Can Yoga Pranayama Practices Improve Burnout in Elite Mountain Bikers: A Single-arm Pilot Study

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Abstract

Mountain bike (MTB) racing is a highly intensive physical activity and requires a high degree of technical ability to perform at the elite athlete level, which might compromise mental well-being, increasing symptoms of anxiety and depression through overtraining, injury, and burnout. Yoga Pranayama is the key to bringing about psychosomatic integration and harmony. This study aimed to explore the effects of yoga pranayama practices (YPP) on elite mountain bikers' burnout. This is a single-arm pilot study. Twenty-seven subjects practiced 30 sessions of YPP seven times a week for 1 month. The outcomes measured were blood biochemical parameters accompanied by complete blood count and athlete burnout score. Cubital vein blood test and burnout questionnaire were conducted at baseline and after 1 month. Test results showed a significant decrease in cortisol (CO) ($P = 0.001$) and urea nitrogen ($P < 0.001$) and an increase in testosterone: CO ratio ($P = 0.001$). This study indicates that YPP might improve burnout in elite mountain bikers.

Keywords: *Athlete burnout, mountain biker, pranayama, yoga*

Introduction

Mountain bike (MTB) racing is described by the Union Cyclist International (UCI) as Cross-country (XCO), Downhill, Four cross, Enduro, Pump track, Snow Bike, and E-MTB. The circuit of cross-country (XCO) MTB (XCO-MTB) events comprises a significant amount of uphill, downhill, and flat terrains. The course can have natural and/or artificial obstacles, such as tree stumps or tree trunks, rock gardens, stairs, bridges, and drops (UCI regulations, Part 4 MTB, version from January 01, 2023), and XCO-MTB became more popular after its inclusion in the 1996 Olympic Games, named in this first appearance as Olympic cross-country (XCO), which is highly intensive and lasting approximately 1 h 30 min. During the race, the different terrain conditions require the mountain bikers to have a high degree of technical ability to control and stabilize the bicycle.[1] The mean power output, speed, and heart rate in XCO-MTB were 283 ± 22 W (4.31 ± 0.32 W. kg^{-1}, 68% ±5% maximal aerobic power), 19.7 ± 2.1 km. h^{-1}, and 172 ± 11 bpm (91% ±2% max heart rate), respectively; power output measured during uphill climbs is frequently above maximal aerobic power, which is about 500 W for elite-level cyclists.[1,2] The XCO racing is further described by Hays *et al*. that 37.0 ± 17.9% of the race was performed above the second ventilatory threshold at a mean intensity of 87% $VO_{2\ max}$ and 25% of the race was spent above maximal aerobic power. The varied static, eccentric, and concentric phases were observed in MTB, compared to the concentric muscle action-dominated road cycling.[3]

Given the characteristics of MTB, the risk of accidents with consequent acute injuries will always be present during training sessions, especially during competitions.[4] Halson *et al*. indicate that a state of overreaching in trained cyclists can already be induced after 7 days of intensified training with limited recovery.[5] Intense physical activity performed at the elite athlete level might compromise mental well-being, increasing symptoms of anxiety and depression through overtraining, injury, and burnout.[6] Based on the Cognitive-Affective Stress Model proposed by Smith,[7] when athletes are exposed to demands such as high training loads or

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exceed performance expectations. They will cognitively appraise the situation relative to their ability to respond to these demands. This interpretation of their ability to meet these demands leads to a physiological response, which leads to behavioral and coping responses. Such responses may include athlete burnout. Burnout affects athletes due to the complex interaction between multiple stress factors, inadequate recovery, and frustration due to unmet expectations and goals,[8] and presence as a fundamental factor of the causes of sport abandonment.[9]

Findings suggest that burnout is associated with a stress response to threatening situations, sustained activation of the autonomic nervous system, and dysfunction of the sympathetic adrenal medullary axis, leading to a release of cortisol (CO) from the adrenal cortex into the bloodstream. The presence of CO interferes with some cognitive processes, decreasing performance outcomes, and increasing the duration required for optimal recovery. CO is a catabolic hormone while testosterone (TE) is an anabolic hormone that is required for promoting protein synthesis, red blood cell production, and glycogen replenishment and for reducing protein breakdown, the TE/CO ratio has been proposed as a marker of training adaptation, and it is considered more sensitive to training stresses than either measure alone.[10-12] As commonly used marker of exercise-induced muscle trauma, the measures of serum creatine kinase (CK) and urea nitrogen activity can be used as parameters determining the physical fitness level and training adaptations of cyclists and may reflect the fatigue status after training, even potentially involved in several types of depression like work-related stress. Adaptations to endurance and altitude training suffer when iron levels are insufficient (serum ferritin (SF), 12 mg/L^{-1}) for hemoglobin (Hb) to efficiently transport oxygen to exercising muscle tissue (Hb, females, $<12\ g/d^{-1}$; males, $<13\ g/dL^{-1}$). Useful biomarkers in the assessment of iron deficiency include ferritin, hematocrit (Ht), Hb, and red blood cell indices.[13-15]

According to Swami Svatmarama, the author of Hatha Yoga, "Disturbed breath leads to a disturbed mind, hence cultivate a steady and quiet breath in order to control the mind and prolong the life."[16] Pranayama, defined as a manipulation of breath movement, is the key to bringing about psychosomatic integration and harmony.[17] Practicing pranayama brings the balance between the Sympathetic and Para-Sympathetic Nervous Systems and Anabolic and Catabolic processes, and homeostasis is restored.[18] It has been hypothesized that sustained and enhanced sympathetic activity, reduced parasympathetic vagal activity, and delayed sympathetic recovery may be the biological processes linking chronic stress to burnout.[11] Raju *et al*. suggested that athletes may be able to postpone anaerobic thresholds by incorporating the pranayama practices.[19] Several studies[20-22] have validated yoga modules, including pranayama practices as a critical element, such as Nadi-shuddhi and bhramari, by 8–30 yoga experts for various psychological disorders. Experiments are underway to understand the efficacy and utility of yoga pranayama practices (YPP) on psychological stress, sleep, serum biomarkers, and gene expression. The primary purpose of the present study was to investigate the impact of YPP on elite mountain biker' burnout syndrome and the related blood biochemical parameters on stress response and recovery.

Methods

This was a single-arm pilot study conducted in the MTB team of the Chenggong District Sports Training Center, Kunming Yunnan, China, with an altitude of 1895 m, from March 7 to April 6, 2022. Mountain biking in Yunnan province has always been advantageous across the country.

Intervention

The YPP was a 60-min session seven times a week, lasting for 1 month. Seven pranayama were practiced from 9:00 pm to 10:00 pm. The module was examined by 8 yoga experts and performed under the supervision of one trained and certified yoga instructor. Table 1 shows the duration and experts' ratings for the different breathing techniques.

Outcome measure

The outcomes measured were blood biochemical parameters, including urea nitrogen (BUN), CK, TE, CO, TE: CO ratio, SF, white blood cells (WBC), red blood cells (RBC), Hb, Ht, and score in the Athlete Burnout Questionnaire (ABQ), listed in Table 2. The ABQ was developed by Raedeke and Smith[23] and revised by Chinese scholar Sun and Zhang[24] The five-point Likert Scale was used, and to determine athlete burnout, items 1 and 14 were reversed before scores were summed up, so that higher scores indicated higher levels of athlete burnout. In addition, we adopted the formula of athlete burnout weighted total score established by Liancheng and Liwei[25] ($S_{\text{weighted total score}} = S_{\text{emotional/physical exhaustion}} \times 0.21 + S_{\text{reduced sense of accomplishment}} \times 0.47 + S_{\text{sport devaluation}} \times 0.32$) to calculate the athlete burnout total score.[26] All measures were gathered before and after 1 day of the intervention.

Data collection procedure

The biochemical outcome was measured using a cubital vein blood test. The blood extraction was done by two medical laboratory technicians in the Chenggong District Sports Training Center Sports Trauma Clinic from 7:00 am to 8:00 am in a fasting state, 1 day before, and the 2nd day after the intervention. 6 ml blood samples were extracted, 4 mL with ethylenediaminetetraacetic acid (EDTA) (anticoagulation) and 2 mL without EDTA were separately stored in vacuum tubes, and testing was completed within 5 h. The instrument calibration and quality control were performed prior to testing. Blood samples with EDTA were tested for the RBC, Hb, WBC, and Ht and analyzed by Beckman LH680, test reagents were LYSE S 3III diff Lytic (Beckman Coulter 8546983 COULTER LYSE S III diff Lytic Reagent Kit), PAK

Table 1: Yoga breathing practices were retained in the final module with expert ratings of scores

Yoga pranayama practice	Duration (min)	Scoring (1–5) (number of experts)	Content validity ratio (%)
Kapalbhati Pranayama	10	1 (0), 2 (0), 3 (0), 4 (1), 5 (7)	98.0
Abdominal breathing	10	1 (0), 2 (0), 3 (0), 4 (0), 5 (8)	100
Thoracic breathing	5	1 (0), 2 (0), 3 (0), 4 (0), 5 (8)	100
Shoulder (clavicular) breathing	5	1 (0), 2 (0), 3 (0), 4 (1), 5 (7)	98.0
Complete yogic breathing	10	1 (0), 2 (0), 3 (0), 4 (1), 5 (7)	98.0
Nadi Shodhana Pranayama	10	1 (0), 2 (0), 3 (0), 4 (0), 5 (8)	100
Bhramri Pranayama	5	1 (0), 2 (0), 3 (0), 4 (0), 5 (8)	100

Table 2: Outcome measures

Biochemical outcome (blood test)	Psychological outcome (athlete burnout questionnaire)
Urea nitrogen (BUN)	EPE
CK	RSA
TE	SDE
CO	
TE/CO	
Ferritin (SF)	
WBC	
RBC	
Hb	
Ht	

BUN: Blood urea nitrogen, CK: Creatine kinase, TE: Testosterone, CO: Cortisol, TE/CO: Testosterone/Cortisol ratio, SF: Serum ferritin, WBC: White blood cell, RBC: Red blood cell, Hb: Hemoglobin, Ht: Hematocrit, EPE: Emotional/physical exhaustion, RSA: Reduced sense of accomplishment, SDE: Sport devaluation

(Beckman Coulter 8547166 COULTER HmX PAK Reagent Kit), and COULTER CLENZ (Beckman Coulter LH Series RETIC PAK Reagent Kit); Blood samples without EDTA were centrifuged at 3000 rpm for 10 min and serum was collected for BUN, CK, TE, CO, and SF testing. The TE, CO, and SF concentrations were analyzed by Beckman ACESS 2, and the test reagents were ACCESS TE, ACCESS CO, ACCESS FERRITIN, and Wash Buffer II. The serum CK and BUN concentrations were analyzed by Beckman Unicel DxC 600, and the test reagents were BUN 2 × 300, CK 2 × 400, ISE electrolyte Buffer, and ISE electrolyte reference.

The ABQ score was collected through an online ABQ 1 day before and the 2nd day after the intervention.

Statistical analysis

All statistical analyses were completed using IBM SPSS statistic version 26.0 (IBM Corporation) for Windows. Descriptive statistics were conducted to summarize the sample characteristics and study variables. All data were presented as mean ± standard deviation All statistical tests used an α level set at $P < 0.05$ with two-tailed analysis. The suitability of data for parametric analysis was checked with Kolmogorov–Smirnov test and Q-Q plots. The changes in biochemical parameters and burnout score before and after the YPP intervention were determined using paired samples *t*-test or Wilcoxon signed-rank test for abnormality; effect size was reported by Cohen's d. In addition, multiple linear regression analysis and Pearson's correlation was also used. The biochemical data were analyzed separately for males and females since there might be significant differences in the observed values, as informed by Zhijun *et al*.[27]

Results

Twenty-seven athletes living in plateau for generations participated in the intervention, and none of them had practiced yoga pranayama before. Three of them were withdrawn from the training team due to personnel changes and one had chosen to withdraw from the study because of his lack of patience and adaptability to yoga pranayama. Moreover, we were missing the post-ABQ score data of one participant. Hence, we collected twenty-three data on biochemical parameters and twenty-two data on ABQ scores; all participants maintained attendance for all 30 YPP sessions, except two participants who had missed 3 days of classes due to match schedule and COVID-19 quarantine, respectively. Figure 1 describes the study design, and Table 3 shows the athletes' demographic details. There were no adverse events or side effects from participation in YPP.

Biochemical changes

As shown in Table 4, a statistically significant decrease in BUN ($t[22] = 4.62$, $P < 0.001$) and CO ($t[22] = 6.13$, $P = 0.001$) was observed for both male and female athletes; the within-group effect size at the end-point assessment was large (Cohen's $d = 0.96$ and $d = 1.28$, respectively). Moreover, a statistically significant increase in the mean CK levels($z = 204$, $P = 0.012$) is observed, but when analyzed separately there are no significant changes in CK($t(8) = -0.518$, $P = 0.618$) for female athletes, and less deviation was found at post-test, compared to male athletes. Though, no significant changes in TE($z = 108$, $P = 0.361$), the TE:CO ratio ($z = -2.555$, $P = 0.001$) was a statistically significant decrease for both genders. A statistically significant decrease in SF ($t (22) = 2.763$, $P = 0.025$) was observed only in female athletes. Changes in complete blood count are shown in Table 5. The WBC, RBC, Hb, and Ht levels were statistically significantly decreased; however, it was only the case in male athletes. According to multiple linear regression analysis, the athlete's age, gender, age of eligibility, and technical grade did not significantly predict the biochemical changes.

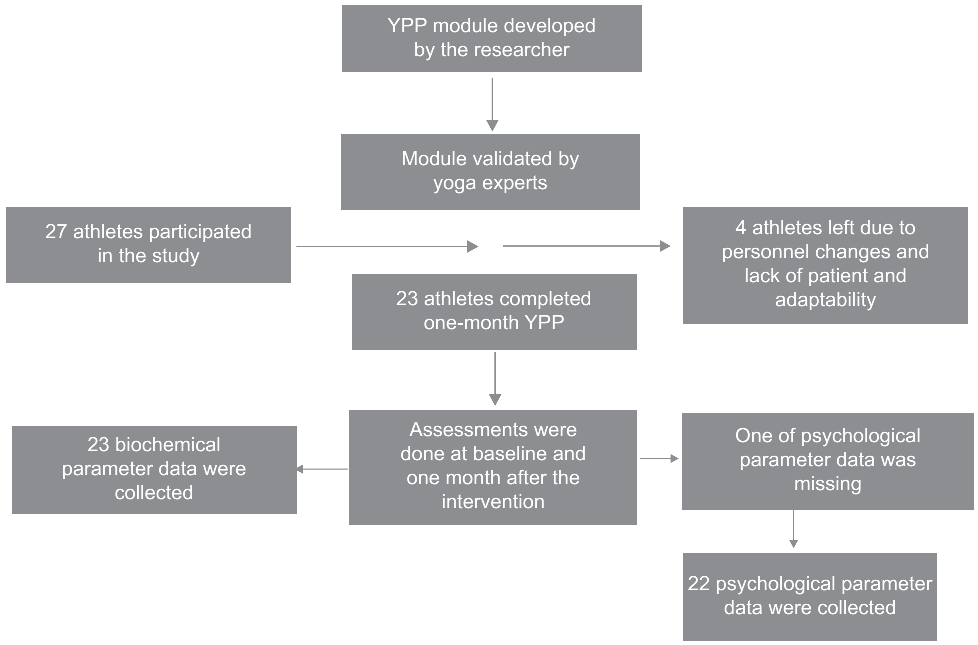

Figure 1: Study outline

Table 3: Demographic characteristics of the study subjects

Characteristics	Levels	Values
Age		20.5±2.4
Gender	Male	14
	0Female	9
Height		169.8±7.2
Weight		62.1±7.1
BMI		21.5±1.4
Athletes technical grades	Highest class	11
	First class	9
	Second class	2
	No class	1
Age of eligibility (years)	1	4
	3	4
	4	7
	6	4
	8	4

BMI: Body mass index

Athlete burnout questionnaire scores

The total questionnaire Cronbach's α coefficients for the two measurements of athlete burnout in this study were 0.799 and 0.833, respectively. Table 5 shows the changes in ABQ scores before and after YPP. No significant changes were observed. Multiple linear regression analysis indicated no significant effect that age, gender, age of eligibility, and technical grade have on either total ABQ score or individual scores of emotional and physical exhaustion (EPE), reduced sport achievement (RSA), and sport devaluation (SDE). However, the results of Pearson's correlation indicated that there was a significant moderate positive correlation (r = 0.44 and P = 0.038) between total ABQ scores and TE levels, and so did individual EPE scores and changes in CO levels (r = 0.43 and P = 0.045).

Discussion

To our knowledge, this is the first study to demonstrate the benefit of short-term YPP on burnout in elite mountain bikers. Review on athlete burnout suggested that mindfulness-based interventions could be of great interest in preventing and treating burnout symptoms.[28] Findings from this exploratory study provide early, pilot-level evidence of the efficacy of pranayama in improving burnout among elite mountain bikers. Beneficial effects of pranayama in healthy individuals[17] and medical students[29] have been established, however, little research has been conducted into the specific effects of pranayama on athletes. Results from one earlier randomized control trial done in India, in 1994 evaluated the effects of pranayama on oxygen consumption and blood lactate in national-level volleyball athletes indicating better oxygen delivery or utilization because of Pranayama practice. It is suggested that Pranayama may be included in the regular workout of sportspersons to improve performance.

Compared to previous studies involving elite cyclists in China by Zhijun *et al.*[15] who established a reference range of some biochemical indexes for native plain endurance athletes during altitude training, and Qu *et al.*[30] who measured once blood biochemical indicators of athletes living in the plateau for generations during winter training, very similar levels in some biochemical indexes (e.g. posttest BUN, TE: CO ratio, WBC, RBC, Hb, and Ht) were observed. However, considering the data obtained from previous studies is composed of road cyclists and MTB cyclists, it is difficult to compare the biochemical

Table 4: Changes in biochemical parameters and complete blood count after one-month yoga pranayama practices intervention

	Pretest	Posttest	t/Z	P
BUN (mmol/L)				
Male	8.0±1.3	6.5±0.9	3.391[a]	0.005**
Female	6.5±1.2	5.3±1.2	3.222[a]	0.012**
Total	7.4±1.4	6.0±1.2	4.622[a]	0.000***
CK (U/L)				
Male	216.3±70.4	344.4±224.6	−2.271[b]	0.023*
Female	155.4±57.4	162.9±35.8	−1.244[a]	0.214
Total	192.5±71.0	273.4±196.2	−2.516[b]	0.012**
TE (ng/dL)				
Male	574.4±72.4	538.5±79.2	−1.476[b]	0.140
Female	60.3±16.0	60.7±17.0	−0.416[b]	0.678
Total	373.2±262.6	351.5±246.3	−0.913[b]	0.361
CO (μg/mL)				
Male	25.2±3.1	21.2±3.5	5.710[a]	0.001***
Female	24.7±3.3	22.1±1.6	2.840[a]	0.022*
Total	25.0±3.0	21.5±3.0	6.126[a]	0.001***
TE: CO ratio				
Male	23.0±3.1	25.9±4.8	−2.291[b]	0.022*
Female	2.5±0.6	2.7±0.7	−2.073[b]	0.038*
Total	15.0±10.5	16.8±12.1	−2.555[b]	0.011**
SF (ng/mL)				
Male	90.0±51.4	80.6±48.6	1.332[a]	0.206
Female	37.7±24.7	29.9±19.7	2.763[a]	0.025*
Total	69.5±49.7	60.8±46.7	2.009[a]	0.057
WBC (10^9/L)				
Male	6.4±1.5	5.9±1.2	2.819[a]	0.014**
Female	6.3±1.3	5.7±1.0	2.110[a]	0.068
Total	6.4±1.4	5.8±1.1	3.543[a]	0.002**
RBC (10^{12}/L)				
Male	5.5±0.3	5.3±0.3	3.767[a]	0.002**
Female	4.8±0.2	4.7±0.2	0.774[a]	0.461
Total	5.2±0.5	5.1±0.4	3.359[a]	0.003**
Hb (g/L)				
Male	167.5±9.4	163.6±9.3	4.244[a]	0.001***
Female	145.0±7.4	144.6±6.2	0.356[a]	0.731
Total	158.7±14.1	156.1±12.4	3.207[a]	0.004*
Ht (%)				
Male	49.5±0.03	48.0±0.03	4.810[a]	<0.001***
Female	42.7±2.8	42.4±2.7	0.610[a]	0.559
Total	46.8±4.2	45.8±3.6	3.761[a]	0.001***

*P<0.05, **P≤0.01, ***P≤0.001, [a]Paired samples *t*-test, [b]Wilcoxon signed rank test. BUN: Blood urea nitrogen, CK: Creatine kinase, TE: Testosterone, CO: Cortisol, SF: Serum ferritin, WBC: White blood cell, RBC: Red blood cell, Hb: Hemoglobin, Ht: Hematocrit, YPP: Yoga pranayama practices

differences or draw conclusions about the training status of MTB athletes.

Urea is a classic fatigue marker in endurance disciplines, suggesting protein breakdown during prolonged exercise, increased urea along with decreased insulin-like growth factor 1 (IGF-1) have previously been reported during a fatigued state. A statistically significant decreased BUN levels in the current study confirm the findings of Manickam,[31] who also reported notable improvements in BUN among the tribal Taekwondo players in the experimental groups of Power yoga, and findings of Himashree *et al*.[32] in which a significant reduction in urea as compared with their preYoga levels and with the exercise group. However, lower BUN may be due to low protein intake or impaired metabolic activity in the liver;[12] therefore, changes in BUN alone are not that reliable for reflecting athlete fatigue state. IGF-1 should be included to track training fatigue and recovery in future studies.

Table 5: Changes in emotional/physical exhaustion, reduced sense of accomplishment, and sport devaluation after 1-month yoga pranayama practices intervention

	Pretest	Posttest	t	P
EPE (male)	2.97±0.54	2.80±0.43	1.129	0.281
EPE (female)	3.04±0.40	3.02±0.39	0.229	0.824
EPE	3.00±0.48	2.90±0.42	1.131	0.271
RSA (male)	2.23±0.75	1.98±0.58	1.207	0.251
RSA (female)	2.60±0.53	2.62±0.69	−0.244	0.813
RSA	2.38±0.55	2.25±2.78	1.072	0.296
SDE (male)	2.37±0.58	2.34±0.54	0.182	0.859
SDE (female)	2.33±0.57	2.24±0.58	0.580	0.578
SDE	2.35±0.56	2.30±0.55	0.472	0.642
Total (male)	2.43±0.42	2.27±0.55	1.382	0.192
Total (female)	2.60±0.47	2.60±0.55	0.494	0.634
Total	2.50±0.44	2.40±0.56	1.375	0.184

EPE: Emotional/physical exhaustion, RSA: Reduce sense of accomplishment, SDE: Sport devaluation, YPP: Yoga pranayama practices

The increase in CK activity after training is ordinarily attributed to the muscle cell membrane and tissue damage due to large muscle tension and eccentric exercise, both pre and posttest CK levels in male athletes are higher than reported by Zhijun *et al*.[15] and Qu *et al*.,[30] which are 181.0 U/L and 160.0 ± 60.6, respectively. However, it should be kept in mind that muscular damage is only one aspect of strain and fatigue and other aspects like vegetative balance, anabolic-catabolic balance or psychological alterations may play a role in the overall need for recovery.

Changes in CO levels in our study are supported by a previous promising study by Martarelli *et al*.[33] in which diaphragmatic breathing was identified as a practice to blunt exercise-induced oxidative stress in elite athletes, the experimental group observed a decrease in CO levels after the intervention and significantly higher melatonin levels that evening (P < 0.05). The total average TE decreased after 1 month of training and YPP, although not reaching statistically significant levels, and reductions are only observed in male athletes. It may indicate that the training volume is too high or getting more involvement for male athletes,[12] or YPP is more effective in preventing a reduction in TE levels in female athletes. The TE: CO ratio is considered valuable in the assessment of tiredness and prevention of overtraining syndrome, previous study has shown a significant increase in the T/C ratio after yoga stretching,[34] in the present study, the TE: CO ratio increased post-YPP for both male and female athletes.

ABQ scores at baseline are at a medium level, consistent with a previous study conducted on elite athletes which are around 2.67.[26] Hough *et al*.[35] reported that subjects` fatigue and burnout scores were higher after a cycling training period, which is the opposite in the present study that the mean scores of the EPE, RSA, SDE, and total ABQ were slightly decreased after YPP, indicating YPP might prevent athletes from burnout and even improve it if prolonging the intervention period or applying a more integrated approach of yoga practices (e.g. combine asana, pranayama, meditation, and relaxation technique all together). YPP could also be effective in acting as a support, as described low social support from trainers or coaches was associated with burnout in the review of the mental health of elite athletes.[36] While the importance of elite athlete mental health is gaining attention, targeted, disorder-specific models of care are yet to be established for this group, yoga is such a model to capitalize on early-intervention principles and establish cross-discipline collaboration. Results from this study also indicate favorable accessibility of YPP in Chinese elite MTB athletes.

Limitation

The limitations arising from the present study's design include the requires biomarker monitoring at multiple time points throughout training and intervention, a single-arm design with no control group, a single-site study, and a lack of follow-up data.

Conclusion

One-month regular and continued YPPs might improve burnout syndrome in elite mountain bikers. However, a randomized controlled trial with a longer intervention and integrated yoga module is needed to replicate these findings and determine the intervention effects' stability.

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Conflicts of interest

There are no conflicts of interest.

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