SECTION – SPORT SCIENCES

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CARDIORESPIRATORY RESPONSE AND ENERGY SYSTEM CONTRIBUTION DURING SPEED ENDURANCE WORKOUT IN A HIGHLY TRAINED SPRINTER: A PRELIMINARY REPORT

Krzysztof Kusy[ABCDEFG], Ewa Zarębska[BC], Monika Ciekot-Sołtysiak[BC], Michał Janowski[BC], Jacek Zieliński[ABDEG]

Department of Athletics, Poznan University of Physical Education, Poland

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Abstract

Purpose. Assessment of the physiological response to individually programmed speed endurance track session in a highly trained sprinter.

Basic procedures. One male sprinter, aged 23 years, a member of the Polish national team, was examined. He underwent the ergospirometric graded exercise test (GXT) to assess aerobic capacity and maximum blood lactate (LA). In the competition period, the same variables were measured during repeated sprints (60 m, 60 m, 100 m and 120 m) on a standard athletic track using a mobile wireless ergospirometer. The energy contribution from aerobic and anaerobic metabolism was calculated from exercise oxygen uptake (VO_2), fast component of post-exercise oxygen consumption and net post-exercise blood lactate concentration.

Main findings. Peak values relative to those obtained during GXT were: 80% for minute ventilation (VE), 111% for breathing frequency (BF), 103% for tidal volume (VT), 79% for peak VO_2, 90% for heart rate (HR) and 84% for oxygen pulse (VO_2/HR). Post-effort peak values were attained at different times: VE 37–46 s, BF 23–34 s, VT 38–67 s, VO_2 46–89 s, HR 36–48 s and VO_2/HR 45–77 s. Peak LA after the last sprint reached 147% of the GXT maximum. The proportions of aerobic, anaerobic alactic and anaerobic lactic acid energy sources were approximately 11.1%, 46.4% and 42.5%, respectively.

Conclusions. The athlete showed typical contribution of aerobic and anaerobic energy delivery during the speed endurance workout. We support the notion that specific speed endurance exercise rely both on anaerobic and aerobic metabolism. Monitoring and control of the actual track sessions using high-tech equipment may help coaches and athletes to determine optimal workout parameters.

Introduction

Physical efforts performed at maximal or near-maximal speed are crucial for success in many sports. Sprint running is the most obvious example. Such exercise is typically associated with anaerobic metabolism. In spite of this common opinion, previous studies demonstrated that the involvement of aerobic energy supply may vary from 3% to 64% during all-out exercise of a duration from 6 to 90 s [1, 2, 3, 4, 5, 6, 7]. The contribution of aerobic metabolism in 100-m and 200-m sprints has been estimated to be about 3–7% and 14-29%, respectively [8, 9, 10].

However, it should be noted that almost all data obtained hitherto were based on cycling [1, 2, 5, 6, 7] and treadmill running [9], which do not strictly reflect the specificity of track running, or on mathematical models with their simplified assumptions [4, 6, 8, 10]. The study of Duffield et al. [11] is probably the only one in which actual track running was used. According to their data, the relative aerobic energy contribution for the 100-m event, as measured by accumulated oxygen deficit, was 21% for males and 25% for females, or 9% and 11%, respectively, based on lactate and phosphate creatine (PCr) measurements. Today, it is clear that virtually all physical activities derive some energy from each of the following three processes: (i) splitting the high-energy PCr, (ii) the nonaerobic breakdown of carbohydrates and (iii) the combustion of carbohydrates and fats in the presence of oxygen [12]. It was also revealed that the time from the onset of a high-intensity exercise to the onset of oxidative processes is shorter than previously believed [12], and that oxygen consumption following a repeated sprint exercise may equal the peak values obtained during a graded test until exhaustion [13].

The assessment of cardiorespiratory response and energy contribution from aerobic and anaerobic sources in competitive speed-power athletes is of great practical interest. Speed endurance is a crucial ability resulting in maintaining a high running speed that tends to decrease in the second/final stage of the 100-m or 200-m distance. The common but unjustified assumption is that very short all-out sprints only activate anaerobic mechanisms of energy production. In fact, even a single sprint exercise triggers aerobic energy sources as well, the contribution of which may increase with each subsequent repetition [13]. Thus, measuring indices of aerobic and anaerobic energy sources provides the coach and athlete with information on the adequacy of the training loads used and gives the opportunity for their optimization (exercise and recovery time, number of repetitions).

To our best knowledge, no data have been published about cardiorespiratory aerobic response to a speed endurance workout and aerobic energy contribution obtained during an actual training session. Thus, the aim of this report is the assessment of the magnitude and time of the response to individually programmed sprint intervals in a highly trained sprinter. We hypothesize that the aerobic response and aerobic energy contribution to speed endurance session will be noticeable despite the assumption regarding the anaerobic character of the exercise.

Methods

Subject

The athlete was a male sprinter, aged 23 years, a member of the Polish national team, specializing in sprints 100 m, 200 m and 4 × 100 m for eight years, whose body height was 183 cm, body mass 80.4 kg and relative fat content 9.5% as measured by dual X-ray absorptiometry (Lunar Prodigy, GE Healthcare, USA). His personal best performances were: 6.63 s (60 m), 10.38 s (100 m), 20.89 s (200 m) and 38.60 s (4 × 100 m). The project, part of which is this study, has been approved by the Ethics Committee at the Karol Marcinkowski Medical University in Poznan.

Graded exercise test

Before the competition period, the athlete underwent an incremental running treadmill test (Pulsar, h/p/cosmos, Germany) until exhaustion in order to obtain physiological characteristics during maximal endurance exercise. The test was completed at the "LaBthletics" Human Kinetics Laboratory of the Poznan University of Physical Education, in the morning, about 2 h after consuming a light breakfast (bread and butter, water, without coffee or tea). Before the trial, the analyzers were calibrated with standard gases of known concentrations and volumetric calibration was done. Main cardiorespiratory variables were measured continuously (breath-by-breath) by means of the MetaMax 3B-R2 ergospirometer and the MetaSoft Studio software (Cortex Biophysic, Germany): breathing frequency (BF), tidal volume (VT), minute ventilation (VE), oxygen uptake (VO_2), carbon dioxide production (VCO_2), respiratory exchange ratio (RER), heart rate (HR) and oxygen pulse (VO_2/HR). Baseline VO_2 was established during the last 10 min of a 30-min pre-exercise rest period. Then, the athlete started the test at a speed of 4 km/h and walked for 3 min. Subsequently, the speed was progressively increased by 2 km/h every 3 min until volitional exhaustion. The athlete was verbally encouraged to give maximal effort throughout the test. Maximal heart rate (HR_{max}) was defined as the highest value recorded during the test. Maximal oxygen uptake (VO_{2max}) was considered to be achieved if the test met at least three of the following criteria [14, 15, 16]: (a) a plateau in VO_2 with increasing speed; (b) respiratory exchange ratio > 1.15; (c) heart rate within 5 beats/min of the age-predicted HR_{max} [17], (d) blood lactate concentration after exercise greater than 7 mmol/L and (e) the rating of perceived exertion was 19 or 20 as indicated by the athlete on the Borg Scale [18]. VO_{2max} was expressed in ml/min (absolute values) and in ml/kg/min (relative to body mass). Maximal oxygen pulse was derived by dividing VO_{2max} by HR_{max}. Venous blood samples were obtained from the antecubital vein at rest and immediately after the maximal test. Lactate concentration was assayed using chip sensor technology (Biosen C-line analyser, EKF Diagnostics, Germany/USA).

Track session

The measurements were performed during the taper phase before the main competition on a standard 400-m running track during windless weather and the air temperature at 26ºC. The aim of the session was to develop speed endurance. The session was designed by a coach and included the following main parts: (i) a 40-min warm-up (jogging, stretching, skipping drills and other technique drills, preliminary "run-throughs" at increasing speed), (ii) four maximal sprints from a standing start 60 m + 60 m + 100 m + 120 m followed by passive recovery and (iii) a 30-min cool-down (stretching, jogging). Actual recovery times between the sprints slightly differed from the planned ones and were 5 min 5 sec. (vs. the planned 5 min) after the first 60 m, 7 min 40 sec. (vs. the planned 8 min) after the second 60 m, 8 min 6 sec. (vs. the planned 8 min) after the 100-m sprint and 10 min 27 s (end of recording data) after the 120-m sprint. The wireless mobile ergospirometry system was worn by the athlete during the main part (ii) of the session, consisting of maximal sprints, that lasted for 35 minutes. During this time, cardiorespiratory variables were measured using the same methods and apparatuses as in the laboratory (see above). Capillary blood for lactate concentration was obtained from the finger tip immediately before the session, after the warm-up and 3 min after the last sprint. Sprint times were measured automatically to the nearest 0.01 s using photocells (Brower Timing TC-System, USA).

Energy contribution calculations

The calculations were performed according to the algorithm suggested by Beneke et al. [19]. In brief, net aerobic energy was calculated from the VO_2 above baseline during each sprint. We assumed the O_2 equivalent equal to 21.1 kJ/l. The energy produced from anaerobic alactic metabolism was estimated from the fast component of post-exercise oxygen consumption (EPOC) and the O_2 equivalent. The times of collecting EPOC data were the same as recovery times after consecutive sprints (see above). The time course of VO_2 during recovery after each sprint was fitted into a bi-exponential curve based on the following equation:

$$VO_2(t) = A_f e^{-t/\tau_f} + A_s e^{-t/\tau_s} + VO_{2base}$$

where $VO_2(t)$ is oxygen consumption at time t, A_f and A_s are amplitudes of the fast and slow component, respectively, τ_f and τ_s are corresponding time constants and VO_{2base} is oxygen consumption at baseline. The fast component of EPOC was calculated as the product of $A_f\ \tau_f$. The bi-exponential model was constructed using OriginPro software, version b9.3.226 (OriginLab Corp., USA). Net energy produced from anaerobic lactic acid metabolism was determined from net lactate concentration (post-exercise minus pre-exercise), body mass and O_2-lactate equivalent. The latter was assumed to be 3 ml O_2/kg/mmol/l, i.e. 63 J/kg/mmol/l. Aerobic and anaerobic alactic energy production was estimated for each sprint separately, whereas anaerobic lactic acid energy contribution was calculated as one total value (lactate concentration was measured before the first and after the last sprint).

Results

The comparison between peak cardiorespiratory variables obtained at VO_{2max} during the laboratory graded test versus the speed endurance track session are shown in Table 1. In Figures 1–4, the detailed time

Table 1. Exercise characteristics at maximal oxygen consumption during a laboratory treadmill test until exhaustion (LAB) and peak values after consecutive sprints during track session (TRACK). Percentage of maximal laboratory values is shown in brackets.

	LAB	TRACK			
		60 m	**60 m**	**100 m**	**120 m**
Time [s]	888	6.76	6.68	10.85	13.06
Av. speed [m/s]	–	8.88	8.98	9.22	9.19
VE [l/min]	137.3	87.8 (64%)	107.1 (78%)	104.0 (76%)	109.9 (80%)
VT [l]	2.08	2.15 (103%)	2.07 (99%)	2.14 (103%)	2.15 (103%)
BF [/min]	66	44 (67%)	56 (85%)	63 (95%)	73 (111%)
VO_2 [l/min]	3.72	2.77 (74%)	2.95 (79%)	2.91 (78%)	2.80 (75%)
VCO_2 [l/min]	4.37	3.13 (71%)	3.19 (72%)	3.22 (73%)	3.10 (70%)
RER	1.05	1.28 (122%)	1.47 (140%)	1.44 (137%)	1.32 (126%)
EPOC [l/min]	3.49	2.54 (72%)	2.72 (77%)	2.68 (76%)	2.57 (73%)
HR [/min]	194	162 (84%)	166 (86%)	172 (89%)	174 (90%)
VO_2/HR [ml]	19.2	17.1 (89%)	17.8 (93%)	16.9 (88%)	16.1 (84%)
LA [mmol/l]*	11.0	–	–	–	16.2 (147%)

[*] venous blood in laboratory, capillary blood during track session

Abbreviations: BF breathing frequency; EPOC excess post-exercise oxygen consumption; HR heart rate; LA blood lactate; RER respiratory exchange ratio; VCO_2 exhaled dioxide; VE minute ventilation; VO_2 oxygen uptake; VO_2/HR oxygen pulse; VT tidal volume

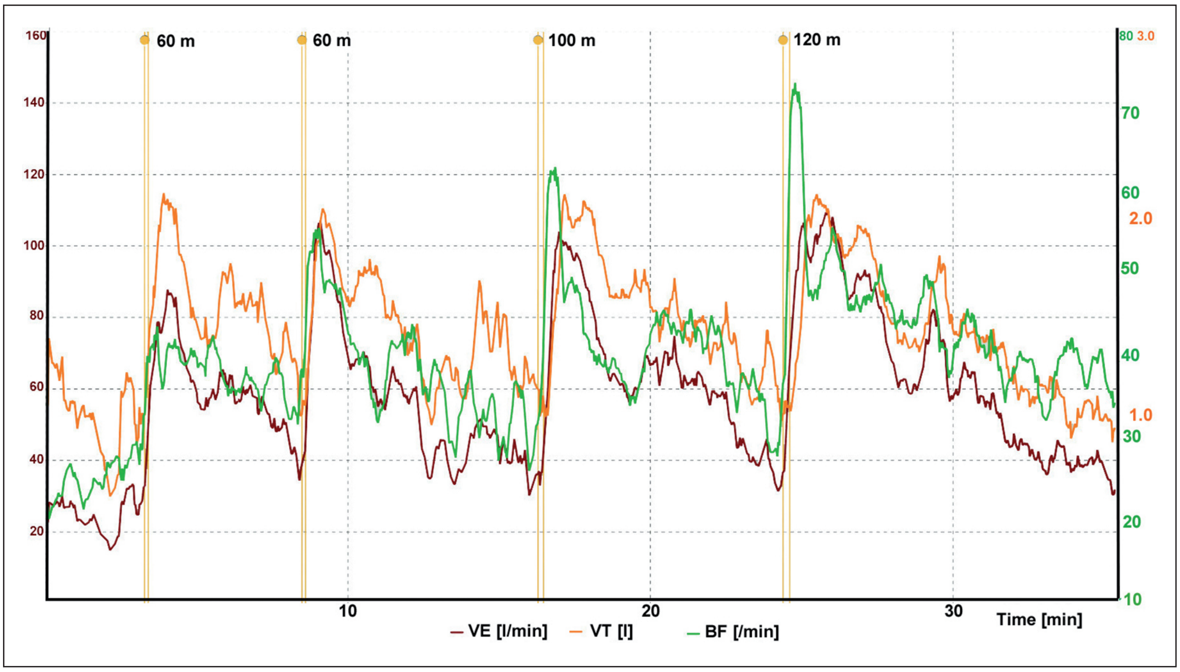

Figure 1. Time course of minute ventilation (VE, brown line), tidal volume (VT, orange line) and breathing frequency (BF, green line) during an actual speed endurance track session in a highly trained sprinter. Vertical yellow lines denote the start and completion times of consecutive sprints

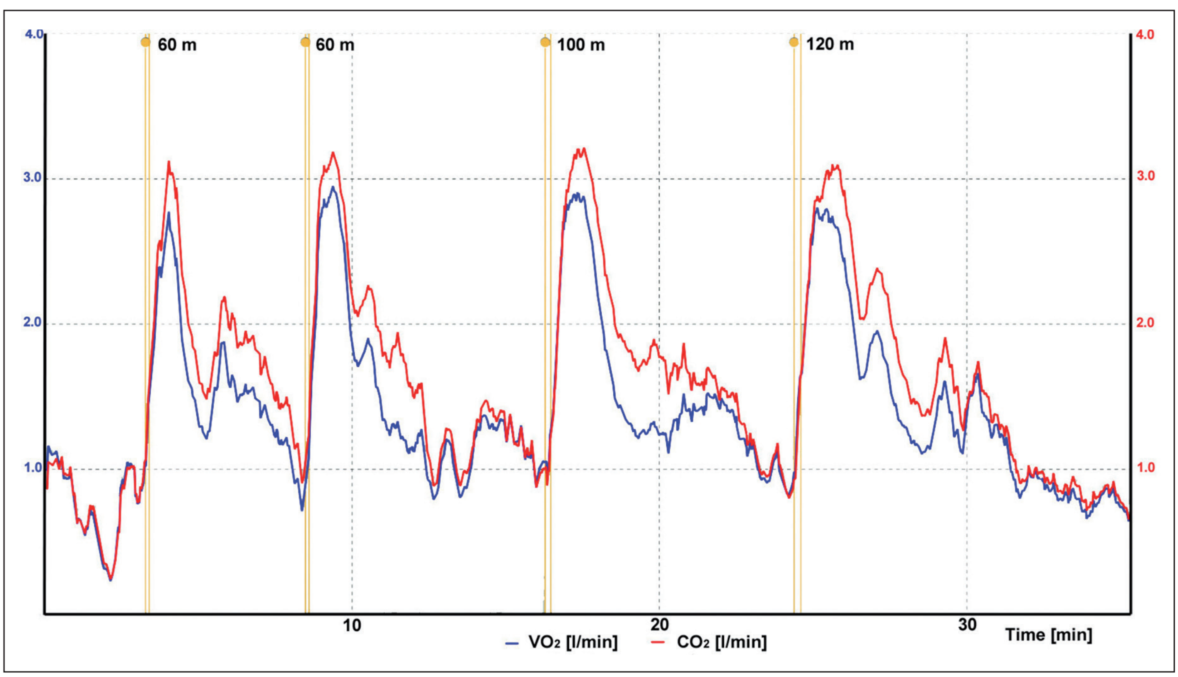

Figure 2. Time course of oxygen consumption (VO_2, blue line) and carbon dioxide production (VCO_2, red line) during an actual speed endurance track session in a highly trained sprinter. Vertical yellow lines denote the start and completion times of consecutive sprints

courses of main cardiorespiratory parameters are presented. A clear increase in all parameters was observed after each sprint. VE increased from 64% of the value at VO_{2max} following the first (60 m) sprint to 80% following the last (120 m) sprint. Similarly, BF increased from 67% to 111% of the value at VO_{2max}. The increase in VT was similar across the four sprints (up to 99–103% of its value at VO_{2max}). VO_2 and VCO_2 reached between 70%

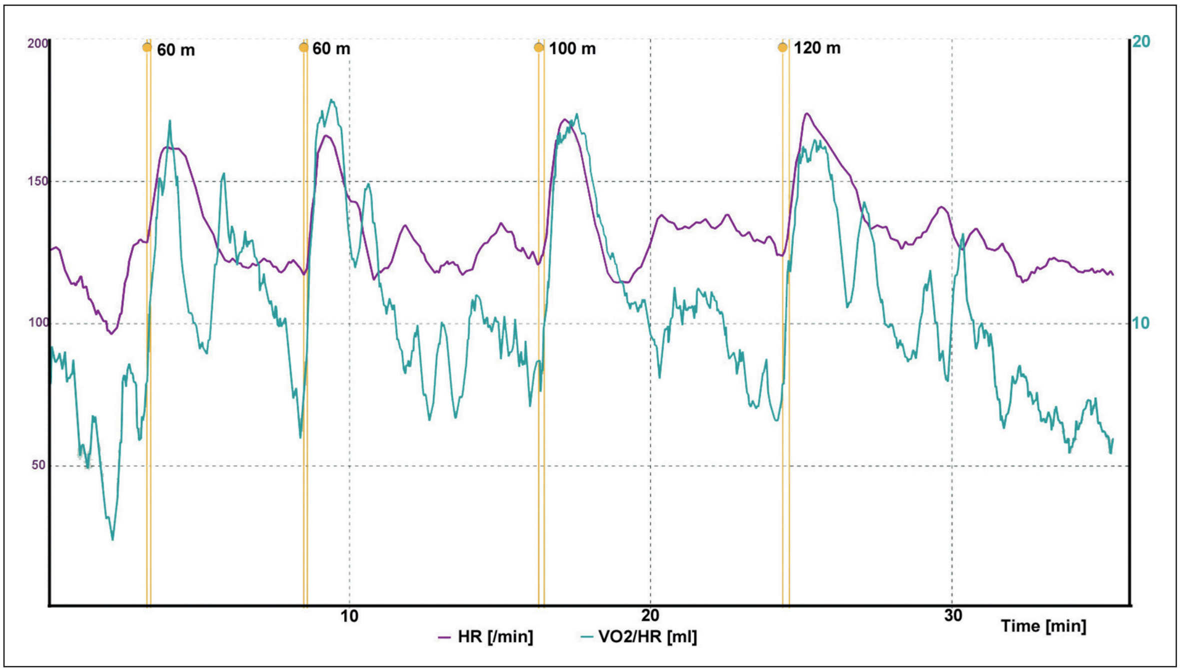

Figure 3. Time course of heart rate (HR, purple line) and oxygen pulse (VO_2/HR, green line) during an actual speed endurance track session in a highly trained sprinter. Vertical yellow lines denote the start and completion times of consecutive sprints

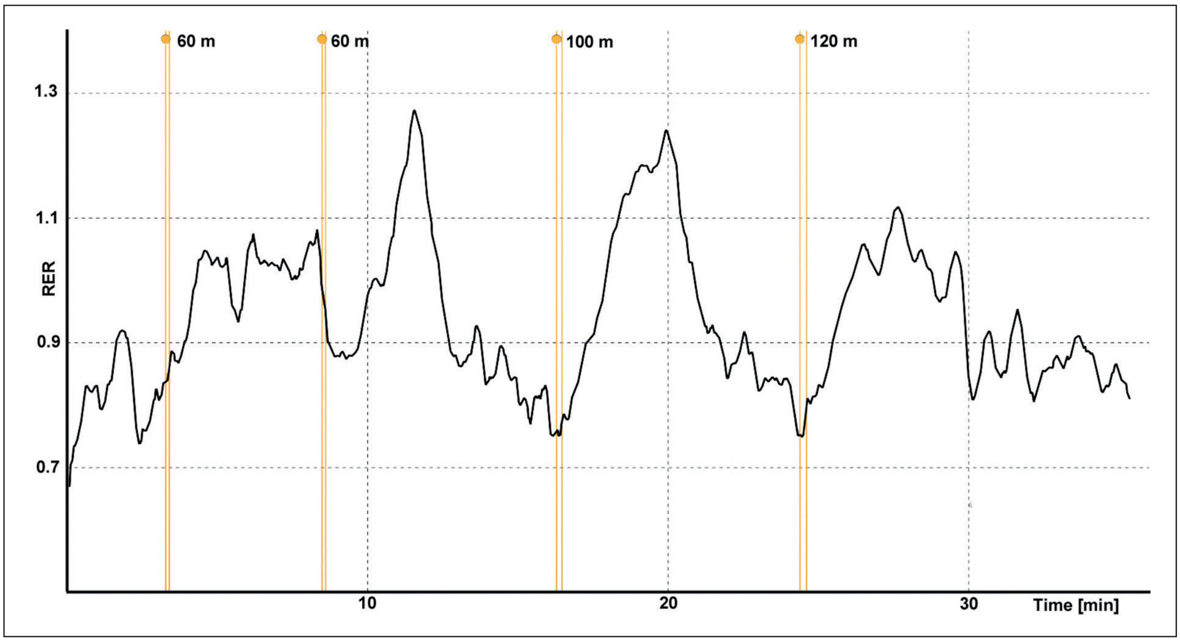

Figure 4. Time course of respiratory exchange ratio (RER) during an actual speed endurance track session in a highly trained sprinter. Vertical yellow lines denote the start and completion times of consecutive sprints

and 79% of their maximal values. HR and VO_2/HR approached 84–90% of maximum value. Post-effort RER reached 122–140% of the value at VO_{2max}.

The times of reaching peak values following the sprints were different depending on the parameter and successive sprints (Table 2). Peak VE and BF were attained within a narrow time range between 37 s and 46 s and 23 s and 34 s, respectively. The time to reach peak VT increased with each consecutive sprint from 38 s to 67 s. Similarly, the times to attain peak VO_2, VCO_2, RER, HR and VO_2/HR values increased with each sprint from 46 s to 89 s, 47 s to 76 s, 175 s to 196 s, 36 s to 48 s

Table 2. Times to reach the peak values* after consecutive sprints (seconds)

	60 m	60 m	100 m	120 m
VE	46	37	42	43
VT	38	40	52	67
BF	27	34	34	23
VO_2	46	54	66	89
VCO_2	47	56	76	74
RER	175	185	218	196
HR	36	43	53	48
VO_2/HR	45	56	77	63

* time from the start of the sprint until obtaining post-exercise peak value

Abbreviations: BF breathing frequency; HR heart rate; RER respiratory exchange ratio; VCO_2 exhaled dioxide; VE minute ventilation; VO_2 oxygen uptake; VT tidal volume

Table 3. The contribution of aerobic and anaerobic energy sources to the energy expenditure during four consecutive sprints

	Total	Consecutive sprints			
		60 m	60 m	100 m	120 m
Exercise VO_2 [l]	0.83	0.05	0.04	0.22	0.51
Energy from aerobic metabolism VO_2 [kJ]	17.54	1.08	0.92	4.73	10.81
EPOC, fast component [l]	3.08	0.34	1.13	0.95	0.66
Energy from anaerobic alactic metabolism [kJ]	73.62	7.57	26.90	21.81	17.34
∆ LA [mmol/l]	13.32				
Energy from anaerobic lactic acid metabolism [kJ]	67.47				
Total energy [kJ]	158.63				
Energy contribution [%]:					
– aerobic	11.1				
– anaerobic alactic	46.4				
– anaerobic lactic acid	42.5				

Abbreviations: EPOC – excess post-exercise oxygen consumption; LA – blood lactate; VO_2 – oxygen uptake

and 45 s to 77 s, respectively. During the recovery intervals, all cardiorespiratory variables returned to pre-exercise values but maintained significantly above baseline (resting) values (Fig. 1–3). Pre-exercise LA was 1.90 mmol/l and following the warm-up, 2.88 mmol/l. Peak LA, measured after the last sprint, reached 147% of the maximum value measured during the maximal graded test until exhaustion (Table 1).

Total metabolic energy expended during four sprints was estimated to be 158.63 kJ (Table 3). The proportions of aerobic, anaerobic alactic and anaerobic lactic acid energy sources were approximately 1.1 : 4.6 : 4.3, respectively, as calculated from exercise VO_2, fast component of EPOC and net post-exercise lactate concentration. From the second 60-m sprint to the 120-m (last) sprint, the aerobic energy delivery increased by 9.89 kJ and the anaerobic alactic energy decreased by 9.56 kJ.

Discussion

The main finding of this report is that, as expected, repeated sprints performed during an actual track session in a highly trained sprinter elicited a strong cardiorespiratory response and aerobic metabolism noticeably contributed to the total energy production. Although anaerobic energy sources were estimated to deliver as much as ~89% of the total energy during the whole sprint workout, the remaining ~11% were provided by aerobic metabolism. Our results are, in general, consistent with studies in which the aerobic energy contribution during sprint exercise (6–20 s cycling or 100-200 m running) was estimated to be 5–18% [1, 4, 5, 10]. However, the reported results are affected by measurement and calculation methods and, for a 100-m sprint, may vary from 9% to 11%, based on lactate and phosphate creatine measures, or from 21% to 25% if calculated from accumulated oxygen deficit [9, 11].

The magnitude and delay of respiratory response was dependent on the measured variable and sprint order. The strongest respiratory response, reaching or exceeding the intensity at VO_{2max}, was revealed for VT, BF and RER. The remaining cardiorespiratory variables attained submaximal levels (70–90% of values at VO_{2max}). Similar relative values were found in healthy young men (21 ± 2 years) performing a single sprint on a cycle ergometer [20]. Time to reach peak VO_2, VO_2/HR, VCO_2, RER, VT and BF increased with consecutive sprints, whereas it was relatively constant for VE and HR. The respiratory reaction was accompanied by a very high concentration of blood LA immediately after the last sprint and changes in proportion of aerobic and anaerobic alactic sources of energy.

Ventilation

Interestingly, VE (a product of VT and BF) increased to submaximal values after consecutive sprints despite "supramaximal" increases in BF and VT. The explanation is the desynchronization of VT and BF. These two peak values, even if extremely high, did not overlap: peak BF was attained sooner than peak VT. Peak magnitudes of VT were constant but the times to reach peak VT became longer with each subsequent sprint. In contrast, peak BF increased with subsequent sprints at constant peak times. As a result, VE reached values below those at VO_{2max} (Table 1, Figure 1).

Oxygen uptake

In recreationally trained subjects, it was found that brief, all-out sprint interval exercise produced significantly higher values of post-exercise VO_2 in magnitude and duration than after moderate aerobic exercise [21]. The literature concerning the respiratory response to a single or repeated sprint exercise in highly trained athletes is very scarce and, to our best knowledge, virtually no attempts were made to assess the response during actual track and field training sessions. In the study of Duffield et al. [11] on club- and national-level sprinters, peak VO_2 and peak HR after a single 100-m sprint attained 33% VO_{2max} and 91% HR_{max}. The observed VO_2 was clearly lower than that attained by our athlete. The discrepancy is connected with different criteria to determine peak values: the end of sprint distance in Duffield et al. [11], and delayed post-exercise maximum value in this study. However, peak HR was similar despite different measurement assumptions because HR increased faster than VO_2, already at the very early stage of exercise. McGawley and Bishop [13] measured oxygen uptake during two bouts consisting of five consecutive 6-s sprints on a cycle ergometer in female European football players (national league). VO_2 increased to 93% (1st bout) and 102% (2nd bout) VO_{2max} after the last sprint. In our study, peak VO_2 after each consecutive sprint was lower and equal to 74–79% VO_{2max}, even though the distance and exercise time increased. The differences may be attributed to recovery times between sprints, which were only 24 s in the study by McGawley and Bishop, and 5–10 minutes in our track session. Incomplete recovery results in the start from an elevated baseline. This in turn causes the increase in peak VO_2. The longer recovery periods in our study brought about a return to VO_2 levels from before the first sprint. Consequently, post-sprint peak VO_2 values did not reach the VO_{2max} level (Table 1). However, pre-exercise values were attained later, after each subsequent sprint.

Blood lactate

In this study, peak LA after the last sprint was high (16.2 mmol/l) and comparable to the levels observed by Locatelli and Arsac [8] after single 100-m sprints performed by competitive athletes during an actual competition. Such a high blood LA concentration is characteristic of so called "anaerobic lactic training", which is a classic method in developing speed endurance. In fact, a considerable contribution of aerobic metabolism must be taken into account (see section below). The explanation of high blood LA levels during intense exercise is that phosphate sources (mainly PCr) become depleted, causing acidosis [22] and reduced glycogenolysis [23].

In practical terms, the levels of LA after a sprint exercise depend on the time and number of repetitions, as well as recovery duration. In healthy young males, peak values in LA were 4.4 mmol/l after a single sprint (cycling), 7 mmol/l after five 10-s sprints and 8.7 mmol/l after a 30-s sprint [24]. It was revealed that when multiple sprints were performed, the first of the ten 6-s sprints resulted in a small increase in blood LA to about 2 mmol/l, after the fifth sprint LA increased to 9.3 mmol/l, and after the ninth sprint LA reached 12.6 mmol/l and remained constant during the 10 min of post-exercise recovery [25]. In trained athletes, after a single 100-m actual track sprint, peak LA reached values from 8 to 16 mmol/l [8, 11, 26], which is consistent with our data. Hirvonen et al. [26] revealed that post-exercise blood LA levels increased with the distance and time of single sprints: 40-m, 60-m and 80-m track sprints elicited lactate responses equal to 4.5, 5.9 and 7.8 mmol/l, respectively. Thus, blood LA levels are higher when the distance, time and repetition number of sprints are higher and the recovery time is shorter. It is also suggested that highly-trained athletes can produce and tolerate higher lactate concentrations [27]. Based on the previous reports mentioned above, we may conclude that the LA levels in our sprinter were typical for a highly trained athlete.

Aerobic energy contribution

Sprint interval training sessions are typically aimed at stimulation of anaerobic energy sources using maximal or submaximal short-duration exercise separated by recovery periods. However, a substantial "admixture" of aerobic metabolism must always be taken into account, which seems to be unavoidable as demonstrated previously (see Introduction). The clearly noticeable contribution of aerobic metabolism as early as a few seconds from the beginning of a sprint exercise results from the fact that anaerobic energy sources get near their limits very quickly and need time to restore after exercise. That is why the recovery time and number of repetitions are crucial to the effects of such a specific session. Dawson et al. [28] found that in trained subjects, PCr repletion after a 1 × 6 s sprint was approximately 70% complete after 30 s of recovery and almost complete (90%) after 3 min of recovery. After 5 × 6 s sprints, each separated by only 24 s, PCr repletion was less than 50% complete after 30 s of recovery and only approximately 80% complete after 3 min. Full recovery from a multiple sprint exercise usually requires about 30 min for VO_2 and blood LA levels to decline to resting values [21]. Admittedly, in our athlete, recovery times (5–10 min) allowed VO_2 and other cardiorespiratory parameters to return to pre-exercise values, but post-exercise times to reach peak VO_2 lengthened with each sprint and the aerobic energy demand increased. Simultaneously, the contribution of alactic anaerobic energy metabolism decreased, which suggests that full recovery of PCr was not possible.

The contribution of aerobic metabolism may increase from ~10% to ~40% of the whole energy delivery with each successive sprint separated by short recovery intervals [13]. It is related to a decrease in anaerobic adenosine triphosphate (ATP) resynthesis by 65% after multiple sprints [25]. 88% to 100% of muscle PCr is expended during 5.5 s in a 11-s sprint, depending on an athlete's performance level, and glycolysis is the main anaerobic energy source at the end of the run [26]. However, these both sources are still insufficient. Thus, it is suggested that, based on exercise protocols with short recovery intervals up to 30 s, aerobic energy contribution serves to offset the decline in anaerobic energy production during a repeated sprint exercise [13, 25, 29].

In support of the above view, the decline in power output is much smaller than the decrease in muscle PCr concentration and smaller than the decline in ATP production rate from anaerobic sources [13, 25]. In other words, sprint performance level is maintained in spite of the significant depletion of anaerobic sources. Such a phenomenon, although to a lesser extent because of relatively long recovery periods, was observed in our athlete. On the one hand, the contribution of aerobic metabolism increased and anaerobic (alactic) metabolism decreased with each repetition. On the other hand, the level of performance was maintained as measured by average running speed. From this point of view, the analysed speed endurance workout was properly planned and performed. However, this and other studies impose some questions: Which is the most optimal strategy for developing speed endurance ability? Should we strengthen the aerobic metabolic adaptation in order to offset the rapidly declining anaerobic capacity? Or vice versa: Should we mainly promote anaerobic capacity to extend the time during which anaerobic metabolism is efficient enough? Each of the approaches require a different workout programme as regards distance/time, number of repetition and recovery intervals. We speculate that each athlete has his/her own proportion of aerobic and anaerobic metabolism in a particular exercise that results in best performance (highest running speed). Modern measurement methods and knowledge enable coaches and researchers to determine such parameters for individual athletes. This study shows one of such ways. Future research should focus on algorithms that would help to precisely tailor speed-endurance exercise parameters to the needs of a highly-trained athlete.

Limitation and strengths

The main limitation of this preliminary report is that only one athlete was examined and the results cannot be generalized. However, the training of highly competitive athletes is strictly tailored to individual needs, hence they usually perform different training drills as was the case here. Also, some unexpected oscillations of respiratory variables that could obscure the calculations were observed, resulting from non-standard behaviour of the athlete in contrast to laboratory conditions. Moreover, the maximal test was performed much earlier than the track session, however, we revealed in our previous study that VO_{2max} did not significantly change in sprinters between the pre-competition and competition phase of the annual training cycle [30]. The strength of our report is that accurate and precise measuring methods were used during the actual track session, which allowed for the collection of unique data.

Conclusions

The athlete we studied showed typical contribution of aerobic (~11%) and anaerobic (~89%) energy delivery during the speed endurance workout. Our observations are consistent with evidence from other studies and support the notion that specific speed endurance exercise relies on both anaerobic and aerobic metabolism. The latter seems to be inseparable from the training routine aimed at development of this ability in highly trained sprinters. The monitoring and control of actual track sessions using high-tech equipment may help coaches and athletes to determine optimal workout parameters, i.e. exercise and recovery time as well as repetition number, to effectively achieve training goals.

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Corresponding author:

dr hab. Krzysztof Kusy
Department of Athletics, Poznan University of Physical Education
e-mail: kusy@awf.poznan.pl
phone: +48 83 55 270