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TRANSITION PERIOD DOES NOT REDUCE POWER AND WORK PERFORMANCE PARAMETERS IN THE 15-SECOND MAXIMAL POWER OUTPUT CYCLE ERGOMETER TEST IN YOUNG MALE AND FEMALE SPRINT ATHLETES

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ABSTRACT
Purpose. The aim of the study was to determine the changes in maximal anaerobic power and work output observed in a 15-second maximal power ergometer test following a four to five week-long transition period in a group of young sprinters. **Methods.** Sixteen young sprinters (six women and ten men) were asked to perform a 15-second maximal power output cycle ergometer test (a modified variant of the standard Wingate test). Blood samples were obtained from subjects before the test and three minutes after exercise in order to measure lactate (LA), hydrogen ion (H^+) and bicarbonate (HCO_3^-) concentrations. The tests were conducted twice, at the beginning (T1) and the end (T2) of the transition period for each of the sprinters. **Results.** Changes in the body weight and the body fat content of the sprinters following the transition period were non-significant. When comparing pre- to post-transition period performance, there were no significant changes in total work output (W_{tot}) and maximal power (P_{max}), however these parameters' ratios to body weight were found to slightly increase in the group of males. A significant increase in the number of total pedal revolutions in males was also observed. There were no changes in the time of maintaining maximal power (Tm) and time to reach maximal power output (Tr) in both groups. No statistically significant changes in the values of the selected parameters ΔLA, ΔH^+, ΔHCO_3^- and also the ratio of ΔH^+ to W_{tot} were noted between the tests performed at T1 and T2. **Conclusion.** The four to five week-long transition period did not diminish power and work performance in 15-second maximal power output test in young sprint athletes. Moreover, some of the performance parameters increased in the group of male sprinters.

Key words: transition period, anaerobic power and work output, young sprint athletes

Introduction

It is well-known that training stimuli trigger a series of numerous adaptive changes in muscle tissue (hypertrophy, increase in enzyme activity), which in turn improves the body's physical fitness [1– 3]. An opposite phenomenon can also be seen when training is ceased; it may also cause changes in muscle tissue (skeletal muscle atrophy, decrease in enzyme activity) resulting in a decrease in physical endurance [1, 4]. In shaping the performance capabilities of sprinters, a decrease in training volume during tapering and the use of a training break can enhance the body's adaptive processes (e.g., an increase in the cross-sectional area of fast-twitch muscle fiber) and improve some anaerobic capacity parameters [2, 5, 6]. In addition, a too high training volume can inhibit adaptive processes and performance improvements [6]. Therefore, the effective training of athletes is considered to be one that uses positive training stimuli while regulating the intensity and volume of training load as well as the optimal use of training breaks [5].

It was already known in the 1920s that an athlete's training break cannot last for too long a time; hence, the introduction of year-round training, but by then it was recommended to limit training following the competitive season in order to provide the athlete with a recovery period. Matveyev's studies have had a large impact on the training periodization definition and determining definition of macro-cycle as well as training periods being part of macro-cycle [7]. According to this author, the phenomenon of using phasic sports training – the buildup, maintenance and periodic loss of it – is the basis for periodization of the training process. In such a way, the transition period is a necessary consequence of the competition period as it provides athletes with active rest and recovery and prevents the negative effects of applied training and competition loads. However, transition period should not exclude training altogether so as maintain an athlete's fitness level and that their next training cycle can start from a higher level than from the previous cycle [7].

Currently, the transition period is accepted as part of the training macro-cycle and it serves as a period of physical and psychological recovery for athletes after the competitive season. In particular, it is characterized by a significant reduction in training volume and intensity [8, 9]. However, there is limited data on how an athlete's body reacts to the significantly lower training loads and changes of training stimuli commonly used in the transition period. Therefore, the aim of this study was to analyze the changes of selected parameters of anaerobic endurance, measured by a 15-second maximal-power output cycle ergometer test, in young male and

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female sprinters at the beginning and the end of their transition period.

Material and methods

The study involved 16 young sprinters (ten men, six women) who specialize in the 100–200 and 400 m sprint distances. All of the athletes had experience in sprint competition and were classified as being in the second sports class (determined by the Polish Association of Athletics) at the start of the study. The transition period length was different for each athlete due to their individual training cycles, for 15 of the sprinters this was on average 31 days, while one subject had their transition period extended to 49 days due to illness. During the transition period, the athletes took part in two to four training sessions per week, which included team games and cross-country runs at a low or moderate intensity. All participants provided their written consent to participate in the study, which had been approved by Ethics Committee at the University School of Physical Education in Wrocław, Poland.

Each subject performed the 15-second maximal power output test on cycle ergometer twice, at the beginning (T1) and the end (T2) of the transition period. The equipment used in this study included a 824E Ergomedic ergometer (Monark, Sweden) and MCE 2.3 analysis software (JBA, Poland). The maximal power test was based on the classic Wingate test, which was shortened in duration and the prescribed load was based on 7% of the subject's body weight [10]. The use of a shortened 15-second test allowed for the measurement of maximal anaerobic power output but avoided the acute effects of fatigue caused by the full-length 30-second test. In each test, the time of a single pedal revolution was monitored. In addition, the following parameters were measured: the total number of the pedal revolutions (N); total work (W_{tot}); maximum power (P_{max}), calculated as the mean power of all revolutions when power was equal or greater than 97.7% of peak power; time required to reach P_{max} (Tr); and the time of maintaining P_{max} (Tm).

An arterialized blood sample was collected from the subjects both before the five-minute warm-up prior to the test and then three minutes after the test was completed, with the following blood parameters analyzed: hematocrit (HCT) (ABX Mikros 60, Horiba, France), pH, bicarbonate concentration (HCO_3^-) (248 RapidLab, Bayer, Germany) and lactate (LA) concentration (colorimetric method using reagents from Sentinel Diagnostics, Italy). In the blood plasma collected prior to the warm-up, the creatine kinase (CK) activity was also measured (a colorimetric method using reagents from BioSystems, Spain) to confirm whether no overload of physical activity was performed in the days preceding the study. Post-workout concentrations (C) of the selected analyzed biochemical parameters in arterialized blood (not plasma) were corrected by taking into account the change in HCT by the formula:

$$C_{corrected\ post\text{-}workout} = C_{measured\ post\text{-}workout} \times HCT_{rest}/HCT_{post\text{-}workout}$$

Table 1. Anthropometric characteristics of subjects

	Age (years)	Weight (kg)	Fat (%)	Height (cm)
Male	19.6 ± 2.11	70.6 ± 3.52	10.4 ± 1.95	179.8 ± 3.08
Female	20.9 ± 0.57	62.4 ± 7.13	22.8 ± 2.51	172.8 ± 5.12

Mean values (± SD)

The subjects were weighed and measured before the exercise test (Radwag, Poland), with body fat content (% Fat) measured with a 6100/XL (Futrex, USA) body composition analyzer. Tests were carried out in the ISO 9001:2001-certified Exercise Research Laboratory at the Physiology and Biochemistry Department of the University School of Physical Education in Wrocław, Poland. The anthropometric characteristics of subjects are shown in Table 1.

The *t*-test for dependent variables was used to compare the values at the beginning (T1) and end of the transition period (T2) separately for both sexes. Statistical calculations were performed using Gnumeric and Microsoft Excel software. Statistical significance was set at 0.05.

Results

The results of tests carried out at the beginning (T1) and end (T2) of the transition period show that in the group of males there was a statistically significant increase in P_{max}, expressed per kilogram of body mass, and W_{tot}, expressed per kilogram of body mass, as well as an increase in the number of total revolutions (Tab. 2). No changes of these parameters were found in the group of females. No significant differences between T2 and T1 in body mass and fat content were observed (Tab. 3). Based on statistical analysis, no significant changes in the other parameters related to the work performance during the test, i.e., W_{tot}, P_{max}, Tm and Tr, were found (Tab. 2).

No statistically significant changes in the values of the selected blood parameters ΔLA, ΔH^+, ΔHCO_3^- and also the ratio of ΔH^+ to W_{tot} were noted between T1 and T2 (Tab. 3). The creatine kinase values measured in plasma collected before the tests were not higher than 347 [U/L] in men and 401 [U/L] in women.

Discussion

The results of the study point to some changes in the anaerobic performance of young sprinters at the beginning and end of the transition period. A review of the available literature did not find any study that

Table 2. Performance of male and female sprinters in the 15-second maximal power test

Parameters	Male			Female		
	T1	T2	*p*-value T1 vs. T2	T1	T2	*p*-value T1 vs. T2
Body mass (kg)	70.6 ± 3.52	70.4 ± 3.13	0.64628	62.4 ± 7.13	62.1 ± 7.10	0.58449
%Fat (%)	10.4 ± 1.95	10.1 ± 1.13	0.42625	22.8 ± 2.51	22.7 ± 3.45	0.81030
N	37.8 ± 2.87	38.8 ± 2.28	0.00631*	32.0 ± 3.47	32.3 ± 4.00	0.75756
W_{tot} (kJ)	11.06 ± 1.236	11.25 ± 1.025	0.15968	8.17 ± 1.024	8.22 ± 1.384	0.84897
$W_{tot} \cdot$ body mass^{-1} (J $\cdot$kg^{-1})	157 ± 11.9	159 ± 9.7	0.03606*	131 ± 13.6	132 ± 16.2	0.86734
P_{max} (W)	851 ± 88.9	853 ± 76.5	0.83257	656 ± 76.0	654 ± 102.2	0.88809
$P_{max}\cdot$ body mass^{-1} (W $\cdot$ kg^{-1})	12.0 ± 0.88	12.2 ± 0.75	0.03962*	10.5 ± 1.14	10.5 ± 1.26	0.91382
Tr (s)	5.27 ± 0.851	4.80 ± 0.552	0.10104	7.06 ±1.047	6.37 ± 1.395	0.14400
Tm (s)	3.47 ± 0.928	3.38 ± 1.075	0.82903	3.79 ± 0.688	3.55 ± 0.970	0.56040

Values of the parameters in T1 and T2 are means (± SD); * *p*-value ≤ 0.05; N – total number of pedal revolutions;
W_{tot} – total work output; P_{max} – maximum power output (calculated as the mean power of all revolutions,
where power was equal or greater than 97.7% of peak power); Tr – time to reaching P_{max}; Tm – time of maintaining P_{max}

Table 3. Metabolic responses of male and female sprinters to the 15-second maximal power test

Parameters	Male			Female		
	T1	T2	*p*-value T1 vs. T2	T1	T2	*p*-value T1 vs. T2
ΔLA (mM)	9.8 ± 1.98	9.4 ± 1.32	0.19659	7.6 ± 1.61	9.1 ± 2.62	0.09510
ΔH^+ (nM)	20.4 ± 4.14	19.7 ± 6.34	0.56216	16.4 ± 4.41	14.6 ± 5.44	0.31840
$\Delta H^+ \cdot W_{tot}^{-1}$ (nM $\cdot$ kJ^{-1})	1.85 ± 0,304	1.74 ± 0.448	0.36303	2.01 ± 0.408	1.73 ± 0.470	0.17292
ΔHCO_3^- (mM)	10.3 ± 2.38	10.9 ± 1.89	0.38113	9.5 ± 1,31	10.0 ± 4.20	0.72920

Values of the parameters in T1 and T2 are means (± SD). Note: no significant T1 vs. T2 changes occurred (*p*-values > 0.05);
ΔLA – post-exercise increase of lactate concentration; ΔH^+ – post-exercise increase of hydrogen ion concentration;
W_{tot} – total work output; ΔHCO_3^- – post-exercise decrease of bicarbonate concentration

considered the effects of training breaks on the power or work parameters of sprinters by use of a several-second maximal test. As such, a discussion on the results of this study needs to be referenced to other studies that differed in terms of participants' fitness level, sports discipline, duration of the training break and what tests were used for analysis.

The subjects declared that they performed no demanding physical activity prior to each of the tests. This was confirmed by the creatine kinase level measured in the subjects' blood, which indicated no physical overload state of the subjects in the test performing days. Although the creatine kinase levels in females (reaching up to 401 U/L) exceeded the norms for physically active individuals (< 200 U/L for female and < 400 U/L for male), these values were still not high enough to suggest physical overloading [6].

An interesting fact observed in the study was the increase in the males' total work in relation to body weight and the increase in the number of pedal revolutions even with no statistically significant changes in their body weight or body fat content. It is obvious that lower limb strength has a significant impact on the work executed in such a short test. Hortobágayi et al. [11] found no change in strength parameters measured by one maximal repetition (1RM) when studying the effects of a two-week training break on professional footballers and powerlifters. Even a six-week training break did not cause any changes in 1RM in subjects recreationally involved in weight training, as Kraemer et al. reported [12]. Undoubtedly, the increase in the ratio of total work output to body mass obtained in our study should be related to an increase in strength, although Hortobágayi et al. [11] and Kraemer et al. [12] found no changes in strength measured by 1RM. It should be marked still, a distinct character of physical effort during 1RM test and 15-second maximal power output test.

Kraemer et al. [12] concluded that a training break has a greater impact on decreasing the parameters associated with power rather than those associated with strength. This conclusion was also confirmed by Izquierdo et al. [13], who observed a higher decrease in power rather than strength after a four-week break from strength training in recreationally strength-trained subjects. However, in our study, P_{max} did not decline and in fact remained at the same level for both males and females. Still, Kraemer et al. [12] found a decrease in P_{max} in the

30-second Wingate test already three weeks after detraining. The differences between our findings and Kraemer et al. may have been caused by the different sports discipline and forms of training the athletes engaged in.

The males' increase in P_{max} in relation to body mass and the increase in the number of revolutions, with no change in Tr or Tm, indicate speed improvement during the relatively short power output measured in this study. A similar trend was found by Linossier et al. [2], where a seven-week break during interval sprint training did not result in a decrease in the maximum power achieved during a several-second maximal power test. Similarly, Andersen et al. [14] examined not-trained subjects and found an increase in speed and power in an unloaded lower-limb test following a three-month break when compared to the results measured immediately after a three-month period of strength training. The lack of significant increases of the above-mentioned parameters in the group of females examined in our study may be due to statistics (due to the small number of female subjects taking part in the experiment) or may be caused by sex-related differences in maximal power output in response to a transition period.

The increase in speed in the maximal power tests observed in this study could be caused by changes in the composition of muscle fibers during a training break. Andersen et al. [14] observed a percentage increase in type IIx muscle fibers three months after ending strength training, although the cross-sectional muscle area returned to the same size measured before training. Taking into account the results of *in vitro* studies finding that IIx fibers contract approximately twice as fast and with greater power than IIa fibers and almost nine to ten times faster than type I fibers, IIx fibers could in fact have caused the high power performance observed in these non-load tests [15–17]. However, such changes in muscle fiber composition were not observed following a two-week break after strength training in a group of powerlifters and former professional footballers, but another study did observe a change in young women 30 weeks after ending a 20-week strength training program through an increase in 1RM values [1, 11].

It seems that breaks significantly longer than two weeks are necessary for the percentage increase of type IIx fibers, although it must be remembered that the changes associated with the adaptation to training stimuli and the training break can vary significantly in individuals of different levels of fitness and practicing different sports disciplines [6, 12]. The four-to-five week break used in our study may have been sufficiently long enough for the changes in muscle fiber composition resulting in a percentage increase of type IIx muscle fibers and, consequently, may have resulted in the increase in some of the parameters related to speed, strength and power during the 15-second maximal power cycle ergometer test. Nowadays, thanks to the ability of being able to test the functional changes in muscle fibers and their composition, it can be inferred that not all aspects related to exercise performance are simply related to the use or absence of a certain training stimuli [18].

It seems that the statistically insignificant changes in weight could have affected the differences in W_{tot} and P_{max} per kg of body weight, which were in fact calculated as being statistically significant. A more comprehensive study should be carried out that monitors changes in body weight and body fat content during the transition period in young sprinters.

No changes in the metabolic parameters (ΔLA, ΔH^+, ΔHCO_3^-) measured in the blood were found in both the males and females in our study. The values of these parameters are related to the glycolytic cost of performed work. Interestingly, the transition period did not result in an increase in acidosis, thus the physiological cost of performing physical work on the glycolytic pathways seems to be unaffected.

There are still too few studies that analyze the changes of young sprinters' performance during the transition period. To better understand this issue, additional studies ought to be conducted with the use of other tests that measure strength, speed and power, combined with an analysis of changes in the composition of muscle fibers as well as the activity of muscle metabolic enzymes.

Conclusions

Our results show that anaerobic performance parameters such as total work, maximum power and the time to reach and maintain maximal power obtained by the young male and female sprinters during a 15-second maximal power output cycle ergometer test did not significantly change after a four-to-five week transition period. Some of the measured parameters had even improved, for example the number of pedal revolutions and the ratios of total work and maximal power to body mass increased in males even with no changes in body weight and body fat content. Transition period did not result in significantly augmented acidosis in result of performed workout during 15-second maximal power output cycle ergometer test, that may indicate a similar glycolytic cost of work.

The above results clearly show the constancy or slight improvement in performance parameters measured during 15-second maximal power output test in young male and female sprinters after the transition period. Break in the regular training, that is the transition period, does not cause decrease in all anaerobic performance parameters, as one considers sometimes.

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