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Determinants of 300 and 1000 Meters Running Performance in Young Track and Field Athletes

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Abstract

This study aims to define the running performance parameters in young track athletes using simple field tests. Twenty seven young athletes, divided in two age groups (Children, CH, 12-13 years old and Young Adolescents, YA, 14-15 years old), performed a 300 and 1000m time trial (t300m and t1000m, respectively), as well as aerobic and anaerobic field tests. For both groups, t1000m performance correlates were primarily aerobic (r=-0.866 - -0.899) and secondarily anaerobic (r=-0.519 - -0.846) and anthropometric (r=0.698 – 0.770), while t300m performance correlates were primarily anaerobic (r=-0.553 - -0.898) and secondarily aerobic (r=-0.638 - -0.656) and anthropometric (r=-0.638). t1000m was predicted from aerobic, anaerobic and anthropometric factors (CH: adjusted R^2=0.948, SEE=6.86 sec, YA: adjusted R^2=0.982, SEE=5.83 sec). For the t300m the power output and anthropometric parameters were most important (CH: adjusted R^2=0.406, SEE=3.97 sec, YA: adjusted R^2=0.871, SEE=2.13 sec). Simple field tests can estimate running performance with sufficient accuracy in young track athletes.

Keywords: performance, physiology, children, adolescents

1. Introduction

It is well known that cardiorespiratory endurance is not only one of the most important factors affecting athletic performance, but also indicates a good physical fitness level in human (Saltin & Astrand, 1967; Mitchell, Sproule & Chapman, 1958). Many studies have shown significant relationship between middle distance (400m – 1 mile) running performance parameters and aerobic (Almarwaey, Jones & Tolfrey, 2003; Tanaka et al., 1983; Padilla, Bourdin, Barthelemy & Lacour, 1992; Brandon, 1995), anaerobic (Brandon, 1995) and power output (Zagatto, Beck & Gobatto, 2009; Paradisis, Tziortzis, Zacharogiannis, Smirniotou & Karatzanos, 2005) factors. A series of studies examining the factors affecting middle distance running performance, from 600yd to 2 miles, in children aged 7-15 years old have been conducted. Running time for the 600yd (548.64m) is negatively related (r=-0.62 - -0.66) with VO_2max in 12-13 years old boys (Metz & Alexander, 1970) and 7-12 years old children (Cureton, Boileau, Lohman & Misner, 1977). It is also found that height, %body fat, VO_2max and t50yd explained 71% of the 600yd and 66% of 1 mile (1609m) performance time, with t50yd and %body fat being the most important predictors (Cureton et al., 1977). Average 1 mile running velocity in 12 years old boys was correlated with VO_2max (r=0.77), %body fat (r=-0.56), as well as with maximum cardiac index and stroke index (r=0.41 and 0.39, respectively), while the combination of %body fat and VO_2max explained 60% of average 1 mile running velocity variation (Rowland, Kline, Goff, Martel & Ferrone, 1999). Similar results were also found in 12 years old children, as VO_2max and body mass were found to be the best predictors of average 1 mile running velocity (Nevill, Rowland, Goff, Martel & Ferrone, 2004).

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In 11-12 years old girls, 1000m running time correlates negatively with VO_2max (r=-0.70) and positively with the sum of five skinfolds (r=0.92). It is also reported that the sum of five skinfolds, the results of a step test and the maturity level explain 90% of 1000m running time variation, while none of the physiological variables examined seems to add significant percentage of variation in the model (Gutin et al., 1978). Furthermore, 1200m running time in 10-11 years old children is negatively correlated with the Wingate test mean power and peak power output (r=-0.82 and -0.79, respectively), as well as with VO_2max and velocity at $4mmol.l^{-1}$ (r=-0.80 and -0.74, respectively) blood lactate concentration (Rotstein, Dotan, Bar-Or & Tenenbaum, 1986). Other research shows that 2km running time in 10-14 years old children correlates negatively with aerobic (r=-0.73 , -0.73 and -0.50 with VO_2max, VO_2 at anaerobic threshold and $\%VO_2max$ at anaerobic threshold, respectively) and anaerobic factors (r=-0.77 with anaerobic capacity derived from the Wingate test) and positively with anthropometric factors (r=0.55 with %body fat). It is also found that the combination of anaerobic capacity and VO_2 at anaerobic threshold explains 66% of 2km running time variation, as well as the combination of anaerobic capacity and VO_2max explains 66.4% of 2km running time variation (Palgi, Gutin, Young & Alejandro, 1984).

It is obvious that aerobic, anaerobic and anthropometric factors affect endurance running performance in children and young adolescents. Although, coaches cannot easily access laboratory settings with their young athletes in order to evaluate physiological parameters and estimate the effectiveness of the training intervention. The purpose of the present research was to study the contribution of simple field tests in 1000m and 300m running performance in young track and field athletes.

2. Materials and Methods

2.1 Experimental Approach to the Problem

To determine the contribution of selected aerobic and anaerobic physiological parameters with running performance in young track athletes, 27 children (n=15) and young adolescents (n=12) performed a series of simple filed tests. Aerobic and anaerobic capacity, power output, explosive strength, maximal speed and anthropometric characteristics were the parameters evaluated in the young athletes. Running performance was evaluated by 300m and 1000m trials in a track. All measures were performed under the same environmental circumstances.

2.2 Subjects

Twenty seven moderately trained young track and field athletes (19 girls and 8 boys) volunteered to participate in this study. The sample was divided in two age groups, children (CH, 14-15years old) and young adolescents (YA, 12-13 years old). Children group consisted of 15 young athletes (12 girls and 3 boys, 12.60±0.50 years old, 1.56±0.06 m, 45.62±7.90 kg, 16.61%±4.11% body fat) and young adolescents group consisted of 12 young athletes (7 girls and 5 boys, 14.83±0.39 years old, 1.68±0.05 m, 55.86±6.68 kg, 17.01%±3.48% body fat). The study was approved by a local university ethics committee and was conducted in accordance with the guidelines of the Declaration of Helsinki. Signed consent was also obtained in by the parents of all participants in the study.

2.3 Procedures

On Day 1, the subjects performed a 20m shuttle run test to determine VO_2max (Leger, Mercier, Gadoury & Lambert, 1988) and vVO_2max (Paradisis et al., 2014). HRmax was measured using a wristwatch with heart rate monitor. The 20m shuttle run test was tested for its validity for children (van Mechelen, Hlobil & Kemper, 1986). On Day 2, the subjects performed a running-based anaerobic sprint test (RAST) to estimate anaerobic power and capacity, a CMJ to determine lower limbs explosive strength and a 40m maximum effort to measure maximal speed (Vmax) during the last 10m (30m to 40m). The anaerobic parameters calculated from the RAST were relative power output variables ($Pmax_{RT}$, $Pmin_{RT}$, $Pmean_{RT}$), relative Fatigue Index 1 (FI^1_{RT}), Fatigue Index 2 (FI^2) and anaerobic capacity (AC). On Days 3 and 4, the subjects completed a 1000m and a 300m trial. All trials were performed at least three days apart. Anthropometric measurements included body height and body mass measurements, as well as body fat percentage calculation, using biceps, triceps, suprailiac and subscapular skinfolds (Durnin & Rahaman, 1967). All tests were checked for validity and reliability.

2.4 Statistical Analyses

The Pearson's r was used to determine the relationship between 1000m running time (t1000m) and 300m running time (t300m) with aerobic (VO_2max_{pred} and vVO_2max_{pred}, HRmax), anaerobic ($Pmax_{RT}$, $Pmin_{RT}$,$Pmean_{RT}$, FI^1_{RT}, FI^2, AC, CMJ and Vmax) and anthropometric (height, body mass, %body fat) variables for each age group.

Furthermore, a stepwise multiple linear regression was applied to t1000m as dependent variable and the t300m, selected aerobic (VO_2max_{pred}, vVO_2max_{pred} and HRmax), anaerobic ($Pmax_{RT}$, $Pmin_{RT}$, $Pmean_{RT}$, CMJ and Vmax) and anthropometric (height, body mass and %body fat) parameters as independent variables for each age group. A stepwise multiple linear regression was also applied to t300m as dependent variable and selected aerobic (VO_2max_{pred}, vVO_2max_{pred} and HRmax), anaerobic ($Pmax_{RT}$, $Pmin_{RT}$, $Pmean_{RT}$, CMJ and Vmax) and anthropometric (height, body mass and %body fat) parameters as independent variables for each age group. Significance level was determined at $P \leq 0.05$ and all analyses were performed using IBM SPSS Statistics 23.

3. Results

Descriptive statistics (Mean ± SD) for the selected variables are shown in Table 1.

Table 1: Descriptive statistics of selected performance, aerobic and anaerobic variables.

Variables	Children	Young Adolescents
t1000m (sec)	254.86 ± 30.20	228.79 ± 43.80
t300m (sec)	56.17 ± 5.15	48.77 ± 5.93
VO_2max_{pred} ($ml.min^{-1}.kg^{-1}$)	49.07 ± 3.09	47.22 ± 4.95
vVO_2max_{pred} ($km.h^{-1}$)	12.82 ± 0.97	13.25 ± 1.96
HRmax (bpm)	197 ± 12	197 ± 11
CMJ (m)	0.22 ± 0.04	0.23 ± 0.05
Vmax ($m.sec^{-1}$)	6.75 ± 0.44	7.26 ± 0.55
$Pmax_{RT}$ ($watt.kg^{-1}$)	5.92 ± 0.67	6.80 ± 1.17
$Pmin_{RT}$ ($watt.kg^{-1}$)	3.99 ± 0.70	5.00 ± 1.18
$Pmean_{RT}$ ($watt.kg^{-1}$)	4.86 ± 0.65	5.80 ± 1.10
FI^1_{RT} ($watt.sec^{-1}.kg^{-1}$)	0.052 ± 0.013	0.050 ± 0.022
FI^2	32.83 ± 7.12	26.49 ± 11.03
AC (watt)	1322.69 ± 245.75	1947.25 ± 462.37

Significant negative correlations were found between t1000m and VO_2max_{pred}, vVO_2max_{pred}, $Pmin_{RT}$, $Pmean_{RT}$ and CMJ (r= -0.519 - -0.899) and significant positive correlations with body mass and %body fat (r=0.770 & 0.698, respectively), while t300m correlated negatively with $Pmax_{RT}$, $Pmin_{RT}$ and $Pmean_{RT}$ (r=-0.553 - -0.670) for CH age group. Concerning YA age group, t1000m negatively correlated with VO_2max_{pred}, vVO_2max_{pred}, $Pmin_{RT}$, $Pmean_{RT}$ and AC (r= -0.631 - -0.891) and positively correlated with t300m, FI^2 and %body fat (r=0.735 – 0.833), while t300m correlated negatively with VO_2max_{pred}, vVO_2max_{pred}, Vmax, $Pmax_{RT}$, $Pmin_{RT}$, $Pmean_{RT}$ and AC (r= -0.638 - -0.898) and positively with t1000m and %body fat (r=0.883 & 0.638, respectively) (Table 2).

Table 2: Correlation matrix of selected aerobic, anaerobic and anthropometric parameters and performance running time for CH and YA age groups.

Variables	Children		Young Adolescents	
	t1000m	t300m	t1000m	t300m
t1000m (sec)	-	0.466	-	0.883**
t300m (sec)	0.466	-	0.883**	-
VO_2max_{pred} ($ml.min^{-1}.kg^{-1}$)	-0.866**	-0.385	-0.891**	-0.638*
vVO_2max_{pred} ($km.h^{-1}$)	-0.899**	-0.425	-0.884**	-0.656*
HRmax (bpm)	0.051	0.070	0.563	0.453
CMJ (m)	-0.606*	-0.335	-0.408	-0.543
Vmax ($m.sec^{-1}$)	-0.287	-0.497	-0.437	-0.753**
$Pmax_{RT}$ ($watt.kg^{-1}$)	-0.397	-0.553*	-0.534	-0.760**
$Pmin_{RT}$ ($watt.kg^{-1}$)	-0.519*	-0.579*	-0.846**	-0.895**
$Pmean_{RT}$ ($watt.kg^{-1}$)	-0.568*	-0.670**	-0.765**	-0.898**
FI^1_{RT} ($watt.sec^{-1}.kg^{-1}$)	0.066	-0.081	0.382	0.115
FI^2	0.438	0.370	0.735**	0.558
AC (watt)	0.299	-0.474	-0.631*	-0.710**
Body height (m)	0.386	-0.109	-0.333	-0.303
Body mass (kg)	0.770**	0.010	0.025	0.077
% Body fat	0.698**	0.049	0.740**	0.638**

* $p<0.05$, ** $p<0.01$

The prediction equations and standardized beta coefficients of the Stepwise Multiple Linear Regression are shown in Table 3 and Table 4, respectively.

Table 3: Running time performance prediction equations for T1000m and T300m.

Prediction Equations (sec)	R	R^2	Adj. R^2	SEE (sec)
CH: t1000m = $444.229 – 15.857*vVO_2max_{pred}–37.105*Pmean_{RT} +1.270*Body Mass + 23.042*Pmax_{RT}$	0.981	0.963	0.948	6.86
CH: t300m = $81.805 – 5.276*Pmean_{RT}$	0.670	0.448	0.406	3.97
YA: t1000m = $-41.589 – 3.877*VO_2max_{pred} + 6.012*t300m +22.078*Vmax$	0.994	0.987	0.982	5.83
YA: t300m = $63.312 – 4.134*Pmean_{RT} + 0.555*\%Body Fat$	0.946	0.895	0.871	2.13

Table 4: Standardized Beta Coefficients of the Stepwise Multiple Linear Regression

Predictor Variables	Standardized Beta Coefficients			
	t1000m CH	t300m CH	t1000m YA	t300m YA
t300m			0.813	
VO_2max_{pred}			-0.438	
vVO_2max_{pred}	-0.507			
Vmax			0.278	
$Pmax_{RT}$	0.515			
$Pmean_{RT}$	-0.803	-0.670		-0.765
Body Mass	0.332			
% Body Fat				0.326

4. Discussion

The results of the present study showed high correlations between t1000m and aerobic parameters, as well as moderate to high correlations with anaerobic and anthropometric factors for both CH and YA age groups. On the other hand, t300m correlated primarily with power output parameters and secondarily with aerobic and anthropometric factors.

The aerobic variables examined, VO_2max_{pred} and vVO_2max_{pred}, were found to be highly correlated with the t1000m for CH and YA, as well as with the t300m for YA. Previous research has shown that VO_2max strongly correlates with endurance performance in children (Gutin et al., 1978; Metz & Alexander, 1970; Palgi et al., 1984; Rotstein et al., 1986). Similar results are found in adolescents (Almarwaey et al., 2003) and adults (Ingham et al., 2008, Padilla et al., 1992), as VO_2max and vVO_2max correlated significantly with middle distance running performance (800m – 1500m). The relationship between t300m and aerobic parameters indicates that aerobic energy system may have great contribution in the performance for a short duration maximal effort, which is also mentioned in 400m performance in adults (Nevill, Ramsbottom, Nevill, Newport & Williams, 2008).

Power output variables calculated from the RAST seemed to have moderate to high correlation with t1000m and t300m for CH and YA. According to existing literature, anaerobic capacity significantly correlates with 2km running time in 10-14 years old children (Palgi et al., 1984), while Pmean and Ppeak correlate with 1200m running time in 10-11 years old children (Rotstein et al., 1986). Although these studies used Wingate test to evaluate anaerobic parameters and can't be directly comparable with the results of the present study which used the RAST test to estimate anaerobic parameters (Zaggato et al., 2009).

For adult track and field athletes, RAST variables correlate moderately to high with 200m and 400m running time, distances close to 300m (Paradisis et al., 2005; Zaggato et al., 2009). It is quite interesting the fact that power output variables were found to correlate highly with t1000m in CH and YA, as it is well established in adults that anaerobic capacity has a great contribution in total energy expenditure in middle distance running performance (Hill, 1999; Spencer, Gastin & Payne, 1996; Spencer & Gastin, 2001), despite the fact that children have an inhibited anaerobic capacity (Bar-Or, 1983; Eriksson, Gollnick & Saltin, 1973). Furthermore, CMJ and Vmax were significantly correlated with t1000m in CH and t300m in YA, respectively, which confirms that anaerobic factors, such as lower limbs explosive strength and maximal speed, can affect young athletes' running performance in short and middle distances.

The %body fat in YA explained most of the performance variability for t300m and t1000m. Body mass and the %body fat significantly correlated also with t1000m in CH. This fact is also mentioned by Rowland et al. (1999), which support that %body fat and VO_2max explain almost equal amount of the performance running time variation (≈31% and ≈28%, respectively).

Regarding the prediction equations that arose from the stepwise multiple linear regression the best predictor variables for t1000m were vVO_2max_{pred}, $Pmean_{RT}$, body mass and $Pmax_{RT}$ for CH, and VO_2max_{pred}, t300m and Vmax for YA. These results are in accordance with previous published research data. VO_2max seems to be one of the most important predictors of aerobic running performance in children (Cureton et al., 1997; Palgi et al., 1984; Nevill et al., 2004; Rowland et al., 1999). Anaerobic capacity (Palgi et al., 1984) and t50yd, a sprint ability factor (Cureton et al., 1977), as well as anthropometric factors (Cureton et al., 1997; Palgi et al., 1984; Nevill et al., 2004; Rowland et al., 1999), are also important predictors of aerobic performance, revealing the importance of power output and sprint ability variables. The fact that t300m is a predictor variable for t1000m in YA, is similar to the findings of a prediction equation for adults, where running time of 100m and 300m explain 85% of t800m variation (Deason, Powers, Lawer, Ayers & Stuart, 1991).The best predictor variables for t300m were $Pmean_{RT}$ for CH, and $Pmean_{RT}$ and %body fat for YA. These results are in accordance with the findings of other studies that RAST variables can accurately predict short distance running performance (Paradisis et al., 2005; Zagatto et al., 2009), while %body fat seems to be a wider predictor of running performance in young athletes, as it doesn't predict just aerobic performance, as mentioned in a series of studies (Cureton et al., 1977; Palgi et al., 1984; Rowland et al., 1999).

In summary, the present study found moderate to high correlations between t1000m and t300m and many performance parameters for both age groups, CH and YA, using simple field tests that can be easily directed by coaches and performed by the young athletes. For t1000m performance correlates were primarily aerobic and secondarily anaerobic and anthropometric, while for t300m were primarily anaerobic and secondarily anthropometric and aerobic. It is also found that t1000m and t300m can be predicted with accuracy for both age groups, CH and YA. For t1000m the predictor variables were both aerobic, anaerobic and anthropometric, while for t300m were mostly anaerobic and anthropometric.

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