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TRAINING LOAD AND CHANGES IN PHYSIOLOGICAL PARAMETERS AMONG YOUNG CYCLISTS

VPLIV OBSEGA VADBE NA SPREMEMBE FIZIOLOŠKIH KAZALCEV MED MLADIMI KOLESARJI

ABSTRACT

Monitoring several aspects of training load, anthropometric characteristics and physiological characteristics of cyclists can be a very important factor for success in the cycling world. The study aimed to establish the differences between some physiological parameters computed by metabolic gas measurements. The study sample included 86 cyclists age 15 to 18 years (BM = 63.4 ± 7.9 kg, BH = 176 ± 7.4 cm, % body fat = 9.9% ± 3.2 %). In the first part of the study, they completed a questionnaire about the evaluation of the training process, where we identified their training habits – the frequency (13.76 ± 3.7 hours per week) and intensity of their training methods (31.7 ± 19.1% of low-intensity training). In the second part of the study, we did laboratory testing (body composition and incremental cycling test). The results showed that changes depend on the cyclists` age group. The maximal peak power output (+32.1%; p<0.01); relative maximal peak power output (+9.2%; p>0.01), and maximal oxygen uptake (+ +6,1%; p>0.05) . The main finding of the study was that as the age of a cyclist increases, there is a tendency to increase training load and may influence their performance at the laboratory test.

Keywords: cyclists, training load, laboratory test, maximal oxygen uptake, power output

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IZVLEČEK

Pomemben dejavnik spremljanja tekmovalne uspešnosti v kolesarstvu predstavlja nadzor vadbe in spremljanje telesnih značilnosti kolesarjev in fizioloških kazalcev med kolesarjenjem. Cilj raziskave je bilo ugotoviti razlike med mladimi kolesarji različnih starosti in povezanost obsega vadbe in fiziološkimi kazalci pridobljenimi na obremenitvenem testiranju. V vzorec raziskave je bilo vključenih 86 licenciranih mlajših kolesarjev (starih od 15 do 18 let) (TT = 63.4 ± 7.9 kg, TV = 176 ± 7.4 cm, % telesne maščobe = 9.9% ± 3.2 %). V prvem delu študije so izpolnili vprašalnik o vrednotenju procesa treninga, kjer smo ugotovili njihove navade v treningu – pogostost (13.76 ± 3.7 ur/teden) in intenzivnost (31.7 ± 19.1% nizko intenzivne vadbe) njihovih metod treninga. V drugem delu študije smo opravili laboratorijske preiskave (telesna sestava in obremenitveni kolesarski test). Pri analizi rezultatov smo se osredotočili na nekaj izbranih parametrov doseženih na kolesarskem testu, kot so največja moč kolesarjenja (+32.1%; p<0.01), relativna moč kolesarjenja izražena na kg telesne mase (+9.2%; p<0.01) in maksimalnim privzemom kisika (+6,1%; p>0.05). Rezultati so pokazali, da so spremembe odvisne od starostne skupine kolesarjev. Variabilnost obsega vadbe in intenzivnosti vadbe je imela vpliv tudi na rezultate, kjer smo v laboratoriju preverjali sposobnosti kolesarjenja.

Ključne besede: kolesarji, obseg vadbe, obremenitvena testiranja, privzem kisika, moč kolesarjenja

INTRODUCTION

Competitive cycling requires both aerobic and anaerobic capacity (Faria, Parker, & Faria, 2005b; Padilla, Mujika, Orbañanos, & Angulo, 2000). Typical road race events for the junior level may have durations of approximately from 1 to 4 hours. This is why endurance is one of the main components of success in cycling competitions. On the other hand, road bicycling racing requires cyclists to possess the ability to generate a relatively high power output of a short duration during steep climbing in the race finish (Faria, Parker, & Faria, 2005a). Monitoring several aspects of training load and physiological characteristics of cyclists can be a very important factor for success in the cycling world. Measuring power output in the laboratory allows cyclist's physical capacities to be quantified. Taken together, the integration of these measures provides blended data that relate to performance, training adaptation, and talent identification across various cycling disciplines (Menaspà et al., 2012; Novak & Dascombe, 2014; Erp, Foster, & de Koning, 2019). That could be even more important among young cyclists because they gain some important information during the monitoring process. Most cyclists are tested in the performance diagnostic laboratories two to three times a year. The first test is done before the start of the preparation period (in November, December); the second is performed after two to three months of the training process (March, April) and some of them will also do the third test during the competition period (Jurov et al., 2020; Rauter, Vodicar, & Simenko, 2017).

Measurement of physiological characteristics in cycling such as maximal aerobic capacity has been used to quantify the efficiency of energy metabolism pathways (Impellizzeri et al., 2005). High maximal aerobic capacity might be one of the key factors that determine success in cycling (Faria et al., 2005a; Lucia, Hoyos, & Chicharro, 2001). Some other physiological parameters also have some importance. One of them is the ventilatory threshold (VT), which is defined with an incremental test as the point in time when ventilation disproportionately increases to increasing load. Method V-slope can be used to determine VT, which is based on a comparison of oxygen (VO2) and carbon dioxide (VCO2) curve values (Beaver, Wasserman, & Whipp, 1985). A point of respiratory compensation (RC) is a point where ventilation and oxygen uptake starts to rise disproportionately to the amount of carbon dioxide exhaled. At TC point we observe both rise in VE/VO2 and VE/VCO2 (Young, Gutin, Blood & Case, 1983).

Quantification models and the importance of monitoring training load aim to accurately reflect the magnitude of the training stress imposed on the athlete, especially in sports with high training volumes, such as road cycling (Moya Ramon, Ramon, Torres, & Sarabia, 2018).

Monitoring the training load starts by providing a general overview of important training variables that a coach manipulates to control training stress (that is, training volume, training intensity, and training load). Training volume usually refers to the duration of training. Coaches generally report training volume in terms of time (that is minutes per day, hours per week), however, it can also be reported in terms of distance covered. Training intensity refers to how hard someone is training. Many different methods can be used to measure intensity (Sanders, 2018). Some of the more common methods are heart rate, oxygen consumption, weight lifted, power output, blood lactate concentration, or the athlete’s perception of effort during training. Training load is simply the function of training volume and training intensity. A simple method for quantifying training loads from a variety of different training modalities into one simple arbitrary number has been developed (Foster et al., 2001). This method is commonly known as the session-rating of perceived exertion (sRPE) method. The major advantage of the s-RPE method over other reported methods of quantifying training load is that it is simple to measure and relatively easy to interpret. Recent studies have reported that the s-RPE method compares with the more complicated methods of quantifying training loads in endurance sports (Wallace, Slattery, & Coutts, 2014).

Moreover, few authors have studied the objective approach to training, i.e. the real evaluation of the volume of work achieved at different levels of intensity (Bourgois, Bourgois, & Boone, 2019; Erp, Amsterdam, & Sanders, 2019). With this objective approach, training is prescribed by coaches rather than imposed by investigators (Delattre, Garcin, Mille-Hamard, & Billat, 2006). Accurate monitoring of training load can help coaches improve the preparation of their athletes for competition. The study aimed to establish the differences between some physiological parameters measured on the cycle ergometer in the laboratory among cyclists of different ages and also some comparisons with training load will be presented.

METHODS

Participants

The study sample included 86 youth cyclists 15-18 years old. Their mean age was 16.34 ± 1.01 years. All of them were part of the Slovenia cycling federation and they competed at a national or international level of competition. Written informed consent was obtained from all participants.

Experimental procedure

The study was divided into two parts. Before the cyclists did the anthropometric and physiological measurements, they completed the questionnaire. With the questionnaire, we identified their training habits – the frequency and intensity of their training methods.

Variables connected with training load:

- Training volume.
- Training intensity.
- Training load (training load = sRPE x duration (minutes)).

Anthropometric characteristics of cyclists were obtained with bioelectrical impedance (Biospace Inbody 720, USA). For measuring aerobic capacity the following procedure was performed. After 15 minutes of warm-up on a bicycle set up on a cycle ergometer (Cyclus 2, Germany) cyclists proceeded with the incremental test. Cyclists used their racing bikes for the test protocol. Test protocol in the laboratory represented the incremental test - modified cycling test, which is fundamentally a standard Conconi test and is used as a diagnostic tool to assess physiological conditioning of road cyclists. The ambient temperature in the laboratory was 21°C. Heart rate, ventilatory, and gas data were collected during the test with metabolic cart (Cosmed CPET, Italy). The workload was constantly increased until volitional exhaustion (cyclists started protocol at 100 Watts and increased 20 Watts every minute)(Rauter, Milic, Žele, Hvastija, & Vodičar, 2015).

Variables for the analysis:

- BH - Body height - (cm).
- BW - Body weight - (kg).
- BF – Body fat (%).

- SMM – Skeletal muscle mass (%).
- VT- relative power output at VT (W/kg).
- RC - relative power output at RC point (W/kg).
- PPO_R - relative maximal peak power output (W/kg).
- PPO_ maximal peak power output (W/kg).
- VO_2/kg_max relative maximal oxygen uptake (ml/min/kg).

Statistical Analysis

All statistical analysis was done by SPSS was done by SPSS version 26.0 (IBM SPSS Statistics, Chicago, Illinois, USA). Data were presented according to descriptive statistics (Means ± SD). The differences between age categories were established by one-way analysis of variance (ANOVA). For the correlation between training workload and physiological related parameters, Spearman's rank coefficients were used. All statistical significance was set to $p<0.05$ and $p<0.01$.

RESULTS

Table 1 shows the descriptive statistic of anthropometric characteristics and body composition of male road cyclists (BH, BW, BF, SMM). The results in our study showed that changes in many parameters depend on cyclists' age. This could be attributed to differences in body composition that exist in age groups.

Table 1. Anthropometry and body composition

Variables	AGE									
	15		**16**		**17**		**18**		**95% CI**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Lower	Upper
N	24		23		24		15			
BH (cm)	173.1	8.2	177.1	7.1	177.2	7.1	178.3	6.7	174.6	181.9
BW (kg)	57.3	7.0	63.9	7.8	66.0	6.8	68.8	4.8	61.8	65.2
BF (%)	9.4	0.3	9.8	0.3	10.1	0.3	10.5	0.4	9.3	10.7
SMM (%)	50.4	1.9	50.7	2.1	51.0	2.1	51.0	2.2	50.3	51.1

BH and BW are increasing with age because of physical development (Table 1). The average BW between 15 years and 18 years old cyclists was statistically significant (+20.1%; $p<0.01$) which is important when interpreting values of various parameters that are relative to BW. This is why BW and body composition have a significant impact on performance. We know that body fat mass in this aspect represents a non-functional part of BW and thus negatively impacts performance. When riding uphill power output relative to BW is important. In a time trial and especially among the races of young cyclists. However, a ratio of power output to a frontal area (W/dm2) is crucial. It is important to keep this in mind when comparing absolute and relative power values. The results are shown in Table 2 for every age from 15 to 18 years old cyclists. As expected, both absolute and relative power output values were increasing with the age of the cyclists. The maximal power output values of the 15-year-old cyclists are significantly lower than in older age for example 18 years old cyclists (-32%; $p<0.01$). That is a confirmation of the fact that these are still in their growth and development phase. The current UCI racing system divides these cyclists into two racing age categories, that is the U17 group (15–16 years old) and the U19 group (17-18 years old). A substantial part of this difference is gained from 15 to 16 years old cyclists Results of maximal power output values showed the biggest margin (+15%; $p<0.01$) in the first year of the U17 category between 15 and 16 years old cyclists suggesting why transitioning from the first year in U17 to the second year is so challenging. The differences in relative peak power output values between 15 and 18 years old cyclists were significant but smaller (+9%; $p>0.01$).

Table 2. Laboratory testing - Relative and absolute power output and maximal oxygen uptake

Variables	**AGE**									
	15		**16**		**17**		**18**		**95% CI**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Lower	Upper
PPO (W)	286.6	31.9	330	38.5	355	26.9	378.1	25.3	323.7	343.3
PPO_R (W/kg)	5.02	0.41	5.19	0.43	5.41	0.51	5.49	0.29	5.16	5.36
VT (W/kg)	2.71	0.43	2.93	0.32	3.12	0.45	3.51	0.33	2.85	3.04
RC (W/kg)	3.91	0.39	4.15	0.39	4.29	0.41	4.31	0.35	4.06	4.23
VO_2/kg (ml/min/l)	57.7	5.7	60.3	6.1	62.3	5.6	61.2	5.6	58.9	61.5

We also observed some significant differences between 15 and 18 years old cyclists in other physiological parameters, like a power output value at a ventilatory threshold (+29.5%; p<0.01), power output values at RC point (+10.2%; p<0.01), and maximal oxygen uptake(+6.1%; p<0.05).

Table 3 shows significant changes depend on the cyclist's age in training load. The amount of training (hours per week) significantly increase from 15 to 18 years old cyclists (+58.7%; p<0.01). Training load also increase by 49% (p<0.01) from 15 to 18 years old cyclists. No significant differences were found, when we compared the intensity of training by cyclists of different ages.

Table 3. Training intensity and training load

Variables	AGE			
	15	**16**	**17**	**18**
Frequency of training (h/week)	10.22	14.33	15.24	16.22
Low-medium intensity training (%)	59.7	65	66.8	65
High intensity of training (%)	40.3	35	32.2	35
Training load (s-RPE/week)	140422	187543	190359	209238

When we compared the training load with some physiological parameters some significant correlations were found. There was a significant correlation between training volume and maximal oxygen uptake (r=0.512; p>0.01) and also between the training of high intensity and maximal oxygen uptake (r=0.483, p>0.01).

DISCUSSION

Since these athletes are young there is a great opportunity and responsibility to identify talent among them. At a younger age, taller or earlier-maturing athletes have a significant advantage, which does not necessarily carry over to adulthood. Instead of nurturing long-term development, early talent identification can result in early de-selection. Traditional talent identification programs are likely to exclude many promising, late-maturing athletes from development programs. In cycling, there is an ongoing battle against gravity. To be successful in elite races a cyclist must remain in optimal body weight. Differences in BW occur regards to

FM, SMM, and BH. Getting an ideal BW in cycling is mostly done by losing BF. It is thus of no surprise that elite cyclists have very little BF (Faria, Parker, & Faria, 2005c). The results showed that changes in many parameters depend on the cyclists` age group. The variability of training volume and training intensity influenced the relative peak power output, power output at the ventilatory threshold, power output at RC point, and maximal oxygen consumption. The transformation of the cyclists from beginner to the junior level and later to the elite category can be challenging because there are obvious differences in their biological development (Banack, Bloom, & Falcão, 2012). It is important to remember this in developing years when seeking talent and later when selecting cyclists for national or other elite teams.

CONCLUSION

The study aimed to compare the physiological parameters measured in the laboratory to the training load. In this research, we focused on the results of younger cyclists that are competing regularly at national and international level. The main conclusion of our study was that as the age of a cyclist increases, there is a tendency to increase training load and may influence their performance at the laboratory test. The study was part of the project with the cyclists where we collect the data from the younger categories to the elite level. The results will show its value over the years when the amount of data further accumulates. The possibility of interpretation will be greater and this will be very useful for cyclists, coaches, and selectors in the following years. The limitation of our study was in the fact that we made a comparison of different road cyclists. For future research, it might be better to use longitudinal studies with the same road cyclists following their progress from junior to the elite level of cycling. Also, the big limitation of our study was the process of data collection of the training load, where we collected the data throughout the questionnaires. It will be better if we use real data from the training analysis.

Declaration of Conflicting Interests

Authors have no conflicts of interest to declare.

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