EXERCISE INTENSITY AND LOAD DURING DIFFERENT RACES IN YOUTH AND JUNIOR CYCLISTS

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ABSTRACT

Rodríguez-Marroyo, JA, Pernía, R, Cejuela, R, García-López, J, Llopis, J, and Villa, JG. Exercise intensity and load during different races in youth and junior cyclists. *J Strength Cond Res* 24(x): 000–000, 2010—This study analyzed and compared the exercise intensity exerted by Youth and Junior cyclists in single-day and stage races. Heart rate was measured during the races and categorized according to 3 intensity zones: Z1 (below the ventilatory threshold [VT]), Z2 (between the VT and the respiratory compensation threshold [RCT]), and Z3 (above the RCT). The training impulse (TRIMP) was calculated by multiplying the sum of the time spent in each zone by 1, 2, and 3, respectively. Time spent in Z1, Z2, and daily TRIMP were significantly higher ($p < 0.05$) in Junior than in Youth in both single-day races (21.6 ± 1.9 min vs. 14.8 ± 1.6 min, 55.4 ± 2.3 min vs. 34.7 ± 1.9 min, and 257 ± 6 vs. 194 ± 6, respectively) and stage races (49.2 ± 3.4 min vs. 23.5 ± 4.7 min, 51.2 ± 2.6 min vs. 35.3 ± 3.7 min, and 201 ± 10 vs. 147 ± 7, respectively). In Youth and Junior, time and percentage time spent in Z3 and daily TRIMP were also significantly higher ($p < 0.05$) in single-day races (39.0 ± 1.9 min, 40.2 ± 1.9% and 225 ± 7) than in stage races (13.9 ± 1.8 min, 15.2 ± 1.8% and 174 ± 8). In conclusion, the present study showed that races in both Youth and Junior categories are highly demanding and that their intensity and exercise load are related to the total race duration.

KEY WORDS young cyclists, heart rate, training impulse, performance

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INTRODUCTION

Many studies have analyzed and quantified the physiologic demands of professional cycling competition (4,6,11,13,15,16,19,20). Exercise demands in the most important and best-known 3-week stage races, Tour de France, Giro d'Italia, and Vuelta a España, have been studied (4,6,11,13). More recently, physiologic demands of shorter stage races (i.e., 5–8-day stage races) have also been analyzed (20). These studies show the importance of aerobic metabolism in the overall performance of cyclists. However, the position they occupy in the final classification of these races depends on their ability to maintain high intensities during mountain and time trial stages (11,15,16,19). Very few studies have analyzed the physiologic demands of competition on nonprofessional cyclists. To the best of our knowledge, only the studies of Palmer et al. (17) and Neumayr et al. (14) have analyzed the exercise intensity of elite (i.e., amateur) and recreational cyclists in different events.

Some authors (9) consider that measuring power output by way of portable power meters could be the most direct indicator of exercise intensity. However, most studies monitor heart rate (HR) to analyze the physiologic demands of the competition in spite of the numerous factors that can affect it (1). In addition, HR allows us to calculate training or competition load (i.e., volume × intensity) (5). Banister et al. (2) originally developed the concept of the training impulse (TRIMP) as an integrative marker of the exercise load. To calculate the TRIMP, these authors integrated the exercise intensity estimate through the mean HR and the exercise duration. Later on, Foster et al. (5) proposed another way to calculate TRIMP, taking into consideration the total time of exercise and the effort spent in different intensity zones, established according to HR, in which ventilatory thresholds (VT) were determined. This methodology has been used in several studies observing the competition load developed during different 3-week stage races by professional cyclists (6,13,20).

The primary aim of this study was to analyze the intensity and exercise load exerted by Youth and Junior cyclists in the different races they took part in (i.e., single-day races and stage races). A second aim of our study was to determine

TABLE 1. Anthropometrical characteristics and physiologic values measured during incremental tests performed in precompetition (test 1) and competition (test 2) period (mean ± *SEM*).*

	Youth category			Junior category		
	Test 1	Test 2	ICC	Test 1	Test 2	ICC
Age (yr)	15.6 ± 0.1†	15.7 ± 0.1†	0.90	17.5 ± 0.1	17.5 ± 0.2	0.85
Body mass (kg)	62.8 ± 1.6†	59.9 ± 2.2†	0.97	66.3 ± 1.3	64.2 ± 1.6	0.98
Height (cm)	170.2 ± 0.8†	170.9 ± 1.1†	0.95	173.9 ± 1.4	174.2 ± 1.8	0.98
$\dot{V}O_2max$ (ml·kg^{-1}·min^{-1})	58.4 ± 1.5†	61.1 ± 2.4†	0.85	62.3 ± 1.4	65.6 ± 1.1	0.89
HR_{max} (bpm)	199 ± 3	197 ± 2	0.93	195 ± 2	193 ± 2	0.90
$\dot{V}O_2$RCT (ml·kg^{-1}·min^{-1})	47.8 ± 1.5†	49.8 ± 1.9†	0.75	51.7 ± 1.2	52.8 ± 1.2	0.77
% $\dot{V}O_2max$ RCT	81.2 ± 1.7	80.7 ± 1.2	0.72	81.0 ± 1.6	80.8 ± 1.0	0.83
HR RCT (bpm)	182 ± 2	183 ± 3	0.90	179 ± 1	179 ± 2	0.89
$\dot{V}O_2$VT (ml·kg^{-1}·min^{-1})	34.9 ± 1.2†	37.5 ± 1.0	0.78	38.6 ± 1.3	39.2 ± 1.3	0.80
% $\dot{V}O_2max$ VT	59.9 ± 1.8	61.3 ± 0.8	0.72	60.2 ± 1.7	61.7 ± 1.5	0.70
HR VT (bpm)	161 ± 3	164 ± 4	0.92	158 ± 3	157 ± 2	0.78

*$\dot{V}O_2max$ = maximum oxygen consumption; HRmax = maximum heart rate; V_T = ventilatory threshold; RCT = respiratory compensation threshold; %$\dot{V}O_2max$ = percentage of $\dot{V}O_2max$ at which $V_T$and RCT occur; ICC = intraclass correlation coefficient.
†Significant differences with Junior category, $p < 0.05$.

TABLE 2. Cycling race characteristics (mean ± *SEM*).

	Youth category		Junior category	
	Single-day races	Stage races	Single-day races	Stage races
Number of stages		3.0 ± 0.0		4.0 ± 0.0
Total distance (km)		148.5 ± 1.1*		365.7 ± 3.7
Total time of race (h)		3.5 ± 0.5*		9.5 ± 0.3
Length of stages (km)	53.2 ± 1.4*	49.3 ± 2.1*	76.9 ± 1.6	71.2 ± 3.2
Total stage duration (min)	82.0 ± 2.8*	79.6 ± 4.1*	118.4 ± 2.0	113.8 ± 5.1
Maximal altitude (m)	675 ± 250*	525 ± 100*	1119 ± 183	947 ± 201

*Significant differences with Junior category, $p < 0.05$.

TABLE 3. Heart rate (HR) and daily training impulse (TRIMP) during different races in Youth and Junior cyclists (mean ± *SEM*).

Category	Type of race	Maximum HR	Mean HR	TRIMP
Youth	Single-day races	199 ± 1*†	174 ± 1*†	193.8 ± 6.5*†
	Stage races	194 ± 2†	168 ± 2†	147.3 ± 7.4†
Junior	Single-day races	195 ± 1*	171 ± 1*	256.7 ± 5.8*
	Stage races	186 ± 1	162 ± 1	200.6 ± 9.5

*Significant differences with stage races, $p < 0.05$.
†Significant differences with Junior category, $p < 0.05$.

exercise demand behavior over time in each category. We hypothesize that the lower distance in Youth races would allow them to deploy a greater intensity of effort. Furthermore, in both categories, we believe that the accumulated fatigue in stage races would limit the intensity and the competition load developed by cyclists. We also hypothesize that the exercise demands developed by the same cyclists repeating the same races in successive years would be similar.

Methods

Experimental Approach to the Problem

The study was carried out in 3 consecutive cycling seasons. In each of the seasons, the study was divided into 2 parts to quantify the effort exerted by the cyclists. In the first part, all the cyclists were given a maximal oxygen uptake ($\dot{V}O_2max$) test to determine their $\dot{V}O_2max$. We also determined the workload at which both their VT and respiratory compensation threshold (RCT) occurred. The second part of the study consisted of the individual monitoring of the HR response in each race, to subsequently transfer the record to a file in a laptop computer by means of an interface, and to analyze the exercise intensity on the basis of HR data. The HR response was categorized into 3 intensity zones according to the reference HR values corresponding to VT and RCT: low intensity (below VT), moderate intensity (between VT and RCT), and high

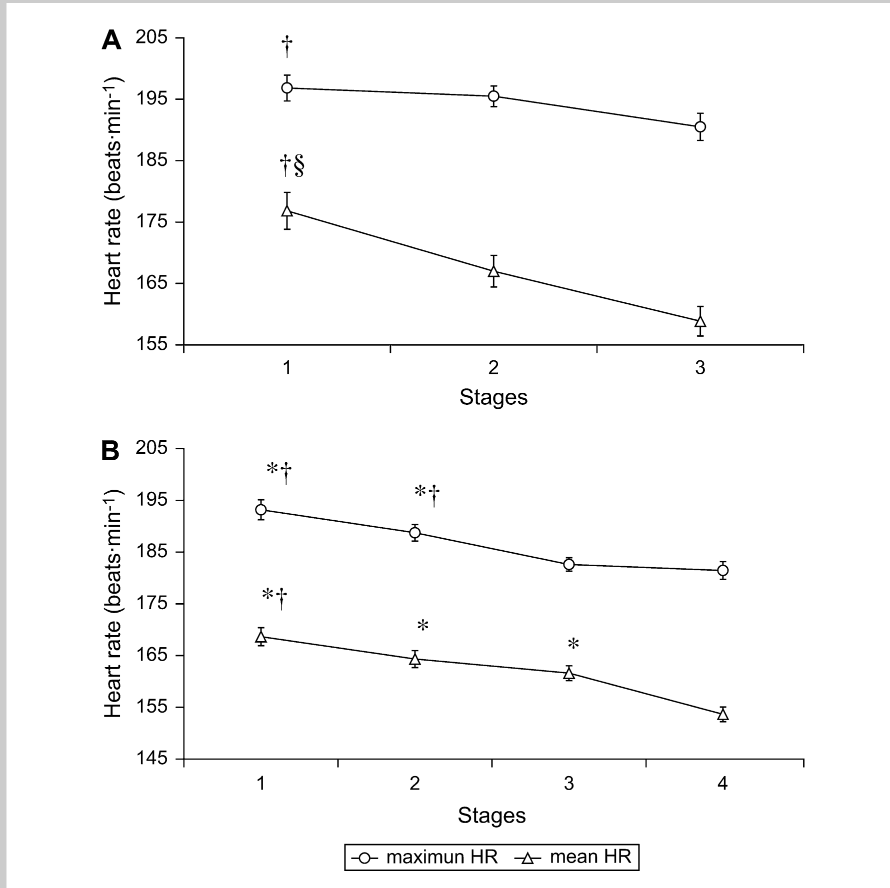

Figure 1. Day-to-day variation in maximum and mean heart rate in Youth (A) and Junior (B) during stage races. Values are mean ± *SEM*. §Significant differences with second stage, $p < 0.05$. †Significant differences with third stage, $p < 0.05$. *Significant differences with fourth stage, $p < 0.05$.

Table 4. Mean (±*SEM*) time spent daily (min) in 3 intensity zones analyzed.*

Category	Type of race	Zone 1 (below VT)	Zone 2 (between VT and RCP)	Zone 3 (above RCP)
Youth	Single-day races	14.8 ± 1.6†‡	34.7 ± 1.9‡	36.5 ± 2.3†
	Stage races	23.5 ± 4.7‡	35.3 ± 3.7‡	17.7 ± 3.4
Junior	Single-day races	21.6 ± 1.9†	55.4 ± 2.3	41.4 ± 3.0†
	Stage races	49.2 ± 3.4	51.2 ± 2.6	13.3 ± 2.0
Mean	Single-day races	18.3 ± 1.3†	45.3 ± 1.7	39.0 ± 1.9†
	Stage races	45.7 ± 3.1	49.0 ± 2.4	13.9 ± 1.8

*V_T = ventilatory threshold; RCT = respiratory compensation threshold.
†Significant differences with stage races, $p < 0.05$.
‡Significant differences with Junior category, $p < 0.05$.

TABLE 5. Mean ($\pm SEM$) percentage of total time spent daily in 3 intensity zones analyzed.*

Category	Types of races	Zone 1 (below VT)	Zone 2 (between VT and RCP)	Zone 3 (above RCP)
Youth	Single-day races	16.0 ± 1.6†	39.1 ± 1.7†	44.9 ± 2.7†‡
	Stage races	28.8 ± 5.4	45.2 ± 3.8	26.1 ± 5.5†
Junior	Single-day races	17.8 ± 1.6†	46.4 ± 1.8	35.7 ± 2.6†
	Stage races	37.5 ± 2.3	49.0 ± 1.8	13.5 ± 1.9
Mean	Single-day races	16.9 ± 1.0†	42.8 ± 1.3†	40.2 ± 1.9†
	Stage races	36.3 ± 2.1	48.5 ± 1.7	15.2 ± 1.8

*V_T = ventilatory threshold; RCT = respiratory compensation threshold.
†Significant differences with stage races, $p < 0.05$.
‡Significant differences with Junior category, $p < 0.05$.

intensity (above RCT) (11,13,19,20). The TRIMP values, as an integrative marker of the competition load, were estimated from total volume and total intensity relative to the 3 intensity zones (5).

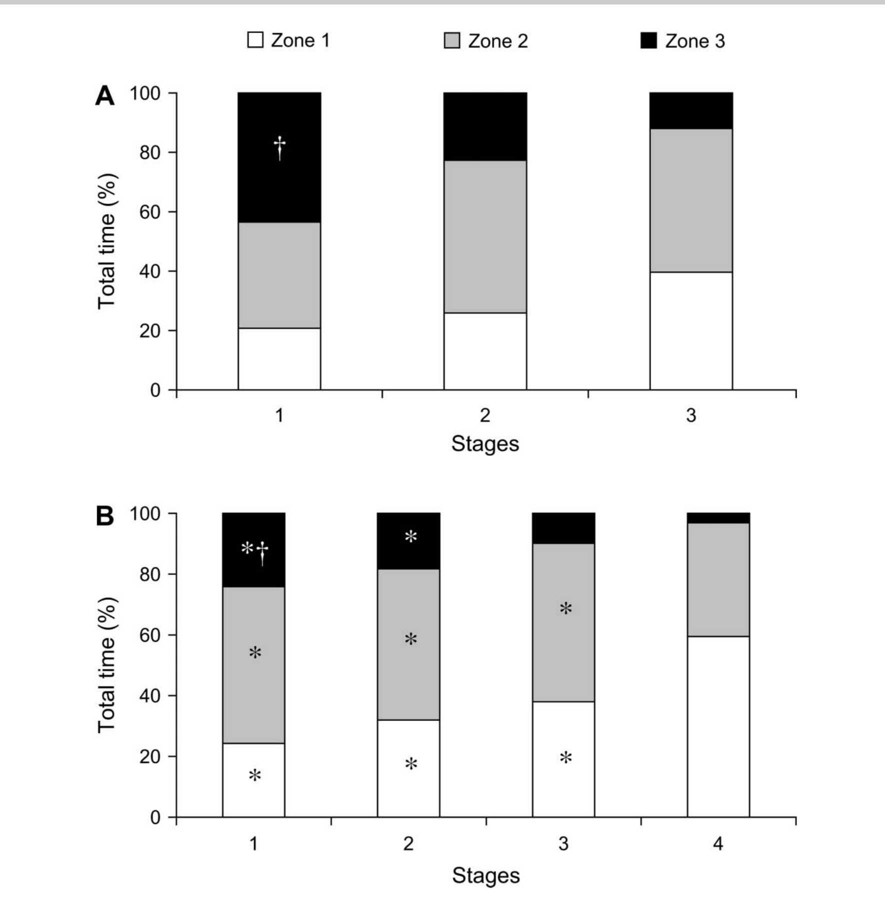

Figure 2. Day-to-day variation in zone 1 (below ventilatory threshold [VT]), zone 2 (between VT and respiratory compensation threshold [RCT]), and zone 3 (above RCT) in Youth (A) and Junior (B) during stage races. Values are mean ± *SEM*. †Significant differences with third stage, $p < 0.05$. *Significant differences with fourth stage, $p < 0.05$.

Subjects

Thirty-five young regional and national cyclists took part in the study, split into groups according to their age and the categories established by the Spanish Cycling Federation: Youth (age, 15–16 yr; $n = 14$) and Junior (age, 17–18 yr; $n = 21$). Youth cyclists had a competition experience of 4 ± 1 years, and they performed between 8,000 and 10,000 km per season. Junior cyclists had a competition experience of 7 ± 1 years, and they performed between 14,000 and 17,000 km per season. Six Youth and 9 Junior cyclists were analyzed for 2 consecutive seasons. Written informed consent was obtained from the subjects and their tutors before starting the study, which was approved by the Ethics Committee of the University of León, Spain.

Procedures

Laboratory Test. The cyclists performed 2 incremental tests in each of the seasons of the study, corresponding to precompetition (March) and competition (June) periods of the season. This enabled us to check the performance of the cyclists and to evaluate the stability of HR values corresponding to VT and RCT over time. The test was performed with the cyclist's own bicycle, which was fixed on a cyclosimulator

(Cateye CS-1000, Cateye Co., LTD, Osaka, Japan) used in previous studies (19,20). The test started at a speed of 27 $km \cdot h^{-1}$, increasing by 1 $km \cdot h^{-1}$ every minute until the cyclist was not able to maintain the set speed. The HR response (Polar Vantage NV, Polar Electro Oy, Finland) and respiratory gases (Medical Graphics System CPX-Plus, Medical Graphics Corporation, MN, USA) were monitored throughout the test. Laboratory environmental conditions (20°C and 40% relative humidity) and warm-up duration (10 min) were standardized for all cyclists. The cyclists were encouraged to have a light training session the day before and a carbohydrate-rich diet.

Ventilatory threshold and RCT were identified separately by 3 researchers according to the following criteria (3): increase in minute ventilation ($\dot{V}_E$) and ventilation equivalent for oxygen ($\dot{V}_E \cdot \dot{V}O_2^{-1}$) with no concomitant increase in ventilation equivalent for carbon dioxide ($\dot{V}_E \cdot \dot{V}CO_2^{-1}$) for the determination of VT and an increase in $\dot{V}_E \cdot \dot{V}O_2^{-1}$ and $\dot{V}_E \cdot \dot{V}CO_2^{-1}$ for the determination of RCT.

Cycling Races. Thirty-eight single-day races (532 recordings) and 4 stage races (56 recordings) were analyzed in Youth, whereas 40 single-day races (840 recordings) and 6 stage races (126 recordings) were analyzed in Junior. Each cyclist's HR was recorded every 5 seconds during all the races analyzed (Polar Team, Polar Electro Oy, Finland). Subsequently, using specific software (Polar Precision Performance v4.0, Polar Electro Oy, Finland), the data were downloaded to the computer to be analyzed and to determine the effort intensities through the recorded HR. Three intensity zones were established according to the reference HR values, corresponding to VT and RCT (9,11,19,20): zone 1 (Z1) below the VT (low-intensity zone), zone 2 (Z2) between VT and RCT (moderate-intensity zone), and zone 3 (Z3) above RCT (high-intensity zone). These zones were used to determine the daily TRIMP by multiplying the time spent in Z1, Z2, and Z3 by the constants 1, 2, and 3, respectively, the total score being obtained by summating the results of the 3 phases (5).

Statistical Analyses

The results are expressed as mean ± standard error of the mean (*SEM*). The Kolmogorov-Smirnov test was applied to ensure a Gaussian distribution of all results. A 2-way ANOVA (category [Youth vs. Junior] × time [test 1 vs. test 2]) with repeated measures on time was used to analyze the mean values of each physiologic variable recorded during the incremental test. The reliability of the measures was assessed by calculating the intraclass correlation coefficient. Also, a 2-way ANOVA (category [Youth vs. Junior] × races [single-day races vs. stage races]) with repeated measures in races was used to analyze the exercise intensity and competition load. Finally, the analyzed parameters in Youth and Junior over the course of stage races were studied with a 1-way ANOVA with repeated measures. When a significant F value was found, Bonferroni's test was applied to establish significant differences between means. Values of $p \leq 0.05$ were considered statistically significant. Effect sizes (ES) (Cohen's d) were also calculated, and values of less than 0.41,

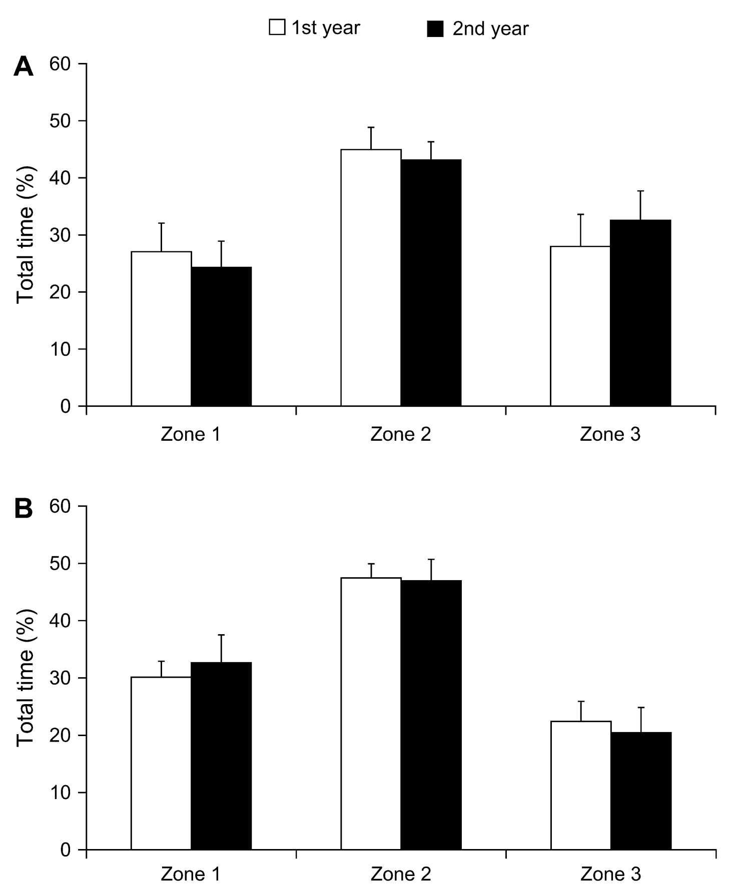

Figure 3. Comparison of exercise intensity distribution in same Youth (A) and Junior (B) cyclists repeating same races in successive years. Values are mean ± *SEM*. See Figure 2 for definition of zones 1 to 3.

0.41 to 0.70, and greater than 0.70 were considered small, moderate, and large, respectively (18). SPSS+ V.15.0 statistical software (Chicago, IL, USA) was used.

Results

Laboratory Test

As shown in Table 1, significant differences ($p < 0.05$) between Youth and Junior were only obtained when comparing body mass (ES = 0.76), height (ES = 0.62), $\dot{V}O_2max$ (ES = 1.22), and $\dot{V}O_2$ reached in VT (ES = 0.72) and RCT (ES = 0.75). No significant differences were found in the analyzed values between the precompetitive and competitive periods in both categories ($p > 0.05$).

Cycling race Characteristics

Table 2 shows the major characteristics of the races analyzed in this study.

Heart Rate

Youth and Junior obtained higher maximum and mean HR in single-day races than in stage races ($p < 0.05$; ES = 0.88–1.96). Significant differences between Youth and Junior were also obtained when comparing maximum and mean HR in the different types of races ($p < 0.05$; ES = 0.72–1.28) (Table 3). When mean HR was given as a percentage of maximum HR, no significant differences ($p > 0.05$) were obtained between Youth and Junior in single-day races (87.7 ± 0.4 and 87.6 ± 0.4%) and stage races (84.4 ± 0.9 and 83.1 ± 0.4%), although significant differences were found when comparing the values of both races in each category ($p < 0.05$; ES = 0.77–0.89).

When we compared maximum and mean HR behavior over the course of stage races, we observed a significant decrease in the analyzed values in both Youth and Junior ($p <$ 0.05; ES = 0.81–1.84) (Figure 1).

Intensity Zones

The highest times (Table 4) and percentage times (Table 5) spent in Z3 were reached in single-day races in both Youth and Junior ($p < 0.05$; ES = 1.15–2.13). However, the cyclists spent significantly more time and percentage time in Z1 ($p < 0.05$; ES = 0.69–2.17) in stage races. No significant differences ($p > 0.05$) were found in the time and percentage time spent in Z2 between the 2 types of races analyzed in Youth and Junior (Tables 4 and 5).

When we compared the exercise intensity carried out by Youth and Junior in the races, significant differences were found in the time spent in Z1 and Z2 in single-day races and stage races ($p < 0.05$; ES = 0.90–2.18) (Table 4). We also found significant differences between Youth and Junior in the percentage time spent in Z3 in single-day races and stage races ($p < 0.05$; ES = 0.84–0.89) and the percentage time spent in Z2 in single-day races ($p < 0.05$; ES = 0.99) (Table 5).

A decrease in exercise intensity was observed over the course of stage races in Youth and Junior (Figure 2). Significant differences were obtained in the percentage time spent in Z3 between the first and the third stages in Youth ($p < 0.05$; ES = 0.98). In Junior, this behavior was also observed, with significant differences in the percentage time spent in Z3 between the first stage and the last 2 ($p < 0.05$; ES = 0.78–1.27), and between the second stage and the last 1 ($p < 0.05$; ES = 1.13). Furthermore, a significant increase was observed in the percentage time spent in Z1 in the last stage ($p < 0.05$; ES = 1.20–2.18) (Figure 2).

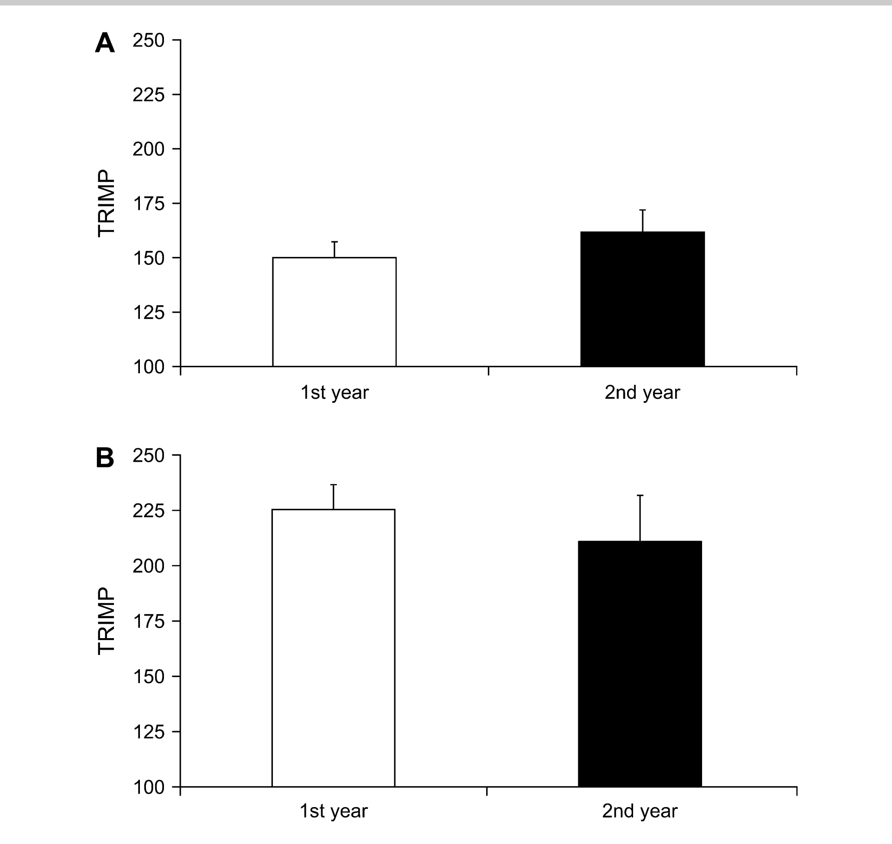

Figure 4. Variation in training impulse score (TRIMP) in same Youth (A) and Junior (B) cyclists during same races in successive years. Values are mean ± *SEM*.

Training Impulse

In both Youth and Junior, the daily TRIMPs in single-day races were higher than those analyzed in stage races ($p < 0.05$; ES = 1.47–1.55). Likewise, in all of the races analyzed, the highest TRIMPs were obtained in Junior ($p < 0.05$; ES = 1.46–2.47) (Table 3).

Exercise Demands Over Time

No significant differences were found ($p > 0.05$) in the effort intensity and the competition load developed by the same cyclists in the same races over 2 consecutive years (Figures 3 and 4).

Discussion

The first finding of this study was that the time and percentage time spent in Z3 by Youth and Junior in stage races (Tables 4 and 5) was similar to that analyzed in professional cyclists (7–30 min and 3–18%, respectively) (4,6,11,13,20). These data may mean that anaerobic capacity could limit performance in professional cyclists, as previously suggested (4). Recent research (12,25) has shown that high-level cyclists generally train in zone 1 (75–80% of the total training volume). The percentage time spent in Z1 and Z2 by Youth and Junior (~48% and ~37%) was similar to that obtained by professional cyclists in 5- to 8-day stage races (~49% and ~33%) (20). However, the shorter length of stages (km) in the stage races analyzed (Table 2) conditioned the time spent in Z2 and Z1, which was lower (~49 and ~46 min) than that obtained by professional cyclists (60–115 and 76–200 min) (4,6,11,13,20).

Exercise intensity distribution selected by cyclists in competition is modulated by total race duration (14,20) in an attempt to avoid overtraining (6). Rodríguez-Marroyo et al. (20) observed how professional cyclists doubled the time and percentage time spent in Z3 during 5- to 8-day stage races versus 3-week stage races. This would explain the differences found in the intensity of effort made by Youth and Junior in stage race, and the higher time and percentage time spent in Z3 during single-day races versus stage races in both Youth and Junior (Tables 4 and 5). Muscular fatigue accumulated over the course of stage races conditions the performance of the cyclists in the last stages (13), limiting the effort developed in high-intensity zones (20). Thus, when the exercise intensity was analyzed over the course of stage races, a decrease in the percentage time spent in Z3 in the last stages was observed, this being compensated by an increase of percentage time spent in Z1 (Figure 2). This behavior was observed in both categories, although it was more marked in Junior because of the greater length of the stage races (Table 2).

The accumulation of fatigue over the course of stage races also could prevent cyclists from reaching higher HR. In fact, both Youth and Junior obtained higher HR in single-day races than stage races. This affected the ability of cyclists to maintain high percentages of maximum HR during stage races. We analyzed a decrease of approximately 10 and approximately 15 bpm in the maximum and mean HR over the course of stage races (Figure 1). A similar decrease in maximum HR has also been observed in professional cyclists throughout 3-week stage races (13,20). Several studies have reported the occurrence of catecholamine exhaustion as the result of overreaching (10), which could be the cause of changes to HR during stage races (13). Despite the catecholamine level not having been measured, it can be speculated that in analyzed stage races there was an overreaching genesis because of the HR behavior (Figure 1).

It has been suggested that when differences appear in the exercise duration, the mere use of indicators that assess exercise intensity are not sufficient to determine the exercise load (16). This is the reason why different studies have used the TRIMP to quantify the exercise load in a single variable, as determined by an integration of exercise intensity and duration (2). Thus, the exercise load in different types of races (i.e., 5-8-21 day stage races) (20) and stages (i.e., time trials, mountain and flat stages) (16) has been described in professional cyclists. The daily TRIMP obtained in professional stage races (~330) by other authors (6,13,20) was approximately 55% and approximately 40% higher than that analyzed in Youth and Junior, respectively. In this study, the higher TRIMP ($p < 0.05$) was analyzed in Junior in every race (Table 3). These differences were caused by the greater length of races in which these cyclists participated (Table 2). When we calculated the TRIMP/km in the analyzed races, the values obtained were similar in single-day races (~3.6 and ~ 3.4 in Youth and Junior, respectively) and stage races (~3.0 and ~2.8 in Youth and Junior, respectively) in both categories. The TRIMP/km analyzed in this study was similar to those found in professional cyclists in 5- to 8-day stage races (~2.8) (20) and slightly higher than that analyzed in 3-week stage races (~2.2) (13,20). A lower daily TRIMP was found in stage races than in single-day races in both categories, despite the length of the races being quite similar (Table 2). The exercise intensity distribution caused by the accumulation of fatigue throughout stage races could be the reason for this (Figure 2).

An important aim of this study was to determine the consistency that relative exercise intensity and TRIMP have over time. No significant differences were found ($p > 0.05$) when exercise intensity and TRIMP were analyzed in the same cyclists in the same races (i.e., stage races and single-day races) in 2 consecutive years (Figures 3 and 4). These results suggest the existence of an optimal pattern of effort to optimize performance in young cyclists. It has been suggested that the central nervous system could subconsciously regulate this effort to perform advantageously (23). These data were consistent with those of other studies carried out on professional cyclists (6). Foster et al. (6) did not find significant differences when comparing exercise intensity and TRIMP analyzed in the same cyclists throughout different weeks of a 3-week stage race in 2 consecutive years. These authors have suggested the existence of an upper limit of approximately 2,000 TRIMP units per week (~2.2 TRIMP/km) during a 3-week stage race. According to the TRIMP consistency over time found in this study, we would suggest that Youth and Junior cyclists would subconsciously regulate effort intensity during races so as not to exceed an upper limit of approximately 3.5 and approximately 3.0 TRIMP/km in single-day and stage races, respectively.

Heart rate as an intensity effort indicator presents a potential limitation that can affect the results obtained in this study. Physiologic factors (e.g., hydration status, glycogen depletion) and environmental factors (e.g., altitude, temperature) can influence HR responses (1). The magnitude of the errors in this study is probably insignificant because below approximately 2,000 m in altitude does not appear to have a significant influence on HR (19). Furthermore, the ability of professional cyclists to maintain adequate levels of hydration and a correct level of nutrient intake during competition has been reported (7). It could be thought that the lesser experience of the cyclists in this study could have a negative influence on this capacity, thus increasing cardiovascular drift. Consequently, it is possible that we have overestimated the effort intensity made by Youth and Junior in the different races. However, Rowland et al. (21) observed that liquid voluntary intake in children during cycling was enough to compensate for the fluid lost during the effort. Other factors, such as the cyclists' age (8,24) and their adaptation to training (22,24,26), could significantly affect the HR analyzed in this study. An approximately 5% per decade decrease in maximum HR with age has been reported (8). It has also been suggested that aerobic training decreases maximal and submaximal HR at a certain absolute workload (22,26). This would explain the lower HR observed in Junior versus Youth (Table 3).

In conclusion, the present study shows that races in Youth and Junior are highly demanding and that their intensity and exercise load are related to total race duration. When TRIMP/km was analyzed, we obtained similar values in Youth and Junior. We believe that cyclists in this study subconsciously regulated their exercise intensity during the different races in order not to exceed an upper limit of approximately 3.5 and approximately 3.0 TRIMP/km in single-day and stage races, respectively. In single-day races, higher exercise intensity and competition loads were observed than in stage races. This was probably caused by an accumulation of fatigue throughout the stages that conditioned a decrease in the percentage time spent in the high-intensity zone (i.e., zone 3). Finally, we observed a stability in exercise intensity and TRIMP obtained by Youth and Junior cyclists in the same races, in which they participated for 2 consecutive years. These results suggest that young cyclists can spontaneously regulate their effort. This mechanism would allow the adoption of more suitable exercise intensities according to the race characteristics to obtain a higher performance.

Practical Applications

Exercise intensity analysis can provide useful information on which to base conditioning programs. When designing specific training programs, it is important to know the physiologic demands of the competition. Many studies have analyzed cycling demands in professional cyclists, but there are none that analyze these demands in young cyclists. Data from this study can be used as reference to adapt training programs and help coaches of young cyclists to develop more specific and scientific training programs. Furthermore, according to the TRIMP/km (~3.5 and ~3.0 in single-day and stage races, respectively) and the competition load consistency over time analyzed in Youth and Junior, competition load according to the length of the races could be estimated beforehand. This could be of great help to coaches in planning training. The exercise intensity behavior and the competition load analyzed during the stage races in this study should be considered to propose different strategies to decrease the accumulation of fatigue in the stage races, for example, by reducing the number of stages, adding recovery days, designing stages with less mountain passes, or limiting the number of stage races per season. Finally, the stability of HR values corresponding to VT and RCT over time observed in this study suggests that a single incremental test should suffice to prescribe and to analyze the exercise intensities during the competition period.

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