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Exercise addiction stability and health effects. A 6-month follow-up post-competition study in amateur endurance cyclists.

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Abstract:	Objective. To study the longitudinal stability of exercise addiction and its health effects in apparently healthy amateur endurance cyclists from pre- to 6-month post-competition. Methods. In total, 330 (30 women) adult cyclists were divided into four groups based on scores on the Exercise Addiction Inventory at both periods: non-risk (n = 262, 79.1%), transient (n = 35, 10.6%), emerging (n = 14, 4.2%) and persistent (n = 20, 6.1%). Results. The prevalence of high-risk exercise addiction was reduced post-competition (16.7% vs. 10.3%, p = 0.017). Of the cyclists with a high pre-competition risk of exercise addiction, 63.6% (35/55) had a transient addiction associated with favourable effects on mental quality of life (effect size [ES] = 0.52, 95%CI: [0.20, 0.86[) and sleep quality (ES = −0.50 [-0.89, −0.12]) and avoided the worsening of depression symptom severity compared to the remaining groups (ES range = 0.51–0.65). The 5.1% (14/275) of cyclists with a pre-competition low risk of exercise addiction presented emerging exercise addiction that was associated with a worsened mental quality of life compared to the remaining groups (ES ranged 0.59-0.91), sleep quality compared to the non-risk (ES = −0.56 [−0.02, −1.10]) and transient (ES = −0.72 [-1.36, −0.08]) groups and anxiety symptom severity compared to the persistent group (ES = 0.51 [1.20, −0.19]). Conclusions. Exercise addiction had a marked transitory component at 6-month post-competition with associated health benefits in amateur endurance cyclists.

Title

Exercise addiction stability and health effects. A 6-month follow-up post-competition study in amateur endurance cyclists.

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Abstract

Objective. To study the longitudinal stability of exercise addiction and its health effects in apparently healthy amateur endurance cyclists from pre- to 6-month post-competition.

Methods. In total, 330 (30 women) adult cyclists were divided into four groups based on scores on the Exercise Addiction Inventory at both periods: non-risk (n = 262, 79.1%), transient (n = 35, 10.6%), emerging (n = 14, 4.2%) and persistent (n = 20, 6.1%).

Results. The prevalence of high-risk exercise addiction was reduced post-competition (16.7% vs. 10.3%, p = 0.017). Of the cyclists with a high pre-competition risk of exercise addiction, 63.6% (35/55) had a transient addiction associated with favourable effects on mental quality of life (effect size [ES] = 0.52, 95%CI: [0.20, 0.86[) and sleep quality (ES = −0.50 [-0.89, −0.12]) and avoided the worsening of depression symptom severity compared to the remaining groups (ES range = 0.51–0.65). The 5.1% (14/275) of cyclists with a pre-competition low risk of exercise addiction presented emerging exercise addiction that was associated with a worsened mental quality of life compared to the remaining groups (ES ranged 0.59-0.91), sleep quality compared to the non-risk (ES = −0.56 [−0.02, −1.10]) and transient (ES = −0.72 [-1.36, −0.08]) groups and anxiety symptom severity compared to the persistent group (ES = 0.51 [1.20, −0.19]).

Conclusions. Exercise addiction had a marked transitory component at 6-month post-competition with associated health benefits in amateur endurance cyclists.

Keywords: exercise addiction; cycling; health; competition; transient; persistent.

INTRODUCTION

A plethora of scientific evidence[1] has consistently demonstrated that physical exercise prevents and treats multiple diseases. However, excessive levels of exercise may be harmful and lead to exercise addiction, defined as "a morbid pattern of behaviour in which the habitually exercising individual loses control over his or her exercise habits and acts compulsively, exhibits dependence and experiences negative consequences to health as well as in his or her social and professional life"[2]. Many researchers claim that exercise addiction should be listed as a mental disorder in diagnostic manuals, but the accumulated literature is still scarce and limited by a lack of conceptual and methodological consistency.[3]

A major limitation in the research on exercise addiction is that almost all of the studies have a cross-sectional design, which limits our knowledge of the stability of exercise addiction and its health effects. To the best of our knowledge, there is only a longitudinal study[4] on "primary exercise addiction"[3], in which exercise addiction manifests a form of behavioural addiction, that did not analyse the health effects and a few longitudinal studies[5–11] on "secondary exercise addiction"[3], in which exercise addiction often emerges as a consequence of the own disorder (in this case eating disorder), and measured compulsive exercise rather than exercise addiction, a more appropriate term that includes both dependence and compulsion.[3] Therefore understanding the stability of exercise addiction and its health effects is thus both a challenge and an opportunity for the public health and scientific community.

A key factor for improving our knowledge of the longitudinal stability of exercise addiction and its health effects is developing scientific studies in practitioners of specific sport disciplines potentially associated with an increased risk of exercise addiction. A recent systematic review[12] established that endurance sports (e.g. cycling) were associated with a higher risk of exercise addiction than power (e.g. weightlifting), mixed (e.g. soccer) and health and fitness disciplines. Longer-distance endurance sports also have an increased risk of exercise addiction/dependence compared to shorter-distance endurance sports.[13–15]

Amateur endurance cycling is a long-distance endurance sport that gathers thousands of practitioners in competitive events characterized by high physical and psychological demands concentrated in a short space of time, which may be linked with an increased risk of exercise addiction pre-competition.

However, the large reduction in exercise training loads post-competition may be linked with a decreased risk of exercise addiction. This study sought to evaluate the changes in exercise addiction and its health effects in amateur endurance cyclists from pre- to post-competition. Considering the aforementioned characteristics of this sport and the possible influence of obsessive passion (which is closely linked to exercise addiction[4,16]), we hypothesized a reduction in the risk of exercise addiction post-competition. Based on the results of a recent cross-sectional study in amateur endurance cyclists[17], we hypothesized that the reduction of the risk of exercise addiction could be associated with better mental health, sleep quality and decreased anxiety symptom severity.

METHODS

Participants

This longitudinal study was part of a research project focused on exploring the association between cycling and health through a web-based experiment on a freely available webpage. This study included apparently healthy respondents aged 18–65 years who were classified as cyclists in May (the period prior to the participation in their main cycling event; hereafter 'pre-competition') and completed the survey again in November (6 months after the cycling event; hereafter 'post-competition'). Individuals were defined as apparently healthy if they self-reported no psychiatric (including eating disorders), pulmonary, musculoskeletal, heart or cancer disease at pre-competition. Individuals with self-reported obesity, hypertension, diabetes and/or dyslipidaemia were included in the study. Cyclists were considered those who reported being amateur endurance outdoor cyclists, engaged in cycling training for a minimum of 7 hours/week, had at least one year of cycling training experience and the intention to participate in May–June road cycling (>100 km) or mountain bike (> 45 km) events. The characteristics of participants are illustrated in Table 2.

Ethics

The protocol was approved by the Committee on Biomedical Ethics of the Aragon Government (PI17/0252). The invitation included a brief introduction to the study, an explanation of the anonymous and voluntary nature of participation in the study and a link to the survey. At the end of the experiment, individuals needed to provide informed consent for the scientific use of the data and provide an email address to receive the results.

Procedure

An invitation to participate in the study was sent via e-mail to the representatives of the 3,426 cycling clubs integrated into the Royal Spanish Cycling Federation in 2016. The study was also made known through media coverage, including on TV and through social media such as Twitter, Facebook and LinkedIn. The experiment included questions on health behaviours and health status and took an average of 40 minutes to complete. Data were collected in the last week of May and November from 2016 to 2018, using the same procedure throughout the study period. To avoid duplicate samples, cases that contained the same email address were eliminated. In 2017 and 2018 we included a warning message before starting the experiment to indicate that those who had already completed the survey should not do so again. Data analysis was conducted in May 2020. There was no compensation for participation.

Measures

Exercise addiction

The risk of exercise addiction was measured with the Spanish version[18] of the Exercise Addiction Inventory[19], which has satisfactory psychometric properties (α value = 0.70 and ICC = 0.92)[18]. The inventory, which can be found in the aforementioned free full-text articles, is composed of six items with 5-point Likert scale responses (1 = strongly disagree, 5 = strongly agree), scores ≥24 indicate a high risk of addiction. Participants were divided into four groups based on the cut-off of 24 on the Exercise Addiction Inventory at pre- and post-competition: non-risk of exercise addiction if scoring below criteria on both measurements, transient risk if scoring ≥24 only pre-competition, emerging risk if scoring ≥24 only post-competition and persistent risk if scoring ≥24 on both measurements.

Health behaviours

The cycling training variables were volume (km/month and hours/week) and frequency (days/week) in the last month and experience (years). Physical activity was measured with the Spanish short-form version of the International Physical Activity Questionnaire[20] by totalling the walking, moderate- and vigorous-intensity activities and expressing the result in metabolic equivalent of task-min/week. Smoking dependence was evaluated with the Spanish version[21] (α value = 0.66) of the revised version of the Fagerström Test for Nicotine Dependence[22], with lower scores indicating lower levels of

dependence. Alcohol use was calculated by transforming the volume of beer, wine and spirits consumed in the last week into standard alcohol units[23], with lower units indicating lower levels of alcohol consumption.

Health status

Quality of life was measured with the Spanish version[24] of the 12-Item Health Survey 2.0[25], which examines eight domains constituting the physical and mental component summary scores (α = 0.85 for the physical component and 0.78 for the mental component), with higher scores indicating better quality of life. Sleep Quality was assessed with the Spanish version[26] (α values ranged from 0.67 for students and to 0.81 for clinical population) of the Pittsburgh Sleep Quality Index[27], which examines seven sleep components that yield a global score, with lower scores indicating better sleep quality. Anxiety and depression symptom severity were separately evaluated with the Spanish version[28] (α = 0.85 for the anxiety subscale and 0.84 for the depression subscale) of the Hospital Anxiety and Depression Scale[29], with lower scores indicating lower symptom severity. Body mass index was calculated using weight and height. The Spanish version of the International Fitness Scale[30] was used to measure the physical fitness level (overall and specific components: cardiorespiratory fitness, muscular strength, speed-agility, and flexibility). Individuals were asked how they perceived their own level compared with their friends' physical fitness using a 5-point Likert scale (very poor = 1, poor = 2, average = 3, good = 4, and very good = 5).

Sociodemographic data

Sex, age, educational status, occupational status, marital status and number of children were determined.

Statistical Analysis

Categorical data were compared by the chi-square test using the Two-Proportions tab of Chapters 10–16 of the Exploratory Software for Confidence Intervals (freely available on the website.[31] The following analyses were performed using SPSS Statistics for Windows, Version 22.0 (IBM Corp, Armonk, NY, USA). The between-group comparisons of pre- and post-competition continuous data were performed using one-way ANOVA followed by a Bonferroni post hoc test. The within- and between-group comparisons of the longitudinal change in continuous data were performed using a

four group (Non-risk/Persistent/Emerging/Persistent) × two time (pre-/post-competition) repeated measures ANOVA, followed by a Bonferroni post hoc test. To minimize the risk of type I statistical error, adjustments for multiple comparisons were made using Bonferroni's method by dividing the significance level of 0.050 by the number of comparisons.

The comparisons of continuous data were also assessed using an approach based on the standardized effect size, with the Cohen's *d* adjusted by correcting for small sample bias, also known as Hedges' *g*, and associated 95% confidence intervals using a free online effect size calculator.[32] For each case, the Cohen's *d* was calculated as follows: (i) between-group (pre-competition): the difference between the mean pre-competition values of two groups divided by the pooled pre-competition standard deviation of these two groups; (ii) between-group (post-competition): the difference between the mean post-competition values of two groups divided by the pooled post-competition standard deviation of these two groups; (iii) between-group (change): the difference between the mean change from the pre- to post-competition measurements of the two groups divided by the pooled pre-competition standard deviation of these two groups; and (iv) within-group: the mean change from the pre- to post-competition measurements divided by the average standard deviation of both repeated measures. The formulae for estimation of Cohen's *d* and associated 95% confidence intervals are available on GitHub.[33] A Cohen's $d \geq 0.50$ was considered a minimally important difference.[34]

RESULTS

A participant flow diagram is shown in Figure 1, and the main results of the risk of exercise addiction are presented in Table 1. Overall, the exercise addiction score and the prevalence of a high risk of exercise addiction were reduced at post-competition. Of those who had high risk at pre-competition, 63.3% presented transient exercise addiction, while only 5.1% of those with a low risk of exercise addiction at pre-competition presented emerging exercise addiction. All results were similar for men and women.

The pre- and post-competition characteristics of the participants (divided into four groups based on exercise addiction scores at both periods) are presented in Tables 2 and 3, respectively. At pre-competition, one-way ANOVA showed between-group differences in the exercise addiction score ($F_{(3, 326)} = 89.5$, $p < 0.001$; $\eta_p^2 = 0.45$), mental quality of life ($F_{(3, 326)} = 7.3$, $p < 0.001$; $\eta_p^2 = 0.06$) and

depression symptom severity ($F_{(3, 326)} = 7.2$, $p < 0.001$; $\eta_p^2 = 0.06$). Paired-group comparisons showed that the non-risk group reported lower exercise addiction scores than the three remaining groups. The emerging group reported higher training frequency than the three remaining groups and lower exercise addiction scores than the transient and persistent groups. The transient group had better physical quality of life and worse mental quality of life and sleep quality than the non-risk and emerging groups, as well as higher depression symptom severity than the non-risk and persistent groups and higher muscular strength than the emerging group. At post-competition, one-way ANOVA showed between-group differences in exercise addiction score ($F_{(3, 326)} = 64.5$, $p < 0.001$; $\eta_p^2 = 0.37$). Paired-group comparisons showed that the non-risk group reported lower exercise addiction scores than the three remaining groups. The emerging group had higher weekly training hours and frequency than the non-risk and transient groups, as well as worse mental quality of life and sleep quality than the non-risk group. The transient group had lower exercise addiction scores than the emerging and persistent groups. The persistent group had higher level of physical activity than the emerging group.

Within- and between-group comparisons of the change from pre- to post-competition are shown in Table 4. Repeated measures ANOVA showed a group × time interaction in exercise addiction score ($F_{(3, 326)} = 27.04$, $p < 0.001$; $\eta_p^2 = 0.20$). Paired-group comparisons showed that the transient group reported a higher reduction of weekly training hours than the persistent group. The emerging group had a higher reduction of weekly physical activity than the transient group, worsened mental quality of life compared with the three remaining groups, increased anxiety symptom severity compared with the persistent group, and worsened sleep quality compared with the non-risk and transient groups. Alcohol use increased in the transient and persistent groups compared with the emerging group. The non-risk, emerging and persistent groups showed increased depression symptom severity compared to the transient group.

DISCUSSION

Three major findings can be highlighted. First, the prevalence of a high risk of exercise addiction in amateur endurance cyclists was reduced from 16.7% to 10.3% over the 6-month follow-up from the competitive cyclist period, and 6.1% and 10.6% of cyclists exhibited persistent and transient exercise addiction, respectively. Second, the transient group showed improved mental quality of life and sleep quality and avoided the worsening of depression symptom severity compared to the remaining

exercise addiction groups. Third, the emerging group showed worsened mental quality of life compared to the remaining groups, sleep quality compared to the non-risk and transient groups and anxiety symptom severity compared to the persistent group.

Our findings showing that the mean score of exercise addiction risk changed from pre- to 6-month post-competition in adult endurance amateur cyclists are consistent with the previous longitudinal study on primary exercise addiction,[4] that analysed the change 12 weeks after starting up a new sport in students and using the Exercise Addiction Inventory, and with all the aforementioned studies[5–11] on compulsive exercise conducted in people with eating disorders. These findings suggest that exercise addiction (and compulsive exercise) seems to be a modifiable risk factor and may encourage exercise and health professionals to seek increasingly appropriate treatments.

Given that the previous longitudinal study on primary exercise addiction[4] did not report the number of individuals at-risk and those not at-risk for exercise addiction, our results on the prevalence of persistent and transient exercise addiction were compared with those of two longitudinal studies[9,10] that reported results on the prevalence of persistent and transient compulsive exercise in people with eating disorders from treatment to 1-year follow-up. Specifically, the prevalence rates of persistent exercise addiction in cyclists (men = 6.0% and women = 6.7%) were lower than those for persistent compulsive exercise found in adults (men = 15.8% and women = 18.8%)[9] and adolescents (girls = 14.0%)[10] with eating disorders. Similarly, the prevalence rates of transient exercise addiction among cyclists (men = 10.7% and women = 10.0%) were lower than those of persistent compulsive exercise found among adults (men = 26.7% and women = 30.2%)[9] and adolescents (girls = 32.0%)[10] with eating disorders. Although exercise addiction and compulsive exercise do not reflect the same phenomenon[3], the lower rates found in our study may be due to people with eating disorders being 3.5 times more likely to have an exercise addiction than those without eating disorders.[35] Considering the high impact of eating disorders on exercise addiction, studies in other healthy populations are necessary to better contextualize our results.

Our finding that approximately two-thirds of cyclists (men = 64.0% and women = 60.0%) with a high risk of exercise addiction at baseline had transient exercise addiction is consistent with the results of the aforementioned studies in adults (men = 59.2% and women = 62.3%)[9] and adolescents (girls = 69%)[10] with eating disorders. The elevated degree of variability for high risk of exercise addiction

suggests the need to re-evaluate the risk of exercise addiction in people at high risk to detect potentially real cases of exercise addiction (i.e. those with persistent exercise addiction) that would require a confirmatory diagnostic interview with specialized professionals. The low percentage of cyclists (men = 5.2% and women = 4.0%) with a low risk of exercise addiction at baseline who had emerging exercise addiction was slightly lower than in adults (men = 10.3% and women = 12.9%)[9] and adolescents (girls = 17%)[10] with eating disorders, which suggests that the re-evaluation of the risk of addiction to exercise in people at low risk to detect potentially new cases of exercise addiction would be few efficient due to the reduced variability of the low risk of exercise addiction. In these individuals it might be more convenient to re-evaluate the risk of exercise addiction after a longer period of time.

The results that the transient exercise addiction group avoided an increase in depression symptom severity compared to the remaining groups could be due to a possible ceiling effect, because it reported higher values at pre-competition. Another interesting result for the transient group is the greater reduction in the number of weekly cycling training hours compared to the persistent group, which suggests the importance of deeply reducing the training volume to reduce the level of exercise addiction in people at high risk of exercise addiction. This is somewhat coherent, but there is no longitudinal data to prove it to date. Despite the reduction, the transient group did not reach the exercise addiction score of the non-risk group at post-competition, which suggests an incomplete recovery of the exercise addiction levels that could be associated with possible relapses in the high risk of exercise addiction. Additionally, the result that the transient and persistent groups increased alcohol consumption compared to the emerging group could reflect a compensatory effect in both groups by reducing the amount of physical exercise performed. In the transient group it could also reflect a substitution of one addiction for another, as has been shown for other addictions such as methadone.[36] follow-up studies analysing possible relapses for high risk of exercise addiction and the start of new addictions such as high alcohol consumption in amateur endurance cyclists with transient exercise addiction may be pertinent to verify our results.

Finally, the result that the emerging exercise addiction group showed worsened mental quality of life, sleep quality and anxiety symptom severity is somewhat expected because they are characteristic symptoms of exercise addiction[3] with accumulated evidence in cross-sectional studies that used the Exercise Addiction Inventory in habitual exercisers[38,39], gym users[40] and amateur endurance outdoor cyclists.[17] These findings underscore the importance of promoting good sports practices in endurance

cycling to reduce the likelihood of the onset of exercise addiction and its associated negative health effects.

Implications for practice

The current study could help raise awareness among health professionals of the importance of considering exercise addiction as a health risk factor in amateur endurance cyclists, with a marked transitory component as a result of the proximity of a competitive event. It may also encourage the scientific community to research the changes in exercise addiction and its health effects in other sport disciplines and/or during other seasonal periods. Our study extends the previous knowledge for amateur endurance cyclists[17] by including four groups of risk of exercise addiction (non-risk, emerging, transient and persistent) instead of two groups (low and high risk), which allows us to identify possible indicators of the change in exercise addiction risk (i.e. transient and emerging) that should be considered when designing trials. According to our results, amateur endurance cyclists with a high risk of exercise addiction (i.e. score ≥24 on the Exercise Addiction Inventory) and higher depression symptom severity may be more likely to have a transient exercise addiction. Those with a low risk of exercise addiction (i.e. score below 24 on the Exercise Addiction Inventory) with a higher score for exercise addiction and training frequency may be more likely to have a emerging exercise addiction. However, our findings require more research with more robust analysis before they can be applied in a more generalized way.

Limitations and Strengths

While this study is the first to measure the change in risk of exercise addiction and its health effects in an apparently healthy population, the findings should be considered within the limitations of this study. First, the study was based on self-reported data, which can involve bias. The findings are limited by the low statistical power due to the small sample size of all groups (n ≤ 35) except for the non-risk group (n = 261). These aspects could explain why we only found a group × time interaction, specifically in the risk of exercise addiction, an expected result because the groups were created based on the changes over time in this variable. There was a disproportionate participation of men (90.1%), although this represents the current situation in Spain for the proportion of men and women participating in endurance cycling events. There was considerable attrition in the follow-up assessment (61.6%). There was also a lack of information on participant lifestyle and cycling habits

during the 6-month follow-up, which may have affected changes in the risk of exercise addiction and health. Despite using emails as a control method for eliminating duplicate participants, there was no control over duplicates or double participation because a person might have more than one email address. There was also no control over respondents and demographic characteristics. Finally, the Exercise Addiction Inventory may not adequately reflect the level of exercise addiction in athletes participating in sport competitions, as suggested by De La Vega et al.[16] and Szabo et al.[2] Future studies should include items on obsessive passion and dedication, because high scores for exercise addiction in passionate and dedicated athletes may represent a "false alarm". Therefore, failing to assess passion and dedication was a major limitation of the current work.

Despite these limitations, this study has several strengths. The Internet-based design of the study, media coverage and anonymous participation prevented missing data,[41] as well as increasing access to more potential participants and may have encouraged individuals to respond to personal questions.[42] Furthermore, well-established, validated and reliable tools that apply norm-based scoring methodology were used.

CONCLUSIONS

The prevalence of amateur endurance cyclists with a high risk of exercise addiction fell from 16.7% at pre-competition to 10.3% at 6-month post-competition, and 6.1% and 10.6% of cyclists exhibited persistent and transient exercise addiction, respectively. The decreased risk of exercise addiction observed in the transient group was associated with favourable effects on mental quality of life, sleep quality and depression symptom severity. The increased risk of exercise addiction observed in the emerging group was associated with unfavourable effects on mental quality of life, sleep quality and anxiety symptom severity.

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Figure 1. Participants flow diagram.

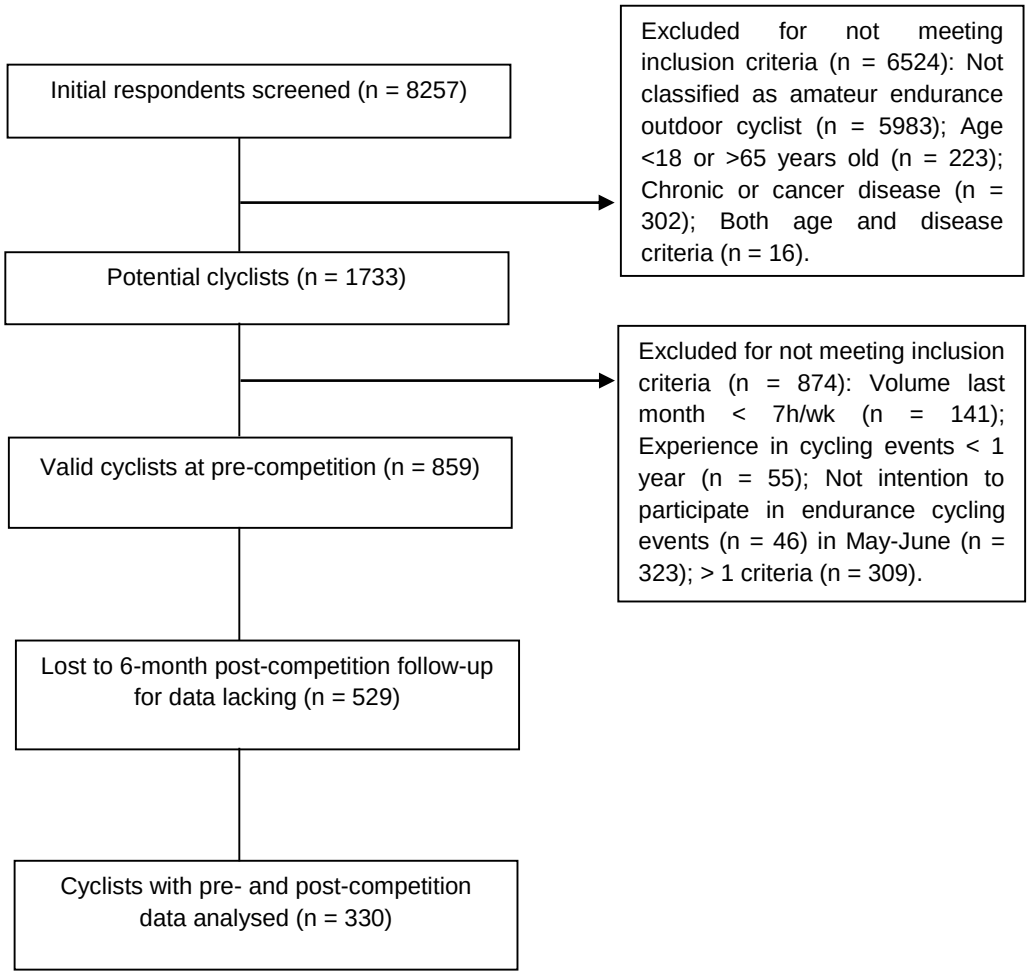

Table 1. Main results of the risk of exercise addiction in amateur endurance cyclists at pre- and post-competition.

	All (n = 330)		Men (n = 300)		Women (n = 30)	
	n	Mean ± SD	n	Mean ± SD	n	Mean ± SD
Score of exercise addiction risk (6-30)						
Pre-competition	330	19.3 ± 4.2	300	19.3 ± 4.2	30	19.6 ± 4.3
Post-competition	330	18.3 ± 4.2	300	18.3 ± 4.2	30	18.8 ± 4.4
p		**< 0.001**		**< 0.001**		0.420
d (95%CI)		0.24 (0.13, 0.35)		0.23 (0.11, 0.34)		0.18 (-0.24, 0.61)
	n	% (95%CI)	n	% (95%CI)	n	% (95%CI)
Prevalence of high exercise addiction risk						
Pre-competition	55	16.7 (13.0, 21.1)	50	16.7 (12.9, 21.3)	5	16.7 (7.3, 33.6)
Post-competition	34	10.3 (7.5, 14.1)	31	10.3 (7.4, 14.3)	3	10.0 (3.5, 25.6)
p		**0.017**		**0.023**		0.448
Varaibility of exercise addiction risk						
Non-risk [low-low]	261	79.1 (74.4, 83.1)	237	79.0 (74.0, 83.2)	24	80.0 (62.7, 90.5)
Transient [high-low]	35	10.6 (7.7, 14.4)	32	10.7 (7.7, 14.7)	3	10.0 (3.5, 25.6)
Emerging [low-high]	14	4.2 (2.5, 7.0)	13	4.3 (2.5, 7.3)	1	3.3 (0.6, 16.7)
Persistent [high-high]	20	6.1 (4.0, 9.2)	18	6.0 (3.8, 9.3)	2	6.7 (1.8, 21.3)
	n/N	% (95%CI)	n	% (95%CI)	n	% (95%CI)
Variability of high and low exercise addiction risk						
Transient/High-risk at Pre-	35/55	63.6 (50.4, 75.1)	32/50	64.0 (50.1, 75.9)	3/5	60.0 (23.1, 88.2)
Emerging/Low-risk at Pre-	14/275	5.1 (3.1, 8.4)	13/250	5.2 (3.1, 8.7)	1/25	4.0 (0.7, 19.5)

Values are the mean ± standard deviation or n (%, 95%CI). Varaibility of risk of exercise addiction includes the four groups based on the cut-off score of 24 on the Exercise Addiction Inventory at pre- and post-competition (for example, non-risk of exercise addiction participants scored below criteria, i.e. low risk of exercise addiction, on both measurements).

CI: confidence intervals, *d*: Cohen's standardized effect size adjusted by correcting for small sample bias, SD: standard deviation.

Chi-square test was used to compare categorical data; unpaired t-test and Cohen's standardized effect size adjusted by correcting for small sample bias were used to compare continuous data; significant *p*-values and minimally important differences are in bold; the thresholds of *p*- and *d*-values were set at 0.025 (0.005/2) and 0.50, respectively.

Table 2. Characteristics of amateur endurance cyclists at pre-competition.

Variables	Descriptive data				Between-group comparisons											
	Non-risk (n = 261)	Transient (n = 35)	Emerging (n = 14)	Persistent (n = 20)	Non-risk vs Transient		Non-risk vs Emerging		Non-risk vs Persistent		Transient vs Emerging		Transient vs Persistent		Emerging vs Persistent	
					p	*d* (95%CI)	*p*	*d* (95%CI)	*p*	*d* (95%CI)	*p*	ES (95%CI)	*p*	*d* (95%CI)	*p*	*d* (95%CI)
Gender (women)	24 (9.2)	4 (11.4)	1 (7.1)	2 (10.0)	0.672		0.795		0.905		0.654		0.870		0.773	
Educational status (non-university studies)	118 (45.2)	18 (51.4)	6 (42.9)	7 (35.0)	0.488		0.863		0.376		0.588		0.239		0.239	
Occupational status (unemployed)	18 (6.9)	3 (8.6)	0 (0.0)	5 (25.0)	0.717		0.309		0.004		0.258		0.096		0.096	
Marital status (single)	23 (8.8)	1 (2.9)	0 (0.0)	0 (0.0)	0.226		0.246		0.166		0.523		0.446		0.446	
Number of children (≥1)	152 (58.2)	18 (51.4)	10 (71.4)	8 (40.0)	0.444		0.328		0.112		0.201		0.414		0.414	
Age (years)	40.2 ± 8.0	39.0 ± 7.8	40.9 ± 7.6	37.4 ± 10.2	1.000	0.15 (-0.20,0.50)	1.000	-0.08 (-0.62,0.46)	0.802	0.35 (-0.11,0.80)	1.000	-0.23 (-0.85,0.39)	1.000	0.18 (-0.37,0.73)	1.000	0.37 (-0.32,1.05)
Experience in cycling (years)	5.6 ± 5.3	6.5 ± 5.3	6.9 ± 4.9	4.9 ± 4.2	1.000	-0.18 (-0.53,0.18)	1.000	-0.24 (-0.77,0.30)	1.000	0.14 (-0.31,0.60)	1.000	-0.06 (-0.68,0.56)	1.000	0.34 (-0.22,0.89)	1.000	0.43 (-0.26,1.12)
Training volume (km/month)	1115.5 ± 484.6	1144.2 ± 483.6	1207.8 ± 347.7	1096.4 ± 409.1	1.000	-0.06 (-0.41,0.29)	1.000	-0.19 (-0.73,0.35)	1.000	0.04 (-0.41,0.49)	1.000	-0.14 (-0.76,0.48)	1.000	0.10 (-0.45,0.65)	1.000	0.28 (-0.40,0.97)
Training volume (h/wk)	11.5 ± 3.4	11.5 ± 3.3	12.8 ± 2.1	11.4 ± 3.4	1.000	-0.02 (-0.37,0.33)	0.831	-0.41 (-0.95,0.13)	1.000	0.03 (-0.42,0.49)	1.000	-0.42 (-1.05,0.20)	1.000	0.05 (-0.50,0.60)	1.000	0.48 (-0.21,1.18)
Training frequency (d/wk)	4.0 ± 1.2	4.2 ± 1.2	5.1 ± 0.9	4.4 ± 1.2	1.000	-0.12 (-0.47,0.24)	0.009	**-0.87 (-1.41,-0.33)**	1.000	-0.31 (-0.76,0.15)	0.105	**-0.80 (-1.44,-0.16)**	1.000	-0.19 (-0.74,0.36)	0.641	**0.60 (-0.09,1.30)**
Exercise addiction (6-30)	17.9 ± 3.4	25.4 ± 1.4	20.6 ± 1.8	25.7 ± 1.6	**<0.001**	**-2.29 (-2.69,-1.90)**	0.010	**-0.81 (-1.35,-0.27)**	**<0.001**	**-2.32 (-2.81,-1.83)**	**<0.001**	**3.11 (2.24,3.98)**	1.000	-0.18 (-0.73,0.37)	**<0.001**	**-2.89 (-3.86,-1.92)**
Physical activity (MET-min/wk)[a]	5832.3 ± 2517.7	6186.1 ± 2493.2	6099.5 ± 3382.7	6946.4 ± 2722.6	1.000	-0.14 (-0.53,0.25)	1.000	-0.10 (-0.68,0.48)	0.429	-0.44 (-0.91,0.03)	1.000	0.03 (-0.65,0.71)	0.746	-0.29 (-0.87,0.30)	1.000	-0.28 (-1.00,0.45)
Smoking dependence (0-16)	0.1 ± 0.6	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	1.000	0.17 (-0.19,0.52)	1.000	0.16 (-0.38,0.70)	1.000	0.16 (-0.29,0.62)	1.000	Error	1.000	Error	1.000	Error
Alcohol use (SAU/wk)	6.2 ± 9.6	4.9 ± 6.2	8.1 ± 13.7	3.7 ± 4.5	1.000	0.14 (-0.21,0.50)	1.000	-0.19 (-0.73,0.35)	1.000	0.27 (-0.19,0.72)	1.000	-0.35 (-0.98,0.27)	1.000	0.21 (-0.34,0.76)	1.000	0.45 (-0.24,1.15)
Physical QoL (0-100)	56.7 ± 4.3	58.9 ± 5.8	54.9 ± 5.0	56.6 ± 6.5	0.044	**-0.50 (-0.86,-0.15)**	0.978	0.41 (-0.13,0.95)	1.000	0.02 (-0.43,0.47)	0.038	**0.72 (0.08,1.35)**	0.435	0.39 (-0.17,0.94)	1.000	-0.28 (-0.97,0.40)
Mental QoL (0-100)	53.5 ± 10.2	44.6 ± 13.4	53.6 ± 8.2	50.2 ± 13.3	**<0.001**	**0.83 (0.47,1.19)**	1.000	-0.01 (-0.55,0.52)	1.000	0.31 (-0.14,0.77)	0.051	**-0.72 (-1.36,-0.09)**	0.387	-0.41 (-0.96,0.14)	1.000	0.29 (-0.40,0.97)
Sleep quality (0-21)	4.3 ± 2.2	5.7 ± 2.4	4.3 ± 2.7	5.2 ± 2.7	0.006	**-0.61 (-0.96,-0.25)**	1.000	0.03 (-0.51,0.57)	0.667	-0.37 (-0.83,0.08)	0.301	**0.57 (-0.06,1.20)**	1.000	0.20 (-0.35,0.75)	1.000	-0.33 (-1.02,0.36)
Anxiety (0-21)	7.7 ± 1.9	8.2 ± 2.0	7.9 ± 1.7	8.0 ± 1.9	0.581	-0.30 (-0.65,0.06)	1.000	-0.10 (-0.64,0.43)	1.000	-0.18 (-0.63,0.28)	1.000	0.19 (-0.43,0.81)	1.000	0.11 (-0.44,0.66)	1.000	-0.08 (-0.76,0.61)
Depression (0-21)	9.2 ± 1.8	10.6 ± 1.7	10.0 ± 2.1	9.7 ± 1.7	**<0.001**	**-0.79 (-1.15,-0.43)**	0.562	-0.45 (-0.99,0.08)	1.000	-0.30 (-0.75,0.16)	1.000	0.32 (-0.30,0.94)	0.487	**0.52 (-0.04,1.07)**	1.000	0.16 (-0.53,0.84)
Body mass index (kg/m^2)	23.8 ± 2.5	23.8 ± 2.6	23.1 ± 1.9	23.6 ± 3.6	1.000	0.01 (-0.35,0.36)	1.000	0.30 (-0.24,0.84)	1.000	0.09 (-0.37,0.54)	1.000	0.29 (-0.33,0.92)	1.000	0.07 (-0.48,0.62)	1.000	-0.17 (-0.85,0.52)
Fitness (1-5)																
Overall	4.2 ± 0.6	4.3 ± 0.9	4.3 ± 0.6	4.3 ± 0.7	1.000	-0.07 (-0.42,0.29)	1.000	-0.07 (-0.61,0.47)	1.000	-0.09 (-0.55,0.36)	1.000	0.00 (-0.62,0.62)	1.000	-0.02 (-0.57,0.53)	1.000	-0.02 (-0.70,0.66)
CRF	4.3 ± 0.7	4.2 ± 0.9	4.5 ± 0.7	4.2 ± 0.8	1.000	0.04 (-0.31,0.40)	1.000	-0.34 (-0.88,0.19)	1.000	0.09 (-0.37,0.54)	1.000	-0.33 (-0.95,0.30)	1.000	0.03 (-0.52,0.58)	1.000	0.38 (-0.31,1.07)
Strength	3.9 ± 0.7	4.1 ± 0.7	3.6 ± 0.7	3.9 ± 0.6	0.881	-0.26 (-0.61,0.09)	1.000	0.34 (-0.20,0.88)	1.000	0.04 (-0.41,0.49)	0.344	**0.58 (-0.05,1.21)**	1.000	0.31 (-0.24,0.87)	1.000	-0.31 (-1.00,0.38)
Speed-agility	3.8 ± 0.7	3.8 ± 0.6	3.6 ± 0.6	3.8 ± 0.6	1.000	0.03 (-0.32,0.38)	1.000	0.21 (-0.33,0.75)	1.000	0.06 (-0.39,0.52)	1.000	0.20 (-0.42,0.82)	1.000	0.03 (-0.51,0.58)	1.000	-0.18 (-0.86,0.51)
Flexibility	3.3 ± 0.9	3.3 ± 0.8	3.4 ± 0.9	3.0 ± 0.8	1.000	-0.08 (-0.43,0.27)	1.000	-0.10 (-0.63,0.44)	1.000	0.29 (-0.16,0.75)	1.000	-0.02 (-0.64,0.60)	1.000	0.41 (-0.14,0.97)	1.000	0.41 (-0.28,1.10)

Values are the mean ± standard deviation or n (%). The four groups were based on the cut-off score of 24 on the Exercise Addiction Inventory at pre- and post-competition (for example, non-risk of exercise addiction participants scored below criteria on both measurements).

[a]Missing data. Reasons: data were unreasonably high and excluded from analysis according to the Guidelines for Data Processing and Analysis of the International Physical Activity Questionnaire (non-risk (n = 23), transient (n = 7), emerging (n = 2), persistent (n = 1)).

CI: confidence intervals, CRF: cardiorespiratory fitness, *d*: Cohen's standardized effect size adjusted by correcting for small sample bias, MET: metabolic equivalent of task, QoL: quality of life, SAU: standard alcohol units, SD: standard deviation.

Chi-square test was used to compare categorical data; one-way ANOVA with Bonferroni post hoc test and Cohen's *d* were used to compare continuous data; significant *p*-values and minimally important differences are in bold; the thresholds of *p*- and *d*-values were set at 0.002 (0.050/25) and 0.50, respectively.

Table 3. Characteristics of amateur endurance cyclists at 6-month post-competition.

Variables	Descriptive data				Between-group comparisons											
	Non-risk (n = 261)	Transient (n = 35)	Emerging (n = 14)	Persistent (n = 20)	Non-risk vs Transient		Non-risk vs Emerging		Non-risk vs Persistent		Transient vs Emerging		Transient vs Persistent		Emerging vs Persistent	
					p	*d* (95%CI)	*p*	*d* (95%CI)	*p*	*d* (95%CI)	*p*	ES (95%CI)	*p*	*d* (95%CI)	*p*	*d* (95%CI)
Training volume (km/month)	660.5 ± 415.3	639.5 ± 387.7	834.2 ± 395.6	784.0 ± 480.3	1.000	0.05 (-0.30, 0.40)	0.772	-0.42 (-0.96, 0.12)	1.000	-0.29 (-0.75, 0.16)	0.838	-0.49 (-1.12, 0.13)	1.000	-0.34 (-0.89, 0.21)	1.000	0.11 (-0.57, 0.79)
Training volume (h/wk)	7.1 ± 3.8	6.7 ± 3.6	9.1 ± 4.0	8.6 ± 4.5	1.000	0.11 (-0.25, 0.46)	0.402	**-0.52 (-1.06, 0.02)**	0.635	-0.38 (-0.84, 0.07)	0.350	**-0.64 (-1.28, -0.01)**	0.556	-0.47 (-1.03, 0.08)	1.000	0.11 (-0.57, 0.80)
Training frequency (d/wk)	3.0 ± 1.6	2.9 ± 1.6	3.8 ± 1.6	3.2 ± 1.3	1.000	0.06 (-0.29, 0.42)	0.411	**-0.50 (-1.04, 0.04)**	1.000	-0.13 (-0.58, 0.33)	0.504	**-0.55 (-1.19, 0.07)**	1.000	-0.20 (-0.75, 0.35)	1.000	0.41 (-0.27, 1.11)
Exercise addiction (6-30)	17.2 ± 3.49	19.9 ± 3.7	25.4 ± 1.3	25.7 ± 1.6	**<0.001**	**-0.76 (-1.12, -0.41)**	**<0.001**	**-2.39 (-2.96, -1.82)**	**<0.001**	**-2.48 (-2.98, -1.98)**	**<0.001**	**-1.68 (-2.41, -0.99)**	**<0.001**	**-1.82 (-2.50, -1.19)**	1.000	-0.20 (-0.89, 0.48)
Physical activity (MET-min/wk)[a]	3331.8 ± 2790.1	3923.4 ± 3490.1	2488.1 ± 2393.6	4471.4 ± 3610.0	1.000	-0.21 (-0.60, 0.19)	1.000	0.30 (-0.28, 0.88)	0.605	-0.40 (-0.87, 0.07)	0.919	0.44 (-0.24, 1.13)	1.000	-0.15 (-0.74, 0.43)	0.390	**-0.60 (-1.35, 0.13)**
Smoking dependence (0-16)	0.1 ± 0.7	0.0 ± 0.0	0.0 ± 0.0	0.4 ± 1.3	1.000	Error	1.000	Error	1.000	-0.33 (-0.78, 0.13)	1.000	Error	1.000	Error	1.000	Error
Alcohol use (SAU/wk)	8.9 ± 12.2	8.7 ± 9.9	6.9 ± 12.1	7.4 ± 9.3	1.000	0.02 (-0.34, 0.37)	1.000	0.16 (-0.37, 0.70)	1.000	0.12 (-0.33, 0.58)	1.000	0.17 (-0.45, 0.79)	1.000	0.13 (-0.42, 0.68)	1.000	-0.05 (-0.73, 0.64)
Physical QoL (0-100)	56.2 ± 4.7	56.5 ± 7.3	54.1 ± 7.1	55.5 ± 5.3	1.000	-0.06 (-0.41, 0.29)	0.747	0.43 (-0.11, 0.97)	1.000	0.14 (-0.31, 0.60)	0.845	0.33 (-0.29, 0.95)	1.000	0.15 (-0.40, 0.70)	1.000	-0.22 (-0.91, 0.46)
Mental QoL (0-100)	56.2 ± 12.5	51.5 ± 12.3	49.2 ± 18.4	52.8 ± 12.3	0.244	0.38 (0.02, 0.73)	0.277	**0.54 (0.00, 1.08)**	1.000	0.27 (-0.18, 0.73)	1.000	0.16 (-0.46, 0.78)	1.000	-0.10 (-0.65, 0.44)	1.000	-0.23 (-0.92, 0.45)
Sleep quality (0-21)	3.8 ± 2.2	4.6 ± 1.9	5.0 ± 3.6	4.9 ± 3.1	0.270	-0.37 (-0.72, -0.01)	0.346	**-0.52 (-1.06, 0.02)**	0.296	-0.46 (-0.92, 0.00)	1.000	-0.16 (-0.78, 0.46)	1.000	-0.12 (-0.67, 0.43)	1.000	0.03 (-0.65, 0.71)
Anxiety (0-21)	7.8 ± 2.0	8.3 ± 1.7	8.4 ± 2.8	7.6 ± 1.7	1.000	-0.25 (-0.61, 0.10)	1.000	-0.29 (-0.83, 0.25)	1.000	0.13 (-0.33, 0.58)	1.000	-0.05 (-0.67, 0.57)	1.000	0.41 (-0.15, 0.96)	1.000	0.35 (-0.33, 1.05)
Depression (0-21)	10.2 ± 2.2	10.5 ± 1.9	10.9 ± 2.1	10.8 ± 2.1	1.000	-0.14 (-0.49, 0.21)	1.000	-0.32 (-0.86, 0.22)	1.000	-0.25 (-0.71, 0.20)	1.000	-0.20 (-0.20, 0.42)	1.000	-0.15 (-0.70, 0.40)	1.000	0.05 (-0.64, 0.73)
Body mass index (kg/m^2)	24.0 ± 2.6	24.2 ± 3.2	23.5 ± 1.9	23.5 ± 3.6	1.000	-0.07 (-0.43, 0.28)	1.000	0.19 (0.19, 0.73)	1.000	0.19 (-0.26, 0.65)	1.000	0.24 (-0.38, 0.86)	1.000	0.21 (-0.34, 0.76)	1.000	Error
Fitness (1-5)																
Overall	4.1 ± 0.6	4.1 ± 0.6	4.2 ± 0.4	4.1 ± 0.6	1.000	-0.07 (-0.43, 0.28)	1.000	-0.17 (-0.71, 0.37)	1.000	0.08 (-0.37, -0.37)	1.000	0.18 (-0.80, 0.44)	1.000	0.00 (-0.55, 0.55)	1.000	0.18 (-0.50, 0.87)
CRF	4.2 ± 0.7	4.3 ± 0.6	4.2 ± 0.7	4.1 ± 0.8	1.000	-0.14 (-0.50, 0.21)	1.000	0.00 (0.00, 0.00)	1.000	0.14 (-0.31, 0.60)	1.000	0.16 (-0.46, 0.78)	1.000	0.29 (-0.26, 0.85)	1.000	0.13 (-0.55, 0.81)
Strength	3.8 ± 0.7	3.9 ± 0.6	3.7 ± 0.9	3.9 ± 0.7	1.000	-0.14 (-0.50, 0.21)	1.000	0.14 (-0.40, 0.68)	1.000	-0.14 (-0.60, 0.31)	1.000	0.28 (-0.34, 0.91)	1.000	0.00 (-0.55, 0.55)	1.000	-0.25 (-0.94, 0.43)
Speed–agility	3.6 ± 0.8	3.7 ± 0.8	3.6 ± 0.8	3.7 ± 0.7	1.000	-0.12 (-0.48, 0.23)	1.000	0.00 (0.00, 0.00)	1.000	-0.13 (-0.58, 0.33)	1.000	0.12 (-0.50, 0.74)	1.000	0.00 (-0.55, 0.55)	1.000	-0.13 (-0.82, 0.55)
Flexibility	3.3 ± 0.9	3.4 ± 0.9	3.2 ± 1.0	3.1 ± 0.8	1.000	-0.11 (-0.46, 0.24)	1.000	0.11 (-0.43, 0.65)	1.000	0.22 (-0.23, 0.68)	1.000	0.21 (-0.41, 0.84)	1.000	0.34 (-0.21, 0.90)	1.000	0.11 (-0.57, 0.80)

Values are the mean ± standard deviation. The four groups were based on the cut-off score of 24 on the Exercise Addiction Inventory at pre- and post-competition (for example, non-risk of exercise addiction participants scored below criteria on both measurements).
[a]Missing data. Reasons: data were unreasonably high and excluded from analysis according to the Guidelines for Data Processing and Analysis of the International Physical Activity Questionnaire (non-risk (n = 23), transient (n = 7), emerging (n = 2), persistent (n = 1)).
CI: confidence intervals, CRF: cardiorespiratory fitness, *d*: Cohen's standardized effect size adjusted by correcting for small sample bias, MET: metabolic equivalent of task, QoL: quality of life, SAU: standard alcohol units, SD: standard deviation.
One-way ANOVA with Bonferroni post hoc test and Cohen's *d* were used to compare data; significant *p*-values and minimally important differences are in bold; the thresholds of *p*- and *d*-values were set at 0.003 (0.050/18) and 0.50, respectively.

Table 4. Within- and between-group comparisons of the change in amteur endurance cyclists from pre- to 6-month post-competition.

Variables	Wiithin-group comparisons								Between-group comparisons											
	Non-risk (n = 261)		Transient (n = 35)		Emerging (n = 14)		Persistent (n = 20)		Non-risk vs Transient		Non-risk vs Emerging		Non-risk vs Persistent		Transient vs Emerging		Transient vs Persistent		Emerging vs Persistent	
	p	*d* (95%CI)	*p*	*d* (95%CI)	*p*	*d* (95%CI)	*p*	*d* (95%CI)	*p*	*d* (95%CI)	*p*	*d* (95%CI)	*p*	*d* (95%CI)	*p*	*d* (95%CI)	*p*	*d* (95%CI)	*p*	*d* (95%CI)
Training volume (km/month)	**<0.001**	**-1.01 (-1.15, -0.86)**	**<0.001**	**-1.13 (-1.61, -0.68)**	**0.002**	**-0.94 (-1.58, -0.41)**	**0.002**	**-0.67 (-1.19, -0.20)**	1.000	0.10 (0.46, -0.25)	1.000	-0.17 (0.37, -0.71)	1.000	-0.30 (0.16, -0.75)	1.000	-0.29 (-0.91, 0.34)	1.000	-0.41 (0.14, -0.97)	1.000	-0.15 (0.53, -0.84)
Training volume (h/wk)	**<0.001**	**-1.20 (-1.39, -1.05)**	**<0.001**	**-1.35 (-1.86, -0.88)**	**0.001**	**-1.10 (-1.91, -0.41)**	0.003	**-0.67 (-1.23, -0.14)**	1.000	0.13 (0.48, -0.22)	0.258	-0.18 (0.36, -0.72)	1.000	-0.46 (-0.01, -0.92)	0.328	-0.34 (-0.96, 0.29)	1.000	**-0.59 (-0.03, -1.15)**	1.000	-0.32 (0.37, -1.01)
Training frequency (d/wk)	**<0.001**	**-0.73 (-0.85, -0.56)**	**<0.001**	**-0.89 (-1.27, -0.54)**	**0.002**	**-0.93 (-1.82, -0.13)**	**0.001**	**-0.92 (-1.59, -0.30)**	1.000	0.18 (0.54, -0.17)	0.028	0.21 (0.75, -0.33)	1.000	0.13 (0.59, -0.32)	0.108	0.03 (-0.59, 0.65)	1.000	-0.05 (0.50, -0.60)	0.760	-0.08 (0.60, -0.76)
Exercise addiction (6-30)	0.004	-0.20 (-0.35, -0.06)	**<0.001**	-1.96 (-2.65, -1.35)	**<0.001**	2.88 (1.80, 4.30)	0.954	-0.03 (-0.58, 0.51)	**<0.001**	**1.48 (1.86, 1.11)**	**<0.001**	**-1.62 (-1.06, -2.17)**	**<0.001**	-0.19 (0.26, -0.65)	1.000	**-6.73 (-8.20, -5.26)**	**<0.001**	**-3.70 (-2.81, -4.58)**	0.024	**2.77 (3.71, 1.82)**
Physical activity (MET-min/wk)[a]	**<0.001**	**-0.94 (-1.12, -0.76)**	0.004	**-0.73 (-1.25, -0.23)**	**<0.001**	**-1.15 (-2.02, -0.41)**	**0.002**	**-0.74 (-1.46, -0.07)**	1.000	-0.26 (0.13, -0.65)	1.000	0.43 (1.01, -0.15)	0.177	-0.01 (0.45, -0.48)	1.000	**0.62 (-0.07, 1.31)**	1.000	0.24 (0.82, -0.35)	0.455	-0.37 (0.36, -1.10)
Smoking dependence (0-16)	0.250	0.08 (-0.13, 0.13)	1.000	Error	1.000	Error	0.026	Error	1.000	0.10 (0.45, -0.26)	1.000	0.09 (0.63, -0.45)	1.000	**-0.56 (-0.10, -1.01)**	1.000	Error	1.000	Error	1.000	Error
Alcohol use (SAU/wk)	**<0.001**	0.24 (0.16, 0.33)	**0.003**	0.45 (0.17, 0.74)	0.541	-0.09 (-0.28, 0.09)	0.026	0.49 (0.04, 0.97)	1.000	-0.12 (0.23, -0.48)	1.000	0.39 (0.93, -0.15)	1.000	-0.11 (0.34, -0.57)	1.000	**0.55 (-0.08, 1.18)**	1.000	0.02 (0.57, -0.53)	1.000	**-0.51 (0.18, -1.20)**
Physical QoL (0-100)	0.250	-0.09 (-0.26, 0.04)	0.015	-0.37 (-0.75, 0.00)	0.610	-0.13 (-1.01, 0.75)	0.430	-0.17 (-0.69, 0.34)	0.460	0.45 (0.80, 0.10)	0.387	0.09 (0.63, -0.45)	1.000	0.14 (0.60, -0.31)	0.055	-0.29 (-0.91, 0.33)	0.789	-0.23 (0.32, -0.78)	1.000	0.04 (0.72, -0.64)
Mental QoL (0-100)	**<0.001**	0.24 (0.11, 0.36)	**0.001**	**0.52 (0.20, 0.86)**	0.171	-0.29 (-0.95, 0.35)	0.343	0.19 (-0.29, 0.69)	**0.001**	-0.38 (-0.03, -0.74)	1.000	**0.71 (1.25, 0.16)**	0.933	0.02 (0.47, -0.44)	1.000	**0.91 (0.26, 1.55)**	1.000	0.32 (0.87, -0.24)	1.000	**-0.59 (0.11, -1.28)**
Sleep quality (0-21)	**<0.001**	-0.23 (-0.33, -0.12)	**0.001**	**-0.50 (-0.89, -0.12)**	0.182	0.21 (-0.26, 0.70)	0.435	-0.11 (-0.42, 0.19)	0.021	0.24 (0.59, -0.12)	1.000	**-0.56 (-0.02, -1.10)**	0.290	-0.09 (0.36, -0.55)	1.000	**-0.72 (-1.36, -0.08)**	1.000	-0.29 (0.26, -0.85)	1.000	0.38 (1.07, -0.31)
Anxiety (0-21)	0.109	0.05 (-0.06, 0.16)	0.779	0.05 (-0.34, 0.43)	0.302	0.20 (-0.24, 0.67)	0.267	-0.24 (-0.59, 0.10)	0.550	0.05 (0.40, -0.31)	1.000	-0.17 (0.37, -0.71)	1.000	0.33 (0.79, -0.12)	1.000	-0.21 (-0.83, 0.41)	1.000	0.27 (0.82, -0.28)	1.000	**0.51 (1.20, -0.19)**
Depression (0-21)	**<0.001**	**0.50 (0.35, 0.64)**	0.836	-0.05 (-0.60, 0.50)	0.191	0.39 (-0.28, 1.09)	0.056	**0.53 (-0.05, 1.13)**	0.012	**0.59 (0.95, 0.24)**	0.480	0.08 (0.61, -0.46)	0.763	-0.03 (0.43, -0.48)	1.000	**-0.51 (-1.14, 0.12)**	1.000	**-0.65 (-0.09, -1.22)**	1.000	-0.10 (0.58, -0.78)
Body mass index (kg/m^2)	0.006	0.08 (0.03, 0.13)	0.010	0.14 (0.02, 0.27)	0.133	0.19 (0.03, 0.38)	0.598	-0.03 (-0.10, 0.04)	1.000	-0.10 (0.25, -0.46)	1.000	-0.09 (0.45, -0.63)	1.000	0.11 (0.57, -0.34)	1.000	0.01 (-0.61, 0.63)	1.000	0.18 (0.73, -0.37)	1.000	0.17 (0.85, -0.52)
Fitness (1-5)																				
Overall	0.011	-0.17 (-0.28, -0.05)	0.032	-0.29 (-0.69, 0.09)	0.670	-0.13 (-0.61, 0.34)	0.076	-0.38 (-0.85, 0.07)	1.000	0.20 (0.55, -0.16)	1.000	-0.05 (0.49, -0.59)	1.000	0.24 (0.69, -0.22)	1.000	-0.20 (-0.82, 0.42)	1.000	0.02 (0.57, -0.52)	1.000	0.28 (0.96, -0.41)
CRF	0.020	-0.14 (-0.25, -0.03)	0.798	0.04 (-0.34, 0.41)	0.107	-0.40 (-0.92, 0.08)	0.499	-0.12 (-0.42, 0.18)	1.000	-0.18 (0.17, -0.53)	1.000	0.27 (0.81, -0.27)	1.000	0.00 (0.45, -0.45)	1.000	0.38 (-0.24, 1.01)	1.000	0.15 (0.70, -0.40)	1.000	-0.24 (0.44, -0.93)
Strength	0.023	-0.14 (-0.25, -0.04)	0.076	-0.25 (-0.50, -0.02)	0.640	0.08 (-0.22, 0.38)	0.695	0.07 (-0.33, 0.48)	1.000	0.13 (0.48, -0.22)	1.000	-0.22 (0.32, -0.75)	1.000	-0.19 (0.27, -0.64)	0.866	-0.34 (-0.96, 0.29)	1.000	-0.33 (0.22, -0.89)	1.000	0.03 (0.71, -0.65)
Speed–agility	0.004	-0.27 (-0.38, -0.15)	0.313	-0.15 (-0.45, 0.13)	1.000	0.00 (-0.39, 0.39)	0.738	-0.07 (-0.59, 0.44)	1.000	-0.01 (0.34, -0.37)	1.000	-0.17 (0.37, -0.70)	1.000	-0.10 (0.36, -0.55)	1.000	-0.17 (-0.79, 0.45)	1.000	-0.10 (0.45, -0.65)	1.000	0.08 (0.77, -0.60)
Flexibility	0.848	0.00 (-0.08, 0.08)	0.602	0.06 (-0.24, 0.38)	0.409	-0.14 (-0.52, 0.22)	0.730	0.06 (-0.22, 0.34)	1.000	-0.05 (0.30, -0.41)	1.000	0.16 (0.70, -0.38)	1.000	-0.04 (0.41, -0.50)	1.000	0.23 (-0.39, 0.85)	0.914	0.01 (0.56, -0.54)	1.000	-0.22 (0.47, -0.90)

Values are the mean ± standard. The four groups were based on the cut-off score of 24 on the Exercise Addiction Inventory at pre- and post-competition (for example, non-risk of exercise addiction participants scored below criteria on both measurements).

[a]Missing data. Reasons: data were unreasonably high and excluded from analysis according to the Guidelines for Data Processing and Analysis of the International Physical Activity Questionnaire (non-risk (n = 23), transient (n = 7), emerging (n = 2), persistent (n = 1)).

CI: confidence intervals, CRF: cardiorespiratory fitness, *d*: Cohen's standardized effect size adjusted by correcting for small sample bias, MET: metabolic equivalent of task, QoL: quality of life, SAU: standard alcohol units, SD: standard deviation.

Repeated measures ANOVA with Bonferroni post hoc test and Cohen's *d* were used to compare continuous data; significant *p*-values and minimally important differences are in bold; the thresholds of *p*- and *d*-values were set at 0.002 (0.050/25) and 0.50, respectively

Title

Exercise addiction stability and health effects. A 6-month follow-up post-competition study in amateur endurance cyclists.

Authors (all PhDs)

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Abstract

Objective. To study the longitudinal stability of exercise addiction and its health effects in apparently healthy amateur endurance cyclists from pre- to 6-month post-competition.

Methods. In total, 330 (30 women) adult cyclists were divided into four groups based on scores on the Exercise Addiction Inventory at both periods: non-risk (n = 262, 79.1%), transient (n = 35, 10.6%), emerging (n = 14, 4.2%) and persistent (n = 20, 6.1%).

Results. The prevalence of high-risk exercise addiction was reduced post-competition (16.7% vs. 10.3%, p = 0.017). Of the cyclists with a high pre-competition risk of exercise addiction, 63.6% (35/55) had a transient addiction associated with favourable effects on mental quality of life (effect size [ES] = 0.52, 95%CI: [0.20, 0.86[) and sleep quality (ES = −0.50 [-0.89, −0.12]) and avoided the worsening of depression symptom severity compared to the remaining groups (ES range = 0.51–0.65). The 5.1% (14/275) of cyclists with a pre-competition low risk of exercise addiction presented emerging exercise addiction that was associated with a worsened mental quality of life compared to the remaining groups (ES ranged 0.59-0.91), sleep quality compared to the non-risk (ES = −0.56 [−0.02, −1.10]) and transient (ES = −0.72 [-1.36, −0.08]) groups and anxiety symptom severity compared to the persistent group (ES = 0.51 [1.20, −0.19]).

Conclusions. Exercise addiction had a marked transitory component at 6-month post-competition with associated health benefits in amateur endurance cyclists.

Keywords: exercise addiction; cycling; health; competition; transient; persistent.

INTRODUCTION

A plethora of scientific evidence[1] has consistently demonstrated that physical exercise prevents and treats multiple diseases. However, excessive levels of exercise may be harmful and lead to exercise addiction, defined as "a morbid pattern of behaviour in which the habitually exercising individual loses control over his or her exercise habits and acts compulsively, exhibits dependence and experiences negative consequences to health as well as in his or her social and professional life"[2]. Many researchers claim that exercise addiction should be listed as a mental disorder in diagnostic manuals, but the accumulated literature is still scarce and limited by a lack of conceptual and methodological consistency.[3]

A major limitation in the research on exercise addiction is that almost all of the studies have a cross-sectional design, which limits our knowledge of the stability of exercise addiction and its health effects. To the best of our knowledge, there is only a longitudinal study[4] on "primary exercise addiction"[3], in which exercise addiction manifests a form of behavioural addiction, that did not analyse the health effects and a few longitudinal studies[5–11] on "secondary exercise addiction"[3], in which exercise addiction often emerges as a consequence of the own disorder (in this case eating disorder), and measured compulsive exercise rather than exercise addiction, a more appropriate term that includes both dependence and compulsion.[3] Therefore understanding the stability of exercise addiction and its health effects is thus both a challenge and an opportunity for the public health and scientific community.

A key factor for improving our knowledge of the longitudinal stability of exercise addiction and its health effects is developing scientific studies in practitioners of specific sport disciplines potentially associated with an increased risk of exercise addiction. A recent systematic review[12] established that endurance sports (e.g. cycling) were associated with a higher risk of exercise addiction than power (e.g. weightlifting), mixed (e.g. soccer) and health and fitness disciplines. Longer-distance endurance sports also have an increased risk of exercise addiction/dependence compared to shorter-distance endurance sports.[13–15]

Amateur endurance cycling is a long-distance endurance sport that gathers thousands of practitioners in competitive events characterized by high physical and psychological demands concentrated in a short space of time, which may be linked with an increased risk of exercise addiction pre-competition.

However, the large reduction in exercise training loads post-competition may be linked with a decreased risk of exercise addiction. This study sought to evaluate the changes in exercise addiction and its health effects in amateur endurance cyclists from pre- to post-competition. Considering the aforementioned characteristics of this sport and the possible influence of obsessive passion (which is closely linked to exercise addiction[4,16]), we hypothesized a reduction in the risk of exercise addiction post-competition. Based on the results of a recent cross-sectional study in amateur endurance cyclists[17], we hypothesized that the reduction of the risk of exercise addiction could be associated with better mental health, sleep quality and decreased anxiety symptom severity.

METHODS

Participants

This longitudinal study was part of a research project focused on exploring the association between cycling and health through a web-based experiment on a freely available webpage. This study included apparently healthy respondents aged 18–65 years who were classified as cyclists in May (the period prior to the participation in their main cycling event; hereafter 'pre-competition') and completed the survey again in November (6 months after the cycling event; hereafter 'post-competition'). Individuals were defined as apparently healthy if they self-reported no psychiatric (including eating disorders), pulmonary, musculoskeletal, heart or cancer disease at pre-competition. Individuals with self-reported obesity, hypertension, diabetes and/or dyslipidaemia were included in the study. Cyclists were considered those who reported being amateur endurance outdoor cyclists, engaged in cycling training for a minimum of 7 hours/week, had at least one year of cycling training experience and the intention to participate in May–June road cycling (>100 km) or mountain bike (> 45 km) events. The characteristics of participants are illustrated in Table 2.

Ethics

The protocol was approved by the Committee on Biomedical Ethics of the Aragon Government (PI17/0252). The invitation included a brief introduction to the study, an explanation of the anonymous and voluntary nature of participation in the study and a link to the survey. At the end of the experiment, individuals needed to provide informed consent for the scientific use of the data and provide an email address to receive the results.

Procedure

An invitation to participate in the study was sent via e-mail to the representatives of the 3,426 cycling clubs integrated into the Royal Spanish Cycling Federation in 2016. The study was also made known through media coverage, including on TV and through social media such as Twitter, Facebook and LinkedIn. The experiment included questions on health behaviours and health status and took an average of 40 minutes to complete. Data were collected in the last week of May and November from 2016 to 2018, using the same procedure throughout the study period. To avoid duplicate samples, cases that contained the same email address were eliminated. In 2017 and 2018 we included a warning message before starting the experiment to indicate that those who had already completed the survey should not do so again. Data analysis was conducted in May 2020. There was no compensation for participation.

Measures

Exercise addiction

The risk of exercise addiction was measured with the Spanish version[18] of the Exercise Addiction Inventory[19], which has satisfactory psychometric properties (α value = 0.70 and ICC = 0.92)[18]. The inventory, which can be found in the aforementioned free full-text articles, is composed of six items with 5-point Likert scale responses (1 = strongly disagree, 5 = strongly agree), scores ≥24 indicate a high risk of addiction. Participants were divided into four groups based on the cut-off of 24 on the Exercise Addiction Inventory at pre- and post-competition: non-risk of exercise addiction if scoring below criteria on both measurements, transient risk if scoring ≥24 only pre-competition, emerging risk if scoring ≥24 only post-competition and persistent risk if scoring ≥24 on both measurements.

Health behaviours

The cycling training variables were volume (km/month and hours/week) and frequency (days/week) in the last month and experience (years). Physical activity was measured with the Spanish short-form version of the International Physical Activity Questionnaire[20] by totalling the walking, moderate- and vigorous-intensity activities and expressing the result in metabolic equivalent of task-min/week. Smoking dependence was evaluated with the Spanish version[21] (α value = 0.66) of the revised version of the Fagerström Test for Nicotine Dependence[22], with lower scores indicating lower levels of

dependence. Alcohol use was calculated by transforming the volume of beer, wine and spirits consumed in the last week into standard alcohol units[23], with lower units indicating lower levels of alcohol consumption.

Health status

Quality of life was measured with the Spanish version[24] of the 12-Item Health Survey 2.0[25], which examines eight domains constituting the physical and mental component summary scores (α = 0.85 for the physical component and 0.78 for the mental component), with higher scores indicating better quality of life. Sleep Quality was assessed with the Spanish version[26] (α values ranged from 0.67 for students and to 0.81 for clinical population) of the Pittsburgh Sleep Quality Index[27], which examines seven sleep components that yield a global score, with lower scores indicating better sleep quality. Anxiety and depression symptom severity were separately evaluated with the Spanish version[28] (α = 0.85 for the anxiety subscale and 0.84 for the depression subscale) of the Hospital Anxiety and Depression Scale[29], with lower scores indicating lower symptom severity. Body mass index was calculated using weight and height. The Spanish version of the International Fitness Scale[30] was used to measure the physical fitness level (overall and specific components: cardiorespiratory fitness, muscular strength, speed-agility, and flexibility). Individuals were asked how they perceived their own level compared with their friends' physical fitness using a 5-point Likert scale (very poor = 1, poor = 2, average = 3, good = 4, and very good = 5).

Sociodemographic data

Sex, age, educational status, occupational status, marital status and number of children were determined.

Statistical Analysis

Categorical data were compared by the chi-square test using the Two-Proportions tab of Chapters 10–16 of the Exploratory Software for Confidence Intervals (freely available on the website.[31] The following analyses were performed using SPSS Statistics for Windows, Version 22.0 (IBM Corp, Armonk, NY, USA). The between-group comparisons of pre- and post-competition continuous data were performed using one-way ANOVA followed by a Bonferroni post hoc test. The within- and between-group comparisons of the longitudinal change in continuous data were performed using a

four group (Non-risk/Persistent/Emerging/Persistent) × two time (pre-/post-competition) repeated measures ANOVA, followed by a Bonferroni post hoc test. To minimize the risk of type I statistical error, adjustments for multiple comparisons were made using Bonferroni's method by dividing the significance level of 0.050 by the number of comparisons.

The comparisons of continuous data were also assessed using an approach based on the standardized effect size, with the Cohen's *d* adjusted by correcting for small sample bias, also known as Hedges' *g*, and associated 95% confidence intervals using a free online effect size calculator.[32] For each case, the Cohen's *d* was calculated as follows: (i) between-group (pre-competition): the difference between the mean pre-competition values of two groups divided by the pooled pre-competition standard deviation of these two groups; (ii) between-group (post-competition): the difference between the mean post-competition values of two groups divided by the pooled post-competition standard deviation of these two groups; (iii) between-group (change): the difference between the mean change from the pre- to post-competition measurements of the two groups divided by the pooled pre-competition standard deviation of these two groups; and (iv) within-group: the mean change from the pre- to post-competition measurements divided by the average standard deviation of both repeated measures. The formulae for estimation of Cohen's *d* and associated 95% confidence intervals are available on GitHub.[33] A Cohen's *d* ≥ 0.50 was considered a minimally important difference.[34]

RESULTS

A participant flow diagram is shown in Figure 1, and the main results of the risk of exercise addiction are presented in Table 1. Overall, the exercise addiction score and the prevalence of a high risk of exercise addiction were reduced at post-competition. Of those who had high risk at pre-competition, 63.3% presented transient exercise addiction, while only 5.1% of those with a low risk of exercise addiction at pre-competition presented emerging exercise addiction. All results were similar for men and women.

The pre- and post-competition characteristics of the participants (divided into four groups based on exercise addiction scores at both periods) are presented in Tables 2 and 3, respectively. At pre-competition, one-way ANOVA showed between-group differences in the exercise addiction score ($F_{(3, 326)} = 89.5$, $p < 0.001$; $\eta_p^2 = 0.45$), mental quality of life ($F_{(3, 326)} = 7.3$, $p < 0.001$; $\eta_p^2 = 0.06$) and

depression symptom severity ($F_{(3, 326)} = 7.2$, $p < 0.001$; $\eta_p^2 = 0.06$). Paired-group comparisons showed that the non-risk group reported lower exercise addiction scores than the three remaining groups. The emerging group reported higher training frequency than the three remaining groups and lower exercise addiction scores than the transient and persistent groups. The transient group had better physical quality of life and worse mental quality of life and sleep quality than the non-risk and emerging groups, as well as higher depression symptom severity than the non-risk and persistent groups and higher muscular strength than the emerging group. At post-competition, one-way ANOVA showed between-group differences in exercise addiction score ($F_{(3, 326)} = 64.5$, $p < 0.001$; $\eta_p^2 = 0.37$). Paired-group comparisons showed that the non-risk group reported lower exercise addiction scores than the three remaining groups. The emerging group had higher weekly training hours and frequency than the non-risk and transient groups, as well as worse mental quality of life and sleep quality than the non-risk group. The transient group had lower exercise addiction scores than the emerging and persistent groups. The persistent group had higher level of physical activity than the emerging group.

Within- and between-group comparisons of the change from pre- to post-competition are shown in Table 4. Repeated measures ANOVA showed a group × time interaction in exercise addiction score ($F_{(3, 326)} = 27.04$, $p < 0.001$; $\eta_p^2 = 0.20$). Paired-group comparisons showed that the transient group reported a higher reduction of weekly training hours than the persistent group. The emerging group had a higher reduction of weekly physical activity than the transient group, worsened mental quality of life compared with the three remaining groups, increased anxiety symptom severity compared with the persistent group, and worsened sleep quality compared with the non-risk and transient groups. Alcohol use increased in the transient and persistent groups compared with the emerging group. The non-risk, emerging and persistent groups showed increased depression symptom severity compared to the transient group.

DISCUSSION

Three major findings can be highlighted. First, the prevalence of a high risk of exercise addiction in amateur endurance cyclists was reduced from 16.7% to 10.3% over the 6-month follow-up from the competitive cyclist period, and 6.1% and 10.6% of cyclists exhibited persistent and transient exercise addiction, respectively. Second, the transient group showed improved mental quality of life and sleep quality and avoided the worsening of depression symptom severity compared to the remaining

exercise addiction groups. Third, the emerging group showed worsened mental quality of life compared to the remaining groups, sleep quality compared to the non-risk and transient groups and anxiety symptom severity compared to the persistent group.

Our findings showing that the mean score of exercise addiction risk changed from pre- to 6-month post-competition in adult endurance amateur cyclists are consistent with the previous longitudinal study on primary exercise addiction,[4] that analysed the change 12 weeks after starting up a new sport in students and using the Exercise Addiction Inventory, and with all the aforementioned studies[5–11] on compulsive exercise conducted in people with eating disorders. These findings suggest that exercise addiction (and compulsive exercise) seems to be a modifiable risk factor and may encourage exercise and health professionals to seek increasingly appropriate treatments.

Given that the previous longitudinal study on primary exercise addiction[4] did not report the number of individuals at-risk and those not at-risk for exercise addiction, our results on the prevalence of persistent and transient exercise addiction were compared with those of two longitudinal studies[9,10] that reported results on the prevalence of persistent and transient compulsive exercise in people with eating disorders from treatment to 1-year follow-up. Specifically, the prevalence rates of persistent exercise addiction in cyclists (men = 6.0% and women = 6.7%) were lower than those for persistent compulsive exercise found in adults (men = 15.8% and women = 18.8%)[9] and adolescents (girls = 14.0%)[10] with eating disorders. Similarly, the prevalence rates of transient exercise addiction among cyclists (men = 10.7% and women = 10.0%) were lower than those of persistent compulsive exercise found among adults (men = 26.7% and women = 30.2%)[9] and adolescents (girls = 32.0%)[10] with eating disorders. Although exercise addiction and compulsive exercise do not reflect the same phenomenon[3], the lower rates found in our study may be due to people with eating disorders being 3.5 times more likely to have an exercise addiction than those without eating disorders.[35] Considering the high impact of eating disorders on exercise addiction, studies in other healthy populations are necessary to better contextualize our results.

Our finding that approximately two-thirds of cyclists (men = 64.0% and women = 60.0%) with a high risk of exercise addiction at baseline had transient exercise addiction is consistent with the results of the aforementioned studies in adults (men = 59.2% and women = 62.3%)[9] and adolescents (girls = 69%)[10] with eating disorders. The elevated degree of variability for high risk of exercise addiction

suggests the need to re-evaluate the risk of exercise addiction in people at high risk to detect potentially real cases of exercise addiction (i.e. those with persistent exercise addiction) that would require a confirmatory diagnostic interview with specialized professionals. The low percentage of cyclists (men = 5.2% and women = 4.0%) with a low risk of exercise addiction at baseline who had emerging exercise addiction was slightly lower than in adults (men = 10.3% and women = 12.9%)[9] and adolescents (girls = 17%)[10] with eating disorders, which suggests that the re-evaluation of the risk of addiction to exercise in people at low risk to detect potentially new cases of exercise addiction would be few efficient due to the reduced variability of the low risk of exercise addiction. In these individuals it might be more convenient to re-evaluate the risk of exercise addiction after a longer period of time.

The results that the transient exercise addiction group avoided an increase in depression symptom severity compared to the remaining groups could be due to a possible ceiling effect, because it reported higher values at pre-competition. Another interesting result for the transient group is the greater reduction in the number of weekly cycling training hours compared to the persistent group, which suggests the importance of deeply reducing the training volume to reduce the level of exercise addiction in people at high risk of exercise addiction. This is somewhat coherent, but there is no longitudinal data to prove it to date. Despite the reduction, the transient group did not reach the exercise addiction score of the non-risk group at post-competition, which suggests an incomplete recovery of the exercise addiction levels that could be associated with possible relapses in the high risk of exercise addiction. Additionally, the result that the transient and persistent groups increased alcohol consumption compared to the emerging group could reflect a compensatory effect in both groups by reducing the amount of physical exercise performed. In the transient group it could also reflect a substitution of one addiction for another, as has been shown for other addictions such as methadone.[36] follow-up studies analysing possible relapses for high risk of exercise addiction and the start of new addictions such as high alcohol consumption in amateur endurance cyclists with transient exercise addiction may be pertinent to verify our results.

Finally, the result that the emerging exercise addiction group showed worsened mental quality of life, sleep quality and anxiety symptom severity is somewhat expected because they are characteristic symptoms of exercise addiction[3] with accumulated evidence in cross-sectional studies that used the Exercise Addiction Inventory in habitual exercisers[38,39], gym users[40] and amateur endurance outdoor cyclists.[17] These findings underscore the importance of promoting good sports practices in endurance

cycling to reduce the likelihood of the onset of exercise addiction and its associated negative health effects.

Implications for practice

The current study could help raise awareness among health professionals of the importance of considering exercise addiction as a health risk factor in amateur endurance cyclists, with a marked transitory component as a result of the proximity of a competitive event. It may also encourage the scientific community to research the changes in exercise addiction and its health effects in other sport disciplines and/or during other seasonal periods. Our study extends the previous knowledge for amateur endurance cyclists[17] by including four groups of risk of exercise addiction (non-risk, emerging, transient and persistent) instead of two groups (low and high risk), which allows us to identify possible indicators of the change in exercise addiction risk (i.e. transient and emerging) that should be considered when designing trials. According to our results, amateur endurance cyclists with a high risk of exercise addiction (i.e. score ≥24 on the Exercise Addiction Inventory) and higher depression symptom severity may be more likely to have a transient exercise addiction. Those with a low risk of exercise addiction (i.e. score below 24 on the Exercise Addiction Inventory) with a higher score for exercise addiction and training frequency may be more likely to have a emerging exercise addiction. However, our findings require more research with more robust analysis before they can be applied in a more generalized way.

Limitations and Strengths

While this study is the first to measure the change in risk of exercise addiction and its health effects in an apparently healthy population, the findings should be considered within the limitations of this study. First, the study was based on self-reported data, which can involve bias. The findings are limited by the low statistical power due to the small sample size of all groups ($n \leq 35$) except for the non-risk group ($n = 261$). These aspects could explain why we only found a group × time interaction, specifically in the risk of exercise addiction, an expected result because the groups were created based on the changes over time in this variable. There was a disproportionate participation of men (90.1%), although this represents the current situation in Spain for the proportion of men and women participating in endurance cycling events. There was considerable attrition in the follow-up assessment (61.6%). There was also a lack of information on participant lifestyle and cycling habits

during the 6-month follow-up, which may have affected changes in the risk of exercise addiction and health. Despite using emails as a control method for eliminating duplicate participants, there was no control over duplicates or double participation because a person might have more than one email address. There was also no control over respondents and demographic characteristics. Finally, the Exercise Addiction Inventory may not adequately reflect the level of exercise addiction in athletes participating in sport competitions, as suggested by De La Vega et al.[16] and Szabo et al.[2] Future studies should include items on obsessive passion and dedication, because high scores for exercise addiction in passionate and dedicated athletes may represent a "false alarm". Therefore, failing to assess passion and dedication was a major limitation of the current work.

Despite these limitations, this study has several strengths. The Internet-based design of the study, media coverage and anonymous participation prevented missing data,[41] as well as increasing access to more potential participants and may have encouraged individuals to respond to personal questions.[42] Furthermore, well-established, validated and reliable tools that apply norm-based scoring methodology were used.

CONCLUSIONS

The prevalence of amateur endurance cyclists with a high risk of exercise addiction fell from 16.7% at pre-competition to 10.3% at 6-month post-competition, and 6.1% and 10.6% of cyclists exhibited persistent and transient exercise addiction, respectively. The decreased risk of exercise addiction observed in the transient group was associated with favourable effects on mental quality of life, sleep quality and depression symptom severity. The increased risk of exercise addiction observed in the emerging group was associated with unfavourable effects on mental quality of life, sleep quality and anxiety symptom severity.

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Figure 1. Participants flow diagram.

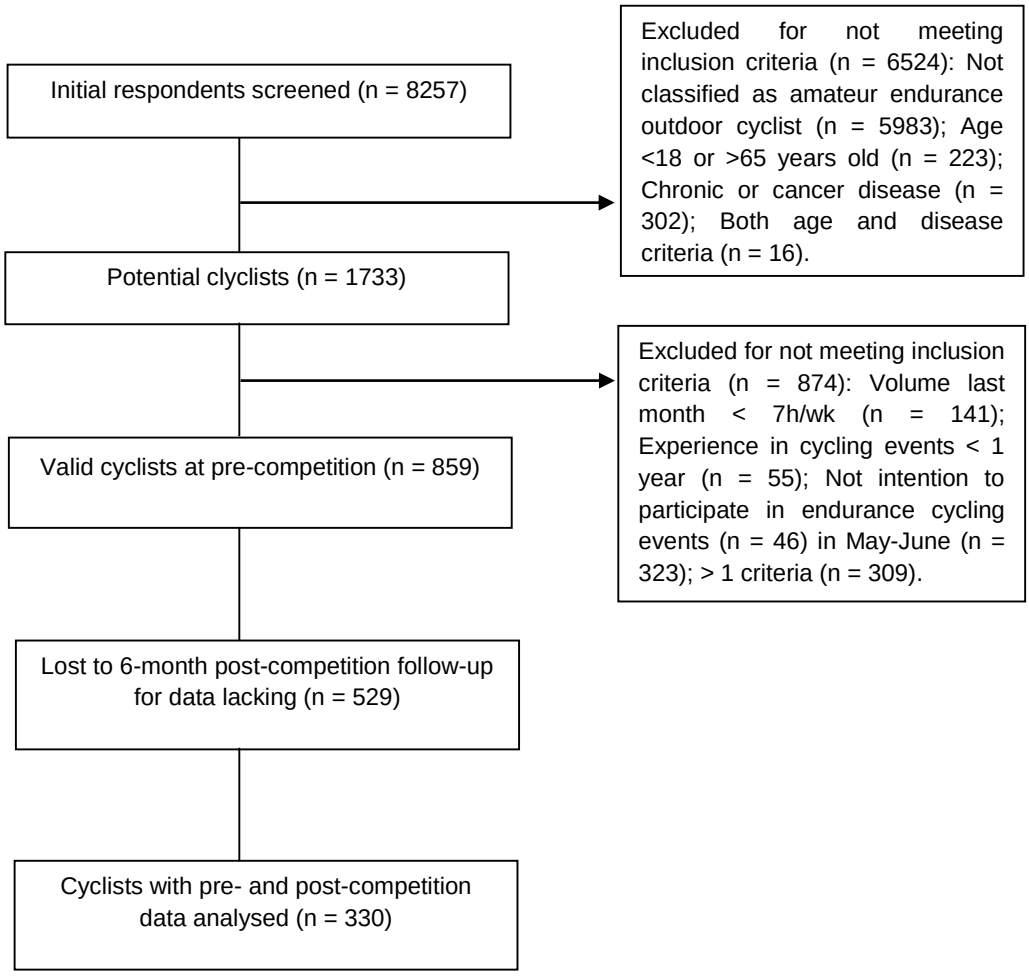

Table 1. Main results of the risk of exercise addiction in amateur endurance cyclists at pre- and post-competition.

	All (n = 330)		Men (n = 300)		Women (n = 30)	
	n	Mean ± SD	n	Mean ± SD	n	Mean ± SD
Score of exercise addiction risk (6-30)						
Pre-competition	330	19.3 ± 4.2	300	19.3 ± 4.2	30	19.6 ± 4.3
Post-competition	330	18.3 ± 4.2	300	18.3 ± 4.2	30	18.8 ± 4.4
p		**< 0.001**		**< 0.001**		0.420
d (95%CI)		0.24 (0.13, 0.35)		0.23 (0.11, 0.34)		0.18 (-0.24, 0.61)
	n	% (95%CI)	n	% (95%CI)	n	% (95%CI)
Prevalence of high exercise addiction risk						
Pre-competition	55	16.7 (13.0, 21.1)	50	16.7 (12.9, 21.3)	5	16.7 (7.3, 33.6)
Post-competition	34	10.3 (7.5, 14.1)	31	10.3 (7.4, 14.3)	3	10.0 (3.5, 25.6)
p		**0.017**		**0.023**		0.448
Varaibility of exercise addiction risk						
Non-risk [low-low]	261	79.1 (74.4, 83.1)	237	79.0 (74.0, 83.2)	24	80.0 (62.7, 90.5)
Transient [high-low]	35	10.6 (7.7, 14.4)	32	10.7 (7.7, 14.7)	3	10.0 (3.5, 25.6)
Emerging [low-high]	14	4.2 (2.5, 7.0)	13	4.3 (2.5, 7.3)	1	3.3 (0.6, 16.7)
Persistent [high-high]	20	6.1 (4.0, 9.2)	18	6.0 (3.8, 9.3)	2	6.7 (1.8, 21.3)
	n/N	% (95%CI)	n	% (95%CI)	n	% (95%CI)
Variability of high and low exercise addiction risk						
Transient/High-risk at Pre-	35/55	63.6 (50.4, 75.1)	32/50	64.0 (50.1, 75.9)	3/5	60.0 (23.1, 88.2)
Emerging/Low-risk at Pre-	14/275	5.1 (3.1, 8.4)	13/250	5.2 (3.1, 8.7)	1/25	4.0 (0.7, 19.5)

Values are the mean ± standard deviation or n (%, 95%CI). Varaibility of risk of exercise addiction includes the four groups based on the cut-off score of 24 on the Exercise Addiction Inventory at pre- and post-competition (for example, non-risk of exercise addiction participants scored below criteria, i.e. low risk of exercise addiction, on both measurements).

CI: confidence intervals, *d*: Cohen's standardized effect size adjusted by correcting for small sample bias, SD: standard deviation.

Chi-square test was used to compare categorical data; unpaired t-test and Cohen's standardized effect size adjusted by correcting for small sample bias were used to compare continuous data; significant *p*-values and minimally important differences are in bold; the thresholds of *p*- and *d*-values were set at 0.025 (0.005/2) and 0.50, respectively.

Table 2. Characteristics of amateur endurance cyclists at pre-competition.

Variables	Descriptive data				Between-group comparisons											
	Non-risk (n = 261)	Transient (n = 35)	Emerging (n = 14)	Persistent (n = 20)	Non-risk vs Transient		Non-risk vs Emerging		Non-risk vs Persistent		Transient vs Emerging		Transient vs Persistent		Emerging vs Persistent	
					p	*d* (95%CI)	*p*	*d* (95%CI)	*p*	*d* (95%CI)	*p*	ES (95%CI)	*p*	*d* (95%CI)	*p*	*d* (95%CI)
Gender (women)	24 (9.2)	4 (11.4)	1 (7.1)	2 (10.0)	0.672		0.795		0.905		0.654		0.870		0.773	
Educational status (non-university studies)	118 (45.2)	18 (51.4)	6 (42.9)	7 (35.0)	0.488		0.863		0.376		0.588		0.239		0.239	
Occupational status (unemployed)	18 (6.9)	3 (8.6)	0 (0.0)	5 (25.0)	0.717		0.309		0.004		0.258		0.096		0.096	
Marital status (single)	23 (8.8)	1 (2.9)	0 (0.0)	0 (0.0)	0.226		0.246		0.166		0.523		0.446		0.446	
Number of children (≥1)	152 (58.2)	18 (51.4)	10 (71.4)	8 (40.0)	0.444		0.328		0.112		0.201		0.414		0.414	
Age (years)	40.2 ± 8.0	39.0 ± 7.8	40.9 ± 7.6	37.4 ± 10.2	1.000	0.15 (-0.20,0.50)	1.000	-0.08 (-0.62,0.46)	0.802	0.35 (-0.11,0.80)	1.000	-0.23 (-0.85,0.39)	1.000	0.18 (-0.37,0.73)	1.000	0.37 (-0.32,1.05)
Experience in cycling (years)	5.6 ± 5.3	6.5 ± 5.3	6.9 ± 4.9	4.9 ± 4.2	1.000	-0.18 (-0.53,0.18)	1.000	-0.24 (-0.77,0.30)	1.000	0.14 (-0.31,0.60)	1.000	-0.06 (-0.68,0.56)	1.000	0.34 (-0.22,0.89)	1.000	0.43 (-0.26,1.12)
Training volume (km/month)	1115.5 ± 484.6	1144.2 ± 483.6	1207.8 ± 347.7	1096.4 ± 409.1	1.000	-0.06 (-0.41,0.29)	1.000	-0.19 (-0.73,0.35)	1.000	0.04 (-0.41,0.49)	1.000	-0.14 (-0.76,0.48)	1.000	0.10 (-0.45,0.65)	1.000	0.28 (-0.40,0.97)
Training volume (h/wk)	11.5 ± 3.4	11.5 ± 3.3	12.8 ± 2.1	11.4 ± 3.4	1.000	-0.02 (-0.37,0.33)	0.831	-0.41 (-0.95,0.13)	1.000	0.03 (-0.42,0.49)	1.000	-0.42 (-1.05,0.20)	1.000	0.05 (-0.50,0.60)	1.000	0.48 (-0.21,1.18)
Training frequency (d/wk)	4.0 ± 1.2	4.2 ± 1.2	5.1 ± 0.9	4.4 ± 1.2	1.000	-0.12 (-0.47,0.24)	0.009	**-0.87 (-1.41,-0.33)**	1.000	-0.31 (-0.76,0.15)	0.105	**-0.80 (-1.44,-0.16)**	1.000	-0.19 (-0.74,0.36)	0.641	**0.60 (-0.09,1.30)**
Exercise addiction (6-30)	17.9 ± 3.4	25.4 ± 1.4	20.6 ± 1.8	25.7 ± 1.6	**<0.001**	**-2.29 (-2.69,-1.90)**	0.010	**-0.81 (-1.35,-0.27)**	**<0.001**	**-2.32 (-2.81,-1.83)**	**<0.001**	**3.11 (2.24,3.98)**	1.000	-0.18 (-0.73,0.37)	**<0.001**	**-2.89 (-3.86,-1.92)**
Physical activity (MET-min/wk)[a]	5832.3 ± 2517.7	6186.1 ± 2493.2	6099.5 ± 3382.7	6946.4 ± 2722.6	1.000	-0.14 (-0.53,0.25)	1.000	-0.10 (-0.68,0.48)	0.429	-0.44 (-0.91,0.03)	1.000	0.03 (-0.65,0.71)	0.746	-0.29 (-0.87,0.30)	1.000	-0.28 (-1.00,0.45)
Smoking dependence (0-16)	0.1 ± 0.6	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	1.000	0.17 (-0.19,0.52)	1.000	0.16 (-0.38,0.70)	1.000	0.16 (-0.29,0.62)	1.000	Error	1.000	Error	1.000	Error
Alcohol use (SAU/wk)	6.2 ± 9.6	4.9 ± 6.2	8.1 ± 13.7	3.7 ± 4.5	1.000	0.14 (-0.21,0.50)	1.000	-0.19 (-0.73,0.35)	1.000	0.27 (-0.19,0.72)	1.000	-0.35 (-0.98,0.27)	1.000	0.21 (-0.34,0.76)	1.000	0.45 (-0.24,1.15)
Physical QoL (0-100)	56.7 ± 4.3	58.9 ± 5.8	54.9 ± 5.0	56.6 ± 6.5	0.044	**-0.50 (-0.86,-0.15)**	0.978	0.41 (-0.13,0.95)	1.000	0.02 (-0.43,0.47)	0.038	**0.72 (0.08,1.35)**	0.435	0.39 (-0.17,0.94)	1.000	-0.28 (-0.97,0.40)
Mental QoL (0-100)	53.5 ± 10.2	44.6 ± 13.4	53.6 ± 8.2	50.2 ± 13.3	**<0.001**	**0.83 (0.47,1.19)**	1.000	-0.01 (-0.55,0.52)	1.000	0.31 (-0.14,0.77)	0.051	**-0.72 (-1.36,-0.09)**	0.387	-0.41 (-0.96,0.14)	1.000	0.29 (-0.40,0.97)
Sleep quality (0-21)	4.3 ± 2.2	5.7 ± 2.4	4.3 ± 2.7	5.2 ± 2.7	0.006	**-0.61 (-0.96,-0.25)**	1.000	0.03 (-0.51,0.57)	0.667	-0.37 (-0.83,0.08)	0.301	**0.57 (-0.06,1.20)**	1.000	0.20 (-0.35,0.75)	1.000	-0.33 (-1.02,0.36)
Anxiety (0-21)	7.7 ± 1.9	8.2 ± 2.0	7.9 ± 1.7	8.0 ± 1.9	0.581	-0.30 (-0.65,0.06)	1.000	-0.10 (-0.64,0.43)	1.000	-0.18 (-0.63,0.28)	1.000	0.19 (-0.43,0.81)	1.000	0.11 (-0.44,0.66)	1.000	-0.08 (-0.76,0.61)
Depression (0-21)	9.2 ± 1.8	10.6 ± 1.7	10.0 ± 2.1	9.7 ± 1.7	**<0.001**	**-0.79 (-1.15,-0.43)**	0.562	-0.45 (-0.99,0.08)	1.000	-0.30 (-0.75,0.16)	1.000	0.32 (-0.30,0.94)	0.487	**0.52 (-0.04,1.07)**	1.000	0.16 (-0.53,0.84)
Body mass index (kg/m^2)	23.8 ± 2.5	23.8 ± 2.6	23.1 ± 1.9	23.6 ± 3.6	1.000	0.01 (-0.35,0.36)	1.000	0.30 (-0.24,0.84)	1.000	0.09 (-0.37,0.54)	1.000	0.29 (-0.33,0.92)	1.000	0.07 (-0.48,0.62)	1.000	-0.17 (-0.85,0.52)
Fitness (1-5)																
Overall	4.2 ± 0.6	4.3 ± 0.9	4.3 ± 0.6	4.3 ± 0.7	1.000	-0.07 (-0.42,0.29)	1.000	-0.07 (-0.61,0.47)	1.000	-0.09 (-0.55,0.36)	1.000	0.00 (-0.62,0.62)	1.000	-0.02 (-0.57,0.53)	1.000	-0.02 (-0.70,0.66)
CRF	4.3 ± 0.7	4.2 ± 0.9	4.5 ± 0.7	4.2 ± 0.8	1.000	0.04 (-0.31,0.40)	1.000	-0.34 (-0.88,0.19)	1.000	0.09 (-0.37,0.54)	1.000	-0.33 (-0.95,0.30)	1.000	0.03 (-0.52,0.58)	1.000	0.38 (-0.31,1.07)
Strength	3.9 ± 0.7	4.1 ± 0.7	3.6 ± 0.7	3.9 ± 0.6	0.881	-0.26 (-0.61,0.09)	1.000	0.34 (-0.20,0.88)	1.000	0.04 (-0.41,0.49)	0.344	**0.58 (-0.05,1.21)**	1.000	0.31 (-0.24,0.87)	1.000	-0.31 (-1.00,0.38)
Speed-agility	3.8 ± 0.7	3.8 ± 0.6	3.6 ± 0.6	3.8 ± 0.6	1.000	0.03 (-0.32,0.38)	1.000	0.21 (-0.33,0.75)	1.000	0.06 (-0.39,0.52)	1.000	0.20 (-0.42,0.82)	1.000	0.03 (-0.51,0.58)	1.000	-0.18 (-0.86,0.51)
Flexibility	3.3 ± 0.9	3.3 ± 0.8	3.4 ± 0.9	3.0 ± 0.8	1.000	-0.08 (-0.43,0.27)	1.000	-0.10 (-0.63,0.44)	1.000	0.29 (-0.16,0.75)	1.000	-0.02 (-0.64,0.60)	1.000	0.41 (-0.14,0.97)	1.000	0.41 (-0.28,1.10)

Values are the mean ± standard deviation or n (%). The four groups were based on the cut-off score of 24 on the Exercise Addiction Inventory at pre- and post-competition (for example, non-risk of exercise addiction participants scored below criteria on both measurements).

[a]Missing data. Reasons: data were unreasonably high and excluded from analysis according to the Guidelines for Data Processing and Analysis of the International Physical Activity Questionnaire (non-risk (n = 23), transient (n = 7), emerging (n = 2), persistent (n = 1)).

CI: confidence intervals, CRF: cardiorespiratory fitness, *d*: Cohen's standardized effect size adjusted by correcting for small sample bias, MET: metabolic equivalent of task, QoL: quality of life, SAU: standard alcohol units, SD: standard deviation.

Chi-square test was used to compare categorical data; one-way ANOVA with Bonferroni post hoc test and Cohen's *d* were used to compare continuous data; significant *p*-values and minimally important differences are in bold; the thresholds of *p*- and *d*-values were set at 0.002 (0.050/25) and 0.50, respectively.

Table 3. Characteristics of amateur endurance cyclists at 6-month post-competition.

Variables	Descriptive data				Between-group comparisons											
	Non-risk (n = 261)	Transient (n = 35)	Emerging (n = 14)	Persistent (n = 20)	Non-risk vs Transient		Non-risk vs Emerging		Non-risk vs Persistent		Transient vs Emerging		Transient vs Persistent		Emerging vs Persistent	
					p	*d* (95%CI)	*p*	*d* (95%CI)	*p*	*d* (95%CI)	*p*	ES (95%CI)	*p*	*d* (95%CI)	*p*	*d* (95%CI)
Training volume (km/month)	660.5 ± 415.3	639.5 ± 387.7	834.2 ± 395.6	784.0 ± 480.3	1.000	0.05 (-0.30, 0.40)	0.772	-0.42 (-0.96, 0.12)	1.000	-0.29 (-0.75, 0.16)	0.838	-0.49 (-1.12, 0.13)	1.000	-0.34 (-0.89, 0.21)	1.000	0.11 (-0.57, 0.79)
Training volume (h/wk)	7.1 ± 3.8	6.7 ± 3.6	9.1 ± 4.0	8.6 ± 4.5	1.000	0.11 (-0.25, 0.46)	0.402	**-0.52 (-1.06, 0.02)**	0.635	-0.38 (-0.84, 0.07)	0.350	**-0.64 (-1.28, -0.01)**	0.556	-0.47 (-1.03, 0.08)	1.000	0.11 (-0.57, 0.80)
Training frequency (d/wk)	3.0 ± 1.6	2.9 ± 1.6	3.8 ± 1.6	3.2 ± 1.3	1.000	0.06 (-0.29, 0.42)	0.411	**-0.50 (-1.04, 0.04)**	1.000	-0.13 (-0.58, 0.33)	0.504	**-0.55 (-1.19, 0.07)**	1.000	-0.20 (-0.75, 0.35)	1.000	0.41 (-0.27, 1.11)
Exercise addiction (6-30)	17.2 ± 3.49	19.9 ± 3.7	25.4 ± 1.3	25.7 ± 1.6	**<0.001**	**-0.76 (-1.12, -0.41)**	**<0.001**	**-2.39 (-2.96, -1.82)**	**<0.001**	**-2.48 (-2.98, -1.98)**	**<0.001**	**-1.68 (-2.41, -0.99)**	**<0.001**	**-1.82 (-2.50, -1.19)**	1.000	-0.20 (-0.89, 0.48)
Physical activity (MET-min/wk)[a]	3331.8 ± 2790.1	3923.4 ± 3490.1	2488.1 ± 2393.6	4471.4 ± 3610.0	1.000	-0.21 (-0.60, 0.19)	1.000	0.30 (-0.28, 0.88)	0.605	-0.40 (-0.87, 0.07)	0.919	0.44 (-0.24, 1.13)	1.000	-0.15 (-0.74, 0.43)	0.390	**-0.60 (-1.35, 0.13)**
Smoking dependence (0-16)	0.1 ± 0.7	0.0 ± 0.0	0.0 ± 0.0	0.4 ± 1.3	1.000	Error	1.000	Error	1.000	-0.33 (-0.78, 0.13)	1.000	Error	1.000	Error	1.000	Error
Alcohol use (SAU/wk)	8.9 ± 12.2	8.7 ± 9.9	6.9 ± 12.1	7.4 ± 9.3	1.000	0.02 (-0.34, 0.37)	1.000	0.16 (-0.37, 0.70)	1.000	0.12 (-0.33, 0.58)	1.000	0.17 (-0.45, 0.79)	1.000	0.13 (-0.42, 0.68)	1.000	-0.05 (-0.73, 0.64)
Physical QoL (0-100)	56.2 ± 4.7	56.5 ± 7.3	54.1 ± 7.1	55.5 ± 5.3	1.000	-0.06 (-0.41, 0.29)	0.747	0.43 (-0.11, 0.97)	1.000	0.14 (-0.31, 0.60)	0.845	0.33 (-0.29, 0.95)	1.000	0.15 (-0.40, 0.70)	1.000	-0.22 (-0.91, 0.46)
Mental QoL (0-100)	56.2 ± 12.5	51.5 ± 12.3	49.2 ± 18.4	52.8 ± 12.3	0.244	0.38 (0.02, 0.73)	0.277	**0.54 (0.00, 1.08)**	1.000	0.27 (-0.18, 0.73)	1.000	0.16 (-0.46, 0.78)	1.000	-0.10 (-0.65, 0.44)	1.000	-0.23 (-0.92, 0.45)
Sleep quality (0-21)	3.8 ± 2.2	4.6 ± 1.9	5.0 ± 3.6	4.9 ± 3.1	0.270	-0.37 (-0.72, -0.01)	0.346	**-0.52 (-1.06, 0.02)**	0.296	-0.46 (-0.92, 0.00)	1.000	-0.16 (-0.78, 0.46)	1.000	-0.12 (-0.67, 0.43)	1.000	0.03 (-0.65, 0.71)
Anxiety (0-21)	7.8 ± 2.0	8.3 ± 1.7	8.4 ± 2.8	7.6 ± 1.7	1.000	-0.25 (-0.61, 0.10)	1.000	-0.29 (-0.83, 0.25)	1.000	0.13 (-0.33, 0.58)	1.000	-0.05 (-0.67, 0.57)	1.000	0.41 (-0.15, 0.96)	1.000	0.35 (-0.33, 1.05)
Depression (0-21)	10.2 ± 2.2	10.5 ± 1.9	10.9 ± 2.1	10.8 ± 2.1	1.000	-0.14 (-0.49, 0.21)	1.000	-0.32 (-0.86, 0.22)	1.000	-0.25 (-0.71, 0.20)	1.000	-0.20 (-0.20, 0.42)	1.000	-0.15 (-0.70, 0.40)	1.000	0.05 (-0.64, 0.73)
Body mass index (kg/m^2)	24.0 ± 2.6	24.2 ± 3.2	23.5 ± 1.9	23.5 ± 3.6	1.000	-0.07 (-0.43, 0.28)	1.000	0.19 (0.19, 0.73)	1.000	0.19 (-0.26, 0.65)	1.000	0.24 (-0.38, 0.86)	1.000	0.21 (-0.34, 0.76)	1.000	Error
Fitness (1-5)																
Overall	4.1 ± 0.6	4.1 ± 0.6	4.2 ± 0.4	4.1 ± 0.6	1.000	-0.07 (-0.43, 0.28)	1.000	-0.17 (-0.71, 0.37)	1.000	0.08 (-0.37, -0.37)	1.000	0.18 (-0.80, 0.44)	1.000	0.00 (-0.55, 0.55)	1.000	0.18 (-0.50, 0.87)
CRF	4.2 ± 0.7	4.3 ± 0.6	4.2 ± 0.7	4.1 ± 0.8	1.000	-0.14 (-0.50, 0.21)	1.000	0.00 (0.00, 0.00)	1.000	0.14 (-0.31, 0.60)	1.000	0.16 (-0.46, 0.78)	1.000	0.29 (-0.26, 0.85)	1.000	0.13 (-0.55, 0.81)
Strength	3.8 ± 0.7	3.9 ± 0.6	3.7 ± 0.9	3.9 ± 0.7	1.000	-0.14 (-0.50, 0.21)	1.000	0.14 (-0.40, 0.68)	1.000	-0.14 (-0.60, 0.31)	1.000	0.28 (-0.34, 0.91)	1.000	0.00 (-0.55, 0.55)	1.000	-0.25 (-0.94, 0.43)
Speed–agility	3.6 ± 0.8	3.7 ± 0.8	3.6 ± 0.8	3.7 ± 0.7	1.000	-0.12 (-0.48, 0.23)	1.000	0.00 (0.00, 0.00)	1.000	-0.13 (-0.58, 0.33)	1.000	0.12 (-0.50, 0.74)	1.000	0.00 (-0.55, 0.55)	1.000	-0.13 (-0.82, 0.55)
Flexibility	3.3 ± 0.9	3.4 ± 0.9	3.2 ± 1.0	3.1 ± 0.8	1.000	-0.11 (-0.46, 0.24)	1.000	0.11 (-0.43, 0.65)	1.000	0.22 (-0.23, 0.68)	1.000	0.21 (-0.41, 0.84)	1.000	0.34 (-0.21, 0.90)	1.000	0.11 (-0.57, 0.80)

Values are the mean ± standard deviation. The four groups were based on the cut-off score of 24 on the Exercise Addiction Inventory at pre- and post-competition (for example, non-risk of exercise addiction participants scored below criteria on both measurements).
[a]Missing data. Reasons: data were unreasonably high and excluded from analysis according to the Guidelines for Data Processing and Analysis of the International Physical Activity Questionnaire (non-risk (n = 23), transient (n = 7), emerging (n = 2), persistent (n = 1)).
CI: confidence intervals, CRF: cardiorespiratory fitness, *d*: Cohen's standardized effect size adjusted by correcting for small sample bias, MET: metabolic equivalent of task, QoL: quality of life, SAU: standard alcohol units, SD: standard deviation.
One-way ANOVA with Bonferroni post hoc test and Cohen's *d* were used to compare data; significant *p*-values and minimally important differences are in bold; the thresholds of *p*- and *d*-values were set at 0.003 (0.050/18) and 0.50, respectively.

Table 4. Within- and between-group comparisons of the change in amteur endurance cyclists from pre- to 6-month post-competition.

Variables	Wiithin-group comparisons								Between-group comparisons											
	Non-risk (n = 261)		Transient (n = 35)		Emerging (n = 14)		Persistent (n = 20)		Non-risk vs Transient		Non-risk vs Emerging		Non-risk vs Persistent		Transient vs Emerging		Transient vs Persistent		Emerging vs Persistent	
	p	*d* (95%CI)	*p*	*d* (95%CI)	*p*	*d* (95%CI)	*p*	*d* (95%CI)	*p*	*d* (95%CI)	*p*	*d* (95%CI)	*p*	*d* (95%CI)	*p*	*d* (95%CI)	*p*	*d* (95%CI)	*p*	*d* (95%CI)
Training volume (km/month)	**<0.001**	**-1.01 (-1.15, -0.86)**	**<0.001**	**-1.13 (-1.61, -0.68)**	**0.002**	**-0.94 (-1.58, -0.41)**	**0.002**	**-0.67 (-1.19, -0.20)**	1.000	0.10 (0.46, -0.25)	1.000	-0.17 (0.37, -0.71)	1.000	-0.30 (0.16, -0.75)	1.000	-0.29 (-0.91, 0.34)	1.000	-0.41 (0.14, -0.97)	1.000	-0.15 (0.53, -0.84)
Training volume (h/wk)	**<0.001**	**-1.20 (-1.39, -1.05)**	**<0.001**	**-1.35 (-1.86, -0.88)**	**0.001**	**-1.10 (-1.91, -0.41)**	0.003	**-0.67 (-1.23, -0.14)**	1.000	0.13 (0.48, -0.22)	0.258	-0.18 (0.36, -0.72)	1.000	-0.46 (-0.01, -0.92)	0.328	-0.34 (-0.96, 0.29)	1.000	**-0.59 (-0.03, -1.15)**	1.000	-0.32 (0.37, -1.01)
Training frequency (d/wk)	**<0.001**	**-0.73 (-0.85, -0.56)**	**<0.001**	**-0.89 (-1.27, -0.54)**	**0.002**	**-0.93 (-1.82, -0.13)**	**0.001**	**-0.92 (-1.59, -0.30)**	1.000	0.18 (0.54, -0.17)	0.028	0.21 (0.75, -0.33)	1.000	0.13 (0.59, -0.32)	0.108	0.03 (-0.59, 0.65)	1.000	-0.05 (0.50, -0.60)	0.760	-0.08 (0.60, -0.76)
Exercise addiction (6-30)	0.004	-0.20 (-0.35, -0.06)	**<0.001**	-1.96 (-2.65, -1.35)	**<0.001**	2.88 (1.80, 4.30)	0.954	-0.03 (-0.58, 0.51)	**<0.001**	**1.48 (1.86, 1.11)**	**<0.001**	**-1.62 (-1.06, -2.17)**	**<0.001**	-0.19 (0.26, -0.65)	1.000	**-6.73 (-8.20, -5.26)**	**<0.001**	**-3.70 (-2.81, -4.58)**	0.024	**2.77 (3.71, 1.82)**
Physical activity (MET-min/wk)[a]	**<0.001**	**-0.94 (-1.12, -0.76)**	0.004	**-0.73 (-1.25, -0.23)**	**<0.001**	**-1.15 (-2.02, -0.41)**	**0.002**	**-0.74 (-1.46, -0.07)**	1.000	-0.26 (0.13, -0.65)	1.000	0.43 (1.01, -0.15)	0.177	-0.01 (0.45, -0.48)	1.000	**0.62 (-0.07, 1.31)**	1.000	0.24 (0.82, -0.35)	0.455	-0.37 (0.36, -1.10)
Smoking dependence (0-16)	0.250	0.08 (-0.13, 0.13)	1.000	Error	1.000	Error	0.026	Error	1.000	0.10 (0.45, -0.26)	1.000	0.09 (0.63, -0.45)	1.000	**-0.56 (-0.10, -1.01)**	1.000	Error	1.000	Error	1.000	Error
Alcohol use (SAU/wk)	**<0.001**	0.24 (0.16, 0.33)	**0.003**	0.45 (0.17, 0.74)	0.541	-0.09 (-0.28, 0.09)	0.026	0.49 (0.04, 0.97)	1.000	-0.12 (0.23, -0.48)	1.000	0.39 (0.93, -0.15)	1.000	-0.11 (0.34, -0.57)	1.000	**0.55 (-0.08, 1.18)**	1.000	0.02 (0.57, -0.53)	1.000	**-0.51 (0.18, -1.20)**
Physical QoL (0-100)	0.250	-0.09 (-0.26, 0.04)	0.015	-0.37 (-0.75, 0.00)	0.610	-0.13 (-1.01, 0.75)	0.430	-0.17 (-0.69, 0.34)	0.460	0.45 (0.80, 0.10)	0.387	0.09 (0.63, -0.45)	1.000	0.14 (0.60, -0.31)	0.055	-0.29 (-0.91, 0.33)	0.789	-0.23 (0.32, -0.78)	1.000	0.04 (0.72, -0.64)
Mental QoL (0-100)	**<0.001**	0.24 (0.11, 0.36)	**0.001**	**0.52 (0.20, 0.86)**	0.171	-0.29 (-0.95, 0.35)	0.343	0.19 (-0.29, 0.69)	**0.001**	-0.38 (-0.03, -0.74)	1.000	**0.71 (1.25, 0.16)**	0.933	0.02 (0.47, -0.44)	1.000	**0.91 (0.26, 1.55)**	1.000	0.32 (0.87, -0.24)	1.000	**-0.59 (0.11, -1.28)**
Sleep quality (0-21)	**<0.001**	-0.23 (-0.33, -0.12)	**0.001**	**-0.50 (-0.89, -0.12)**	0.182	0.21 (-0.26, 0.70)	0.435	-0.11 (-0.42, 0.19)	0.021	0.24 (0.59, -0.12)	1.000	**-0.56 (-0.02, -1.10)**	0.290	-0.09 (0.36, -0.55)	1.000	**-0.72 (-1.36, -0.08)**	1.000	-0.29 (0.26, -0.85)	1.000	0.38 (1.07, -0.31)
Anxiety (0-21)	0.109	0.05 (-0.06, 0.16)	0.779	0.05 (-0.34, 0.43)	0.302	0.20 (-0.24, 0.67)	0.267	-0.24 (-0.59, 0.10)	0.550	0.05 (0.40, -0.31)	1.000	-0.17 (0.37, -0.71)	1.000	0.33 (0.79, -0.12)	1.000	-0.21 (-0.83, 0.41)	1.000	0.27 (0.82, -0.28)	1.000	**0.51 (1.20, -0.19)**
Depression (0-21)	**<0.001**	**0.50 (0.35, 0.64)**	0.836	-0.05 (-0.60, 0.50)	0.191	0.39 (-0.28, 1.09)	0.056	**0.53 (-0.05, 1.13)**	0.012	**0.59 (0.95, 0.24)**	0.480	0.08 (0.61, -0.46)	0.763	-0.03 (0.43, -0.48)	1.000	**-0.51 (-1.14, 0.12)**	1.000	**-0.65 (-0.09, -1.22)**	1.000	-0.10 (0.58, -0.78)
Body mass index (kg/m^2)	0.006	0.08 (0.03, 0.13)	0.010	0.14 (0.02, 0.27)	0.133	0.19 (0.03, 0.38)	0.598	-0.03 (-0.10, 0.04)	1.000	-0.10 (0.25, -0.46)	1.000	-0.09 (0.45, -0.63)	1.000	0.11 (0.57, -0.34)	1.000	0.01 (-0.61, 0.63)	1.000	0.18 (0.73, -0.37)	1.000	0.17 (0.85, -0.52)
Fitness (1-5)																				
Overall	0.011	-0.17 (-0.28, -0.05)	0.032	-0.29 (-0.69, 0.09)	0.670	-0.13 (-0.61, 0.34)	0.076	-0.38 (-0.85, 0.07)	1.000	0.20 (0.55, -0.16)	1.000	-0.05 (0.49, -0.59)	1.000	0.24 (0.69, -0.22)	1.000	-0.20 (-0.82, 0.42)	1.000	0.02 (0.57, -0.52)	1.000	0.28 (0.96, -0.41)
CRF	0.020	-0.14 (-0.25, -0.03)	0.798	0.04 (-0.34, 0.41)	0.107	-0.40 (-0.92, 0.08)	0.499	-0.12 (-0.42, 0.18)	1.000	-0.18 (0.17, -0.53)	1.000	0.27 (0.81, -0.27)	1.000	0.00 (0.45, -0.45)	1.000	0.38 (-0.24, 1.01)	1.000	0.15 (0.70, -0.40)	1.000	-0.24 (0.44, -0.93)
Strength	0.023	-0.14 (-0.25, -0.04)	0.076	-0.25 (-0.50, -0.02)	0.640	0.08 (-0.22, 0.38)	0.695	0.07 (-0.33, 0.48)	1.000	0.13 (0.48, -0.22)	1.000	-0.22 (0.32, -0.75)	1.000	-0.19 (0.27, -0.64)	0.866	-0.34 (-0.96, 0.29)	1.000	-0.33 (0.22, -0.89)	1.000	0.03 (0.71, -0.65)
Speed–agility	0.004	-0.27 (-0.38, -0.15)	0.313	-0.15 (-0.45, 0.13)	1.000	0.00 (-0.39, 0.39)	0.738	-0.07 (-0.59, 0.44)	1.000	-0.01 (0.34, -0.37)	1.000	-0.17 (0.37, -0.70)	1.000	-0.10 (0.36, -0.55)	1.000	-0.17 (-0.79, 0.45)	1.000	-0.10 (0.45, -0.65)	1.000	0.08 (0.77, -0.60)
Flexibility	0.848	0.00 (-0.08, 0.08)	0.602	0.06 (-0.24, 0.38)	0.409	-0.14 (-0.52, 0.22)	0.730	0.06 (-0.22, 0.34)	1.000	-0.05 (0.30, -0.41)	1.000	0.16 (0.70, -0.38)	1.000	-0.04 (0.41, -0.50)	1.000	0.23 (-0.39, 0.85)	0.914	0.01 (0.56, -0.54)	1.000	-0.22 (0.47, -0.90)

Values are the mean ± standard. The four groups were based on the cut-off score of 24 on the Exercise Addiction Inventory at pre- and post-competition (for example, non-risk of exercise addiction participants scored below criteria on both measurements).

[a]Missing data. Reasons: data were unreasonably high and excluded from analysis according to the Guidelines for Data Processing and Analysis of the International Physical Activity Questionnaire (non-risk (n = 23), transient (n = 7), emerging (n = 2), persistent (n = 1)).

CI: confidence intervals, CRF: cardiorespiratory fitness, *d*: Cohen's standardized effect size adjusted by correcting for small sample bias, MET: metabolic equivalent of task, QoL: quality of life, SAU: standard alcohol units, SD: standard deviation.

Repeated measures ANOVA with Bonferroni post hoc test and Cohen's *d* were used to compare continuous data; significant *p*-values and minimally important differences are in bold; the thresholds of *p*- and *d*-values were set at 0.002 (0.050/25) and 0.50, respectively