to ta-VO_2max value. Therefore this equation could be expressed as below;

$$ta\text{-}95\%VO_2max = -\tau \times \ln[1 - (95\%VO_2max - VO_{2baseline}) / A] \quad (3)$$

The t-VO_2max value was calculated as exhaustion time of test (t-exh.) minus ta-95%VO_2max:

$$t\text{-}VO_2max = t\text{-}exh - ta\text{-}95\%VO_2max \quad (4)$$

Analyze of Datas

The normality distribution of datas was determined by Shapiro-Wilks test and it was seen that datas had normal distribution. The datas of this study were analyzed by SPSS statistical package programme (SPSS 16.0, SPPS Inc., Chicago, USA). One-way analyses of variance (one-way ANOVA) was used for comparing ta-95%VO_2max, t-VO_2max and Ve values of young soccer players according to playing positions. The differences according to playing positions were determined by Scheffe's Post Hoc tests from one-way analysis of variance (one-way ANOVA). The correlation among ta-95%VO_2max, t-VO_2max and Vt values of young soccer players was determined by Pearson correlation coefficient. The level of statistical significiance of all analyzes was assumed at $p<0.05$.

Results

Table 1. The Values of VO_2max, Vt, ta-95%VO_2max, t-VO_2max and Et Parameters of Young Soccer Players According to Playing Positions.

Playing Position	**VO_2max (ml/min)**	**VO_2max (ml/kg/min)**	**Vt (ml/min)**	**Vt (ml/kg/min)**	**ta-95% VO_2max (sec)**	**t-VO_2max (sec)**	**Et (sec)**
Goalkeeper	4355,4	51	2818	33	213	171	384
Goalkeeper	4240	53	2960	37	223	143	366
Goalkeeper	4452	53	3108	37	221	157	378
Mean±SD	4349,1±106,1	52,3±1,2	2962±145	35,7±2,3	219±5,3*	157±14	376±9,2
Fullback	4158	63	3102	47	235	122	357
Fullback	4061	62	2882	44	243	128	371
Fullback	4036,2	62	3190	49	283	120	403
Fullback	4650	62	3375	45	227	147	374
Mean±SD	4226,3±287,3	62,3±0,5	3137±204,7	46,3±2,2	247±24,9	129,3±12,3	376,3±19,3
Center-back	5540,1	59	4413	47	271	129	400
Center-back	4114,8	54	3429	45	275	123	398
Center-back	5025	67	3225	43	265	124	389
Center-back	4104	57	3096	43	261	154	415
Mean±SD	4696±709,2	59,3±5,6	3540,8±597,4	44,5±1,9	268±6,2*	132,5±14,6	400,5±10,8
Midfielder	5148	78	4290	65	223	147	370
Midfielder	6179	74	4008	48	257	126	383
Midfielder	4431,2	58	3056	40	229	135	364
Midfielder	4891	67	3139	43	275	135	410
Mean±SD	5162,3±739,8	69,3±8,8	3623,3±618,8	49±11,2	246±24,4	135,8±8,6	381,8±20,4
Winger	4347	63	3243	47	223	138	378
Winger	3685	55	3015	45	271	140	411
Winger	3933	57	2967	43	243	137	380
Winger	3886	58	3015	45	257	145	402
Mean±SD	3962,8±277,8	58,3±3,4	3060±124,1	45±1,6	248,5±20,5	140±3,6	392,8±16,3
Forward	2948	40	2358	32	245	114	359
Forward	4875	65	3525	47	214	130	344
Forward	3922	53	2960	40	233	153	386
Forward	4650	62	3600	48	224	166	390
Mean±SD	4098,8±868,3	55±11,2	3110,8±577,4	41,8±7,4	229±13,2	140,8±23,2	369,8±22
Total	4418,8±668,7	59,7±8	3251±470	44±6,5	245±22**	138±15**	383,1±18,8

**Significiant difference between playing psisitions at p<0.05 level; **Significiant correlation between parameters at p<0.05 level.*

Table 2. The Values of VO_2max, Vt, ta-95%VO_2max, t-VO_2max and Et Parameters of Young Soccer Players According to Playing Positions During Treadmill Test at 100% of vVO_2max.

Playing Position	**$VO_{2baseline}$ (ml/min)**	**A (ml/min)**	**T (sec)**
Goalkeeper	650	3705,4	75
Goalkeeper	690	3550	79
Goalkeeper	515	3937	77
Mean±SD	618,3±91,7	3730,8±194,7	77±2
Fullback	520	3638	82
Fullback	630	3431	86
Fullback	523	3513,2	99
Fullback	515	4135	79
Mean±SD	547±55,4	3679,3±315,5	86,5±8,8
Center-back	750	4790,1	95
Center-back	710	3404,8	98
Center-back	684	4341	93
Center-back	592	3512	92
Mean±SD	684±67,1	4012±666,4	94,5±2,6
Midfielder	484	4664	77
Midfielder	620	5559	89
Midfielder	678	3753,2	81
Midfielder	732	4159	97
Mean±SD	628,5±106,6	4533,8±778,4	86±8,9
Winger	580	3767	84
Winger	475	3210	95
Winger	489	3444	85
Winger	508	3378	90
Mean±SD	513±46,7	3449,8±233,3	88,5±5,1
Forward	570	2378	88
Forward	490	4385	74
Forward	455	3467	81
Forward	521	4129	78
Mean±SD	509±48,8	3589,8±895,7	80,3±5,9
Total	581,8±92,1	3837±644,4	85,8±7,9

The values VO_2max, Vt, ta-95%VO_2max, t-VO_2max and t-exh parameters at 100% v VO_2max test of young soccer players are presented in Table 1. Also, values of $VO_{2baseline,}$ A and τ parameters of young soccer players are presented Table 2. According to correlation analyze results, negative correlation at significiant level between ta-95%VO_2max and t-VO_2max was determined ($r = -0.526$, $p<0.05$). There was no significiant correlation between Vt and other parameters (Ta-95%VO_2max, t-VO_2max) ($p<0.05$).

The results of one-way analysis of variance according to playing positions of young soccer players showed that t-VO_2max and Vt parameters didn't differentiate among playing positions ($p>0.05$). Only ta-95%VO_2max parameters differentiated significiantly among playing positions ($F=3,736$, $p<0.05$). In terms of playing positions, it was seen that ta-95%VO_2max values of centerbacks were higher than ta-95%VO_2max values of goalkeepers (219±5,29 sec., 268±6,22 sec., $p<0.05$, respectively). There was no significiant difference among other playing positions without difference between goalkeepers and centerbacks ($p>0.05$).

Discussion and Conclusion

It was said that oxygen was derived at onset of constant load exercise by anaerobic energy systems. Oxygen debt occured until VO_2 reached plateu level. The ta-95%VO_2max parameter meant that VO_2max was occured. The t-VO_2max parameter related to balance between ta-VO_2max and t-exh parameters (Billat et al., 2000). The ta-95%VO_2max parameter had negative correlation with t-VO_2max parameter. This meant that higher ta-95%VO_2max values caused lower t-VO_2max values. In terms of VO_2max values, it was seen that VO_2max values of young soccer players (59,7±8 ml/kg/min) were similar to VO_2max values of middle (59,8±1,2 ml/kg/min) and long (60,2±1,5 ml/kg/min) distance runners found at study of Kilding et al. (2006). This similarity indicates that young soccer and runners may have similar VO_2max and aerobic capacity values. Soccer is a sport needing high aerobic endurance. Therefore, aerobic capacities of young soccer players must be at high level and similarity to aerobic capacity values of middle and long distance runners can be accepted normally.

Dupont et al. (2010) determined oxygen uptake kinetics by mono-exponentinal model and VO_2 values measured after severe intensity exercise were lower than VO_2max values of young soccer players measured at our study (3648,8±563,7 ml/kg/min, 4418,8±668,7 ml/kg/min, respectively). Amateur young soccer players were involved at both studies and young soccer players placing at our study had higher VO_2 values than young soccer players of other study. Also, Dupont et al. (2005) determined VO_2max values of soccer players playing at regional league and these values (59,4±4,2 ml/kg/min) were paralelled to VO_2max values of our study. Additionally, Dupont et al. (2005) determined relationship between VO_2 kinetics and repeated sprints at this study.

Hill et al. (2003) determined VO_2 kinetics at treadmill and cycle ergometer by three exponentinal model and τ value of phase 3 at treadmill test (86±39 sec). Although determination models

of VO_2 kinetics was different, τ values were determined as similar. It could be said that τ values of three exponentinal model might be similar to τ values of mono-exponentinal model. The VO_2 values at threshold level determined at study of Carter et al. (2002) were similar to Vt values of our study (3036±199 ml/kg, 3251±470 ml/kg, respectively). The Vt is a important variable for athletes performance. The Vt is a deflection point of linearity between minute ventilation and VO_2 (Gökbel, 2012). After Vt, ventilation increases exccessively due to carbondioxide (CO_2) occured by elemination of lactate arising as last product of anaerobic metabolism (MacArdle et al., 2010; Gökbel, 2012). This situation is a factor increased respiratory exchange rate (RER). RER was determined by production of carbondioxide (VCO_2) divided to VO_2 ($RER=VCO_2/VO_2$) and this rate surpasses 1.00 value as VCO_2 increases (Gökbel, 2012).

The Vt is a indicator of endurance performance. There was no correlation between Vt and other parameters (ta-95%VO_2max, t-VO_2max) in our study. The situation could rise from individual aerobic capacities of young soccer players. It is possible individual differences at aerobic capacity values.

According to playing positions of young soccer players, there was no significiant difference among playing positions in terms of t-VO_2max and Vt parameters ($p>0.05$). In terms of ta-95%VO_2max parameter, it was seen that difference between goalkeeper and centerback playing positions was significiant ($p<0.05$). According to Scheffe's test results, no significiant difference among other playing positions was determined ($p>0.05$). Davis et al. (1992) determined that predicted VO_2max values of midfield players were the highest values among all playing positions and these values were higher than predicted VO_2max values of centerbacks ($p<0.05$). Conversely, it was determined that ta-95%VO_2max values were similar to other playing positions without centerbacks. It was said that most of young soccer players had similar aerobic capacity values. The high VO_2max values of players placing at different playing positions could help them during soccer match and these players could eliminate lactate inducing fatigue. Therefore, performances of players could stay at high level without fatigue.

Rampinini et al. (2010) obtained that Yo-Yo intermittent recovery test level 1 and level 2 performances correlated with VO_2max values positively (r=0,74; r=0,47, respectively) and τ values negatively (r= -0,60; r= -0,65, respectively).According to this findings, the shorter τ values meant higher aerobic performance. In our study, it was determined that the shorter ta-95%VO_2max values caused higher values of t-VO_2max. These findings were similar to findings obtained by Rampinini et al. (2010). Boone et al. (2012) obtained that fullbacks and midfielders had higher VO_2max values (61,2 ± 2,7 ml/kg/min; 60,4 ±2,8 ml/kg/min, respectively) than VO_2max values of strikers (56,8 ± 3,1 ml/kg/min) centerbacks (55,6 ± 3,5 ml/kg/min) and goalkeepers (52,1 ± 5 ml/kg/min). The fullbacks and midfielders performed many efforts for positional roles as winning ball and tackling during match. Therefore, they must have high level physical capacity and aerobic endurance. These results confirmed this thesis. In terms of ta-95%VO_2max values, findings of our study didn't report any significiant differences among

playing positions without significiant difference between goalkeepers and centerbacks. In this regard, our study didn't agree with study of Boone et al (2012).

The findings of this research revealed significiant negative correlation between ta-95%VO_2max and t-VO_2max of young soccer players. The VO_2 kinetics of young soccer players were determined by mono-exponentinal model at test of 100 %vVO_2. The Vt didn't have any significiant correlation with ta-95%VO_2max and t-VO_2max parameters. Also, no significiant difference was determined among playing positions in terms of t-VO_2max and Vt parameters . Only, it was seen significiant difference between goalkeepers and centerbacks in terms of ta-95%VO_2max parameter. The many studies at literatüre focused aerobic capacities parameters such as VO_2max and some of them were parallel to our study in terms of results. The VO_2 kinetics are valuable for evaluation of aerobic performance. According to negative correlation between ta-95%VO_{2max} and t-VO_2max parameters, it can be said that t-VO_2max parameters depend on ta-95%VO_2max parameters and reaching to steady-state level as soon as possible during exercise and maintaining exercise at this level were important for aerobic performance within the context of t-VO_2max.

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Ordu University
Physical Education and Sports School
Turkey.
E-mail:arierdal@hotmail.com