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Morphological characteristics and power output in professional road cyclists during the competition phase

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Summary

Study aim: The purpose of this study was to investigate changes in the power output and major morphological characteristics during the competition phase. We hypothesised that substantial overloads occurring during this stage cause a decrease in body mass, fat and power output levels in the cyclists.
Material and methods: Nine members from an affiliated Professional Cycling Group ActiveJet Team were observed during the period between January and September. Their mean age was calculated as 25.1 ± 1.6 years. Each month the main somatic features were determined and the BMI and Rohrer index were measured. The level of adipose tissue was checked using the Tanita BC-418 Ma and the Schoeberer Rad Messtechnik SRM training system was employed to record the maximum level of power output. The following tests were used to collect data: Shapiro-Wilk and ANOVA (assessment of the distribution of variables), Duncan (assessment of the changes of variables), and Pearson correlation coefficient (assessment of power dependence and morphological features). A significance coefficient of $\alpha = 0.05$ was assumed.
Results: The research of the studied group revealed a steady decrease in the body mass and fat percentage but no significant differences in power output levels. Its peak was reached in the middle of the starting phase (1195.3 ± 222.3 W) and the lowest level was noted during the last month of our observation (1114.1 ± 152.1 W; D = 81.2 W, $p = 0.088$). Correlations were found between body mass, fat composition and power output levels: moderate for mass ($r = 0.383$–0.778) and fat ($r = 0.352$–0.629) content to power output and small negative for height to power output. In most cases, however, they were either weak or low ($r = -0.017$–0.339).
Conclusions: Significant changes in the morphological characteristics (body weight 70.2 ± 6.4–69.2 ± 5.9 kg, $p < 0.001$; BMI 21.4 ± 1.9–21.1 ± 1.7, $p < 0.001$; Rohrer index 1.18 ± 0.11–1.16 ± 0.10, $p < 0.001$; fat 9.2 ± 3.2–8.2 ± 2.3, $p < 0.001$) and no differences in power output combined (1151.0 ± 272.4–1114.1 ± 152.1 W, $p = 0.434$) with medium correlations of these determinants (body height – 2.53–0.354; body weight 0.383–0.778; fat 0.352–0.629) indicate the significance of motor characteristics in road racing cyclists. Thus levels in its competency and performance outcomes are determined to a greater extent by factors other than the somatic characteristics.

Keywords: Road racing cyclists – Physique – Fat content – Power output – Sport

Introduction

Road race cycling is the most popular type of cycling. Nearly one million people worldwide are involved and two thousand cyclists consider themselves to be at a professional level. It is classified as endurance-strength activity as the power output during training is extremely important. The key factor determining the muscle work is availability of energy substrates and mechanical efficiency and is decided by reduced levels of body fat content resulting in mass reduction [2, 5, 20].

Despite the lean and slender body structure, professional cyclists are characterised by a high level of power output which every so often determines their success at a particular phase or decides a positive result of a long-

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term race in the final stage. Cycling, like any other sport training, elicits a series of functional changes in the body of the competitor. These are determined by different functions carried out by organs and systems and are often accompanied by changes in body mass [5, 15, 21]. Mass and fat content significantly affect the power output levels in cyclists [4, 18]. Appropriate training, however, allows competitors to maintain its high level up to the fifth decade of life [17]. Research also indicates that linked to the power output morphological and functional changes vary depending on the type of cycling training [16, 23]. Thus tracking and monitoring of the power output levels is particularly important in addition to specialist tests and detailed assessments used in training programmes [6, 10, 19]. It is possible that during the extended starting phase, when considerable efforts are exerted, changes in both the power output levels and somatic characteristics occur with considerable intensity.

The aim of this study is to assess the changes in key morphological characteristics and power output levels in professional road racing cyclists in the nine-month long competition phase. We hypothesise that significant overloads occurring during this period result in a decrease in power output levels, body mass and fat content. A significant correlation between the power output and fat content percentage in the observed competitors is also assumed.

Material and methods

Permission to conduct this study was obtained from the Bioethics Committee of the Ludwik Rydygier Collegium Medicum of Nicolaus Copernicus University in Toruń (no. KB 763/2014). The inclusion criteria for selection of participants were: male gender, sport competitor at international level, below 35 years of age as well as comparable training systems and starting loads. All men were informed about the aim of the study, type and duration of the effort, and the possibility to withdraw from the study without giving any reason. Each potential participant granted voluntary consent for participation in the study.

From January to September 2015, nine competitors of the Professional Cycling Group ActiveJet Team, classified by the International Cycling Union in 25th place among continental groups, were observed. The team consisted of leading Polish cyclists with experience in competing between 7 and 20 years, multiple country champions, often successful in the international arena. In stage races and one-day classics organised in many European countries, i.e. Spain, France, Hungary, the Czech Republic, Slovakia, Germany and Norway, they often placed in the top ten and many won places on the podium. In the nine-month period covered by the research, the athletes of the observed cycling group competed in 7 multi-stage races and 15 one-way classics and carried out training allowing them to maintain a high level of fitness, covering a total distance of 9150 km. The mean age of the examined competitors was 25.1 ± 1.6 years. Each month height and body mass were measured and Rohrer's index and BMI were calculated for each participant. The body composition analyser Tanita BC-418 MA was used to establish the fat content. Furthermore, the maximum level of power output in the subsequent month of observation was predicted using the Schoeberer Rad Messtechnik SRM training system, considered to be the most accurate for this purpose. The study employed individual results of the highest power level in each month and the accompanying morphological features of the cyclists. The SRM system used in the tests was based on the aerodynamic crank mechanism with an inflexible system mounted in the bike, enabling optimal transmission of the pedalling power expressed in watts (W) and its continuous recording [4, 12]. The reason for this approach

Table 1. Morphological characteristics of cyclists

Month of study	Feature (mean ± SD)			
	(n = 9); (age = 19.0–32.0; 25.1 ± 1.6); (height = 176.0–186.0; 181.3 ± 3.2)			
	Body weight	BMI	Rohrer index	Fat [%]
I (January)	70.2 ± 6.4	21.4 ± 1.9	1.18 ± 0.11	9.2 ± 3.2
II (February)	69.7 ± 6.2	21.2 ± 1.7	1.17 ± 0.10	9.1 ± 3.3
III (March)	70.7 ± 5.6	21.5 ± 1.6	1.19 ± 0.09	9.2 ± 3.0
IV (April)	70.1 ± 5.9	21.3 ± 1.7	1.18 ± 0.10	8.6 ± 2.6
V (May)	69.7 ± 5.7	21.2 ± 1.6	1.17 ± 0.10	8.5 ± 2.7
VI (June)	69.3 ± 5.7	21.1 ± 1.6	1.16 ± 0.10	8.2 ± 2.6
VII (July)	69.1 ± 5.5	21.0 ± 1.6	1.16 ± 0.09	8.2 ± 2.6
VIII (August)	68.8 ± 5.6	20.9 ± 1.6	1.15 ± 0.09	8.1 ± 2.6
IX (September)	69.2 ± 5.9	21.1 ± 1.7	1.16 ± 0,10	8.2 ± 2.3

is its greater sensitivity in detection of changes induced by training on shorter endurance routes and consequently better suitability in study of changes occurring during the competition phase [12].

Statistics: In assessment of the distribution of dependent and independent variables, the Shapiro-Wilk test was employed, designed to detect similarities in the variable distribution to the normal distribution, and the ANOVA test, used in research on repeated measurements. = Duncan's multiple range test (MRT), based on multiple comparisons of subgroups, was employed to evaluate changes in the examined characteristics. To establish key morphological features and calculate power outputs the Pearson correlation coefficient was used in each study. A significance level of α = 0.05 was used. Analysis was conducted with Statistica 10.

Table 2. Quantitative comparison of morphological characteristics in cyclists during the nine month competition phase

Month of study	Feature	I	II	III	IV	V	VI	VII	VIII
		p							
February (II)	Body weight	0.692							
	BMI	0.695							
	Rohrer index	0.695							
	Fat mass [%]	0.692							
March (III)	Body weight	0.914	0.773						
	BMI	0.932	0.777						
	Rohrer index	0.932	0.777						
	Fat mass [%]	0.914	0.773						
April (IV)	Body weight	0.051	0.116	0.064					
	BMI	0.054	0.119	0.067					
	Rohrer index	0.064	0.119	0.067					
	Fat mass [%]	0.051	0.116	0.064					
May (V)	Body weight	0.033*	0.081	0.051	0.857				
	BMI	0.036*	0.084	0.057	0.867				
	Rohrer index	0.038*	0.084	0.057	0.867				
	Fat mass [%]	0.033*	0.081	0.051	0.857				
June (VI)	Body weight	0.003*	0.008*	0.004*	0.266	0.350			
	BMI	0.002*	0.005*	0.005*	0.256	0.352			
	Rohrer index	0.001*	0.007*	0.005*	0.257	0.353			
	Fat mass [%]	0.003*	0.008*	0.004*	0.266	0.350			
July(VII)	Body weight	0.002*	0.008*	0.003*	0.251	0.332	0.971		
	BMI	0.002*	0.005*	0.003*	0.254	0.336	0.980		
	Rohrer index	0.003*	0.006*	0.004*	0.254	0.336	0.981		
	Fat mass [%]	0.002*	0.008*	0.003*	0.251	0.332	0.971		
August (VIII)	Body weight	0.001*	0.003*	0.001*	0.133	0.185	0.692	0.718	
	BMI	0.001*	0.002*	0.001*	0.134	0.187	0.670	0.728	
	Rohrer index	0.002*	0.003*	0.002*	0.135	0.184	0.672	0.729	
	Fat mass [%]	0.001*	0.003*	0.001*	0.133	0.185	0.692	0.718	
September (IX)	Body weight	0.001*	0.005*	0.002*	0.185	0.251	0.829	0.857	0.857
	BMI	0.001*	0.005*	0.002*	0.186	0.243	0.901	0.867	0857
	Rohrer index	0.001*	0.005*	0.002*	0.186	0.243	0.902	0.868	0.858
	Fat mass [%]	0.001*	0.005*	0.002*	0.185	0.251	0.829	0.857	0.857

* – statistically significant difference: $p < 0.05$.

Results

Table 1 summarises the results of our research on morphological characteristics and calculated indicators in the observed players. A minor increase in the mean for all characteristics in the first three months of observation was found (Table 1).

The assessment of differences in the mean value of the examined morphological features is presented in Table 2. Statistical significance of changes is firstly noted after 3–4 months in the second half of the competition phase (Table 2).

Power output levels in participants are summarised in Tables 3 and 4. No significant changes in their levels were found. A similar trend was found in morphological characteristics. However, the increase of power output lasted longer than the one observed in morphological traits.

The highest occurred in May (1195.3 ± 222.3 W) and the lowest in September (1114.1 ± 152.1 W) (Tables 3 and 4).

The correlation coefficients between key morphological characteristics and power output in the studied team are presented in Table 5. Consequently, correlations were found between body determinants and power output levels: moderate for mass and fat content to power output and small negative for height to power output. In most cases, however, they were either weak or low. With the exception of the observations from August and September, all correlations between the output power and body weight were statistically significant (Table 5).

Discussion

Previous research of various, often dissimilar, sports confirms the occurrence of multidirectional changes in physical fitness during the competition phase. Based on the findings of the current research, the following can be concluded:

1. The examined cyclists are characterised by significant body height, low or moderate body mass and athletic or leptosomic structure determined by the classification based on calculated Rohrer index values (1.15 ± 0.09–1.19 ± 0.09).

2. Observation of changes over the nine-month starting phase reveals an initial small increase in body mass and

Table 3. Quantitative description of power in cyclists including evaluation of distribution of variables

Month of study	Min–Max	$\bar{x}$	SD	CV	Me	t	p
January	781.0–1762.0	1151.0	272.4	24%	1111.0	0.882	0.166
February	720.0–1765.0	1170.2	299.9	26%	1106.0	0.947	0.655
March	867.0–1589.0	1163.2	231.8	20%	1183.0	0.943	0.613
April	972.0–1661.0	1179.8	221.7	19%	1143.0	0.860	0.097
May	1001.0–1742.0	1195.3	222.3	19%	1145.0	0.755	0.062
June	798.0–1713.0	1166.9	246.0	21%	1100.0	0.853	0.080
July	811.0–1707.0	1117.6	255.6	23%	1103.0	0.841	0.059
August	902.0–1509.0	1146.4	219.5	19%	1087.0	0.913	0.340
September	949.0–1297.0	1114.1	152.1	14%	1018.0	0.791	0.056

Table 4. Quantitative comparison of power in cyclists during the nine-month competition phase

Month of study	I	II	III	IV	V	VI	VII	VIII
	p							
February	0.683	x						
March	0.795	0.882	x					
April	0.541	0.839	0.725	x				
May	0.348	0.594	0.496	0.741	x			
June	0.736	0.944	0.938	0.784	0.546	x		
July	0.478	0.265	0.333	0.189	0.102	0.296	x	
August	0.923	0.614	0.721	0.479	0.301	0.664	0.540	x
September	0.434	0.235	0.298	0.166	0.088	0.264	0.924	0.493

Table 5. Values of correlation coefficients for power and key morphological features

Month of study	Correlation power and body height			Correlation power and body weight			Correlation power and fat mass [%]		
	r	t	p	r	t	p	r	t	p
January	0.249	0.679	0.519	0.740	2.919	0.022*	0.404	1.170	0.280
February	0.519	1.570	0.160	0.679	2.452	0.044*	0.352	0.997	0.352
March	0.116	0.310	0.765	0.706	2.643	0.033*	0.544	1.720	0.129
April	0.156	0.471	0.689	0.778	3.382	0.013*	0.629	2.143	0.069
May	0.339	0.954	0.327	0.775	3.249	0.014*	0.386	1.110	0.304
June	0.231	0.628	0.550	0.714	2.701	0.031*	0.365	1.037	0.334
July	0.135	0.361	0.728	0.705	2.631	0.034*	0.524	1.631	0.147
August	–0.017	-0.044	0.966	0.383	1.098	0.308	0.359	1.020	0.342
September	0.187	0.530	0.630	0.590	1.935	0.094	0.618	2.083	0.076
Together	0.219	1.995	0.050*	0.671	8.064*	0.000*	0.517	4.435	0.000*

* – statistically significant difference: $p < 0.05$

fat content calculated by BMI and Rohrer index, followed by their subsequent decrease.

3. Throughout the entire starting phase the examined participants are able to maintain power output at a similar and maximum level.

4. Despite significant changes in the key morphological features and no differences in the power output, calculated correlation coefficients prove their moderate dependence.

The above statements require a somewhat broader consideration by reference to research outcomes and experience of working with a professional group of cyclists.

It should be noted as a preliminary point that the value of key morphological characteristics and Rohrer index in the examined team do not significantly differ from other groups of professional cyclists; therefore it can be considered as representative of cyclists as a whole. Somewhat greater mean body height as well as lower weight and fat content in comparison to the values found in the group previously tested by PT. Nikolaidis and VE. Papadopulos can be regarded as a symptomatic trend of changes in morphological traits of cyclists [17]. Consequently, the well-known view of morphological conditioning of positive sport outcomes is confirmed.

Currently observed changes in the key morphological features are characteristic for high intensity and volume loads, including the competition phase in cycling [7].

Similar trends were also observed in previous studies of volleyball players. Therefore it can be assumed that the initial increment in size of the key morphological characteristics is consequential to changes occurring during the competition phase, as revealed in previously unpublished studies of highly qualified football players [14]. Despite the assumption of adjusting character of the observed changes (Giada et al. considers age as not significant), a regressive tendency is noted from the middle of the starting phase [7]. The occurrence of further overloads in road racing cycling and the directional impact of sport training on the human body are confirmed in the observation process. Such a view justifies the need for a personalised training programme and its adjustment to the health conditions of the competitor since the demands of professional sports are very high. Considering the above, reports of nutritional errors in some cyclists are rather concerning [5, 9, 20].

In professional road cycling as a discipline, the perception of high physical demands includes health predispositions as well as motoric and hybrid fitness abilities that are manifested by power output. Their level depends on various factors and is considered an important determinant in cycling as reflected in numerous attempts to address the problem [1, 11, 19, 22]. Calculated by the Rohrer index, athletic and leptosomatic body structure encourages exertion of power output. To some extent, the findings regarding body structure as well as the power and strength of road cyclists revealed by previously quoted authors [17] were confirmed. The results of the present study confirm relative stabilisation of the power output levels throughout the entire starting phase. However, in this case research outcomes on motor skills fundamental to cyclists do not correspond to the results of studies of body reactions to prolonged effort intensity or to the aforementioned decrease in power output levels in qualified volleyball players, where power output is also considered as extremely important [13]. Such an observation may indicate good preparation of the examined participants for the competition phase or suggest that in road cycling endurance is more important than power and that perhaps expected changes occur to a greater extent. We base this assumption on the stability of power and strength in cyclists of different ages, as revealed previously by other authors, as well as a decrease in cardiorespiratory parameters, which are key for endurance capacity [4, 17].

Thus our hypothesis on regression of power in cyclists during the competition phase was not confirmed. The coefficients of power dependence and basic morphological features in addition to the different pattern of their changes indicate earlier reactions of morphological characteristics to intense effort and can be viewed as a barometer for subsequent motor changes. Thus, the obtained results confirm our second hypothesis and justify the need for careful maintenance of morphological characteristics in cyclists at a constant and optimal level. Therefore we assume that the group of cyclists selected with regards to their age and type of training as well as efforts to maintain a relatively large lean body mass sustained the level of power throughout the nine-month competition period. This corresponds to the findings of other researchers that confirm a possibility of obtaining a comparable level of this motoric feature by cyclists of different ages [17].

The present study certainly does not exhaust the raised problems. Its relative value results from both the small number of examined competitors and variables adopted for analysis. It appears, however, that in addition to the observed trends in morphological and motoric changes, the obtained results may constitute valuable comparative material for a study of other groups of professional cyclists. The above statement justifies the method used for determining body components and measuring maximum power, as it is widely recognized for its sensitivity in detection and assessment of changes in training during the competition phase [12]. Yet it should be noted that the obtained outcomes on changes in fat percentage, although closely correlating with power output levels, can be accepted for comparison only in studies carried out using the bioelectric impedance method [8].

The present research results lead to three key conclusions.

Conclusions

1. Significant changes in morphological characteristics and no differences in power output levels in addition to average dependence of these features indicate the importance of power for motor ability in road cyclists. Therefore, maintaining its level and performance outcomes are determined to a greater extent by factors other than characteristics covered by the research.
2. A steady decrease of power output levels in cyclists during the competition phase and significant reduction in body weight and fat indicate that changes in somatic characteristics may serve as a barometer for subsequent changes in motor skills, and may occur with greater severity in strength characteristics.
3. Training adjusted to the cycling-specific starting requirements with attention to the optimal values of morphological characteristics allow a high level of cycling power to be maintained in the nine-month competition period.

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