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Greater risk for relative energy deficiency syndrome negatively affects cycling performance

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Abstract

Introduction. Relative Energy Deficiency in Sport (RED-S) has many known negative consequences on health and performance parameters. However, less is clear about the impact on performance in men, especially when athletes do not exhibit clear symptoms of RED-S like serious eating disorder or low bone mineral density with recurring stress fractures. In addition, there is still no available questionnaire for easy detection of RED-S in men. Aim of Study. To determine if a greater risk for RED-S, assessed by a short questionnaire, impacts cycling performance. Material and Methods. Young competitive male road cyclists (n = 47, age 14-22) completed the questionnaire, body composition analysis with bioelectrical impedance and incremental testing (measuring VO_2max, peak power, relative peak power per kg and body fat percentage). These results were expressed relative to the results of cyclists competing at the same age and performing incremental testing in our laboratory (n = 580). In the questionnaire, we assessed number of sick days and injury-related days-of-training and a significant loss of body mass in the last month (>5%). If they had a significant weight loss or number of missed training days in the upper quartile, their risk for RED-S was recognized as increased. Results. 21 of 47 cyclists had an increased risk for RED-S that affected relative peak power (p = 0.008). We found no effect on VO_2max, absolute peak power, and body fat percentage. Conclusions. An increased risk for RED-S as assessed with a short questionnaire affects relative peak power compared to relative peak power in competitive cyclists of the same age. This is a crucial parameter in cycling performance. A high number of cyclists with an increased risk (44.7%) is in agreement with studies suggesting the prevalence of RED-S in competitive cycling is high.

KEYWORDS: relative energy deficiency in sport, road cycling, young athlete, performance, weight loss.

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Introduction

Relative Energy Deficiency in Sport (RED-S) is a relatively new term introduced by the IOC consensus statement in 2014 [9]. The effects on health are well known as RED-S is merely a new, more comprehensive expression expanding the established Female Athlete Triad condition which was introduced in 1997 in scientific literature [12]. In contrast to the Female Athlete Triad, RED-S is not limited only to female athletes but includes males as well and is associated with negative consequences on almost all physiological systems, including cardiovascular, hematological, musculoskeletal, endocrine, reproductive, bone and immune function [9]. Suboptimal growth and development can also be a consequence of RED-S which can have crucial consequences on young developing athletes. In addition, road cycling is recognized as one of sport disciplines at a greater risk for RED-S because of high energy demands coupled with a need for sustaining lean physique [1]. One of the greatest challenges in this scientific area is recognizing RED-S in males as there are no assessment tools available. The Low Energy Availability in Females Questionnaire [7] was developed for females as they exhibit some clear signs that help us

detect RED-S and are related to reproductive function. In males, however, there is still no available questionnaire that would help recognising increased risk for RED-S which could then be confirmed with the well-established Clinical Assessment Tool for RED-S [10]. This is why a series of questions related to RED-S were chosen to assess whether an increased risk for RED-S as observed by a short tool is associated with performance in cyclists.

Aim of Study

To investigate if a greater risk for RED-S assessed by a short questionnaire impacts cycling performance in young road cyclists. The questionnaire included three questions that were previously mentioned in this research area and are not limited to female athletes. We hypothesized that an elevated risk for RED-S as assessed with this short tool is negatively associated with performance-related parameters.

Material and Methods

Institutional ethical approval of the Faculty of Sport was obtained. Cyclists were informed about all procedures before commencing the study. All participants signed an informed consent form. The instructions before the tests were to be well-rested and healthy on the day of the test (no strenuous physical activity last 24 hours and no intensified training last 48 hours). If they had any symptoms of upper respiratory tract, their test was postponed for at least one week. Body mass and body composition were assessed with bioelectrical impedance (Biospace InBody 720, Seoul, Korea). For body height an anthropometer (GPM, Siber Hegner & Co., Switzerland, 2007) was used. Incremental testing was performed on Cyclus 2 ergometer (RBM Electronics, Leipzig, Germany). We measured VO_2max, absolute peak power, and relative peak power per kg. Those under 17 years old (the U17 category) performed the 60 + 15 W protocol (60 W in the first minute and adding 15 W every next minute), and those of 17 years or older (U19 and U23 categories) used the protocol 100 + 20 W. Cyclist warmed up 30 min before and rested 60 s before starting the test. Ventilatory parameters were measured with V2 mask (Hans Rudolph, USA) and Quark CPET (Cosmed, Albano Laziale, Rome, Italy) with Quark 8.1. PC software support. The machine was calibrated every day (O2 and CO2 analyzer and airflow device) before the start of the test.

This study included 47 male road cyclist of different age categories (U17 (n = 12), U19 (n = 16), & U23 (n = 19). According to the performance indicators they belong to the performance level 4 [13]. They completed the questionnaire on the day of incremental testing with indirect calorimetry. The measurements were done in the preparation period. Performance-related parameters are defined by age in cyclists who still haven't completed their growth and development. This is why we compared them to a larger database of cyclists (performance level 4) with parameters measured by identical methods (n = 580) from the last 6 years. A database was made as a standard to be able to compare cyclist's value according to their peers. Z-values were created for the analysis. Each cyclist's parameters were converted to z-values with parameters of cyclists of the same age. For example, a 16-year old from this research was compared to other 16-year olds and not to older or younger participants. In this way we ensured that optimal or suboptimal performance was detected with physiological parameters that are dependent on age.

The questionnaire was composed of three questions. The risk for RED-S was recognized as increased if one or more of the following answers were recorded:

1. more than 5% of body weight loss in the last month,
2. at least 14 days of missed days for training or competition because of illness,
3. at least 20 days of missed days for training or competition because of injury.

Elevated risk for RED-S in the last two questions was established by using upper quartile values of all cyclists since there is no other available cut-off value in current literature.

Analyses were conducted using SPSS for Windows (Version 21.0; SPSS, Inc., Chicago, USA). Data were presented according to descriptive statistics (Means ± ± SD). Mann-Whitney test and Kruskal-Wallis test was used for the analysis. Z-values were created for the analysis. Statistical significance was set to 0.05.

Results

47 competitive cyclists were involved in the study. Their anthropometric characteristics and physiological parameters are shown in Table 1. We observed significant differences in all parameters as participants' age span from 14 to 22 and they were in different stages of growth and development. Even if average relative peak power per kg of body weight from all ages is calculated they are categorized as Level 4 performance according to De Pauw at al. [13], labelling them as well trained.

Standardizing their values according to their peers was necessary. Average values of 580 cyclists measured with same methods and differentiation across age groups (Table 2).

Table 1. Physiological parameters related to performance as measured by bioelectrical impedance and incremental testing according to the age groups

Variables	AGE Group/Category						TOTAL			
	U17		U19		U23					
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	t	p
Body height (cm)	172.1	9.9	178.6	5.7	178.8	4.7	177.1	7.2	4.423	0.018
Body weight (kg)	58.5	9.2	67.2	7.6	69.7	4.7	66	8.3	9.499	≤0.001
Body fat (%)	9.3	1.7	9.3	2,6	9.9	2.1	9.5	2.2	0.378	0.688
Absolute peak power (W)	335.9	51.1	398.3	36.9	446.7	36.6	401.9	59.6	27.260	≤0.001
Relative peak power (W/kg)	5.75	0.37	5.95	0.44	6.39	0.39	6.07	0.48	10.270	≤0.001
VO_2max (mL/min/kg)	59.3	3.7	60.5	2.9	64.3	4.5	61.7	4.4	7.158	0.002

Note: Values are expressed as means; t = t-test

Table 2. Performance-related parameters in cyclists of various ages

Age	14	15	16	17	18	19	20	21	22
N	58	73	102	73	55	38	36	28	14
VO_2max (mL/min/kg)	59.74	61.51	63.13	63.66	64.98	66.14	65.62	66.62	65.85
Relative peak power (W/kg)	5.36	5.54	5.84	5.95	6.20	6.22	6.28	6.41	6.49
Absolute peak power (W)	314.43	358.82	389.82	406.59	420.42	435.55	445.53	451.68	448.14
Body fat (%)	8.89	9.30	9.85	9.52	9.11	9.42	9.27	9.18	7.71

Note: Values are expressed as means

Statistical analysis showed that 21 out of 47 of cyclists had an increased risk for RED-S. Looking at absolute numbers, 3 of them lost more than 5% of body weight during the last month, 8 of them missed more than 20 days of training or competition due to injury and 18 missed more than 14 days due to illness. Interestingly, only 9 cyclists with increased risk answered only one of the questions as positive. Other 12 cyclists had more than one positive answers.

Increased risk for RED-S negatively affected relative peak power ($p = 0.008$). We found no effect on VO_2max ($p = 0.068$), absolute peak power ($p = 0.274$), and body fat percentage ($p = 0.944$).

Discussion

We found that 21 out of 47 of cyclists had an elevated risk for RED-S as assessed with a short questionnaire which supports current literature suggesting that prevalence of RED-S in competitive cycling is high [1]. It is vital to detect athletes at risk for RED-S early [8, 9, 11, 15]. Even more importantly it is essential to detect it in younger athletes as growth and development have been proven to be retarded in confirmed cases of long-term inadequate energy [14].

Since no current assessment tool is available, the three questions used in this paper were selected based on our current knowledge in this area. Cycling as a sport belongs to the group of so-called gravitational sports. Unhealthy weight cycling practices are present in cycling as it is a weight-sensitive discipline [5, 16]. Power to weight ratio is crucial for cycling performance [4], but decreasing weight rapidly can have negative effect on performance regardless of increased performance-related parameters [16]. Losing more than 5% of body weight has been marked as substantial in RED-S Clinical Assessment Tool [10] and implicates further evaluation for sports participation should be evaluated. Injury and illness prevent consistent and high-quality training [2, 3]. Increased risk for injuries and illnesses is part of RED-S. However, no cut-off value has been set with a goal for assessing RED-S. We suggest the values as provided in this research paper could contribute to

determining this value in the future by carrying out similar research with a higher number of participants. In this research, only association between a higher number of missed days and worse performance was studied and RED-S was not directly diagnosed. We suggest this is a logical next step in future research that should be done on well-trained or elite cyclists.

Some other questionnaires are currently being used for assessing the probability of RED-S, like screening for eating disorders or disordered eating or psychological evaluation [2, 3, 8]. These questionnaires are unfortunately not specific and detect just one part of RED-S like an eating disorder that is probable but not necessarily present. This can then lead to further evaluation with a clinical examination by a medical professional or by using the RED-S Clinical Assessment Tool. The argument against these questionnaires is that none of them detect all aspects of RED-S and also that they usually take a lot of time to complete. Thus, they are not appropriate as a screening tool. We suggest using a short screening tool including these three questions could be useful. The prevalence is RED-S is estimated to be high [6] and it would be beneficial to use and repeat screening tools on recreationally and professionally active athletes of disciplines that are of greater risk.

This study showed that increased risk for RED-S was negatively associated with relative peak power in competitive young cyclists. If the risk for RED-S was elevated their crucial performance related parameter was significantly lower as measured in their peers. We suggest regular monitoring of weight cycling practices, increased number of missed days due to injury or illness should be performed in young cyclists in order to optimize their health and performance. These three parameters could in future be further evaluated for creating clear cut-off values. With some other indicators of RED-S they could be a part of a quick and simple assessment tool helping clinicians and coaches protect their athletes from negative consequences of RED-S.

We suspect we failed to show any association between questionnaire to body fat percentage as average values in all ages are low and similar (Table 1). However, we do not know why VO_2max and absolute peak power failed to show any associations. A larger sample of cyclists could help in revealing other connections, which is one of the limitations of this study. Another one is that physiological parameters are just one determinant of performance in cycling and are not equally important in different age groups.

This study amplifies appeals from other studies that there is a need for a better, more comprehensive questionnaire for RED-S in male athletes. We suggest that increased injury and illness risk and rapid weight loss should be included in future screening tool. We suggest short assessment questionnaire is needed to detect elevated risk for RED-S and these three questions should be a part of it. Other questionnaires currently used in this area are usually psychological or nutritional evaluations and do not serve well because they are too long and not specific to be suitable for screening. In addition, we imply that risk for RED-S can be increased in developing cyclists already. This could lead to detrimental effects on health and performance of cyclists later on in their career.

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