Short-term dry cupping improves autonomic nervous activity and sleep quality in university baseball players during a sports season

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Abstract

This study aimed to clarify the benefits of short-term cupping for athletes during preseason conditioning (PSC) and in-season conditioning (ISC). Forty university baseball players were recruited. Participants were divided into cupping (dry cupping at −400 mmHg) and sham (dry cupping at −100 mmHg) groups. Cupping was performed on the upper back and shoulders for 15 min, twice a week for 8 consecutive weeks: 4 weeks each during PSC and ISC. Four-week cupping exerted no significant effects on upper-extremity function during PSC or ISC. Exercise tests during PSC and ISC revealed no postintervention changes in peak power, peak oxygen consumption, or anaerobic threshold. However, cupping during PSC improved the postexercise recovery of low-frequency power (LF; $P = .013$; a heart rate variability component) and that during ISC improved the recovery of the LF/high-frequency power ratio ($P = .004$) and LF% ($P = .037$). Cupping during PSC significantly improved the participants' daytime dysfunction scores on the Pittsburgh Sleep Quality Index ($P = .026$). The benefits of cupping differ between PSC and ISC. Cupping during PSC and ISC markedly improves the postexercise recovery of autonomic activity and sympathetic activity, respectively. However, cupping enhances sleep quality only during PSC.

Introduction

In various phases of a sports season, athletes experience different levels of stress and fatigue; thus, similar health-care measures may lead to different outcomes. Year-round conditioning can be divided into 3 key periods: off-season conditioning, preseason conditioning (PSC), and in-season conditioning (ISC). Notably, PSC and ISC necessitate high training intensity and specialized care. The aim of PSC is to maximize utilization of the energy system specific to the sport, whereas that of ISC is to maintain their fitness level throughout the competition cycle.[1] Inadequate recovery during high-intensity training may result in adverse health effects due to exercise fatigue, ultimately reducing their competition performance.[2,3] Problems commonly associated with overtraining include autonomic imbalance, sleep disturbance, poor performance, and persistent fatigue.[4,5] Ensuring the optimal efficiency of recovery from sports fatigue and autonomic nervous system (ANS) activity across the season is crucial for maintaining athletes' physical function and sports performance.[6,7]

Many athletes use dry cupping for pre-competition health care and in-season recovery. Studies have demonstrated the benefits of cupping for athletes.[8,9] Cupping mitigates muscle fatigue, maintains sports performance,[10,11] promotes ANS activity recovery after intense exercise,[12–14] enhances blood volume and tissue oxygenation,[15,16] and improves sleep quality.[17,18] However, owing to differences in training intensity and competition schedule at different periods of the sports season, the extent of sports fatigue also varies significantly. Few studies have explored the changes in athletes' subjective perceptions and objective physiological responses due to cupping during conditioning at different periods of the season.

The present study was conducted to investigate the short-term benefits of regular cupping for university baseball players during different conditioning periods. During the PSC and ISC periods, regular dry cupping was administered that targeted the upper body muscles (trapezius and deltoids), which are commonly used by baseball players during pitching and batting.

Methods

Participants

This study recruited 50 volunteers from a university baseball team. Considering participants from the same team regularly engaged in collective training, which helped minimize inherent between-team differences in training modes, intensity, cycles, and competition schedules, which could have affected the effectiveness of the experimental intervention. Players who were unable to participate in exercise tests because of musculoskeletal injury and those who already have cupping habits were excluded. Finally, 44 participants were admitted. During the research process, 4 participants dropped out due to low attendance, and finally only the data of 40 athletes (age = 19.5 ± 0.2 years, height = 176.7 ± 0.8 cm, weight = 80.4 ± 2.0 kg) were analyzed (Fig. 1). This study was approved by the Human Research Ethics Review Committee (approval number: NCKU HRECF-107-013-2). All participants received adequate explanations of the study and signed a formal consent form.

Study design

To measure the baseline aerobic fitness, the participants were required to complete a progressive exercise test. This test assessed their peak oxygen consumption (VO_2peak). Because cupping was applied to the shoulders and upper back, an arm-crank exercise test was conducted to evaluate the postintervention change. Each participant's initial VO_2peak value was arranged in descending order and numbered in sequence. By random decision, players with odd numbers were allocated to the cupping group (n = 20), whereas those with even numbers were allocated to the sham group (n = 20). This allocation strategy was adopted to ensure equivalent baseline aerobic fitness levels of the 2 groups (Fig. 1). The tests were conducted in an air-conditioned laboratory. The experimental period spanned from 4 weeks before the start of the baseball season (PSC period) to 4 weeks after its commencement (ISC period). The effects of cupping on the athletes' subjective and objective physical performance, autonomic nervous balance, and sleep quality in different periods were investigated.

Experimental procedure

Standardized cupping intervention

The cupping area was the back, and cupping here can significantly increase heart rate variability (HRV) activity.[12,13] Because baseball players rely on their upper-extremity muscles during throwing and batting. Thus, in addition to 5 cups being attached to the back, 1 cup each was attached at the deltoid muscle of the arms (Fig. 2). The 5 cups used on the back had outer and inner diameters of 6.5 and 5.5 cm, respectively. The 2 cups used on the bilateral deltoid muscle had outer and inner diameters of 5.5 and 4.5 cm, respectively (Shen-Nong Cupping R0416179, Income Instrument, Taiwan). The cupping pressure was set according to previous studies.[19] The cupping group underwent dry cupping at – 400 mmHg, whereas the sham group underwent dry cupping at – 100 mmHg. The cups in the sham group did not fall off or cause apparent bruising (cupping marks). Cupping at – 100 mmHg has been reported to exert no significant effects on individuals' ANS activity,[12] blood flow near the cup, or exercise performance.[11] The participants underwent 15-min cupping on the upper back and shoulders after routine training or competition. Cupping was performed twice a week, with an interval of 2 to 3 days, for 8 weeks.

Functional evaluation of the upper extremities and shoulders

The Chinese version of the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire was used to collect data on the participants' upper-extremity function. This questionnaire comprises the following parts: a disability/symptom unit (DASHs; 30 items) and a self-selected optional unit: highly skilled exercise (DASHe; 4 items). The optional unit is designed for professional athletes and focuses on the unique challenges that they may encounter. To calculate a person's score, all answers were converted into a standardized score out of 100 based on the corresponding value. A higher score indicates a higher level of severity.

The Flexilevel Scale of Shoulder Function (FLEX-SF) questionnaire was employed to evaluate the shoulder girdle's function in all aspects of motion. This questionnaire comprises a main question, which acquires data for classifying respondents' shoulder joint function into the following 3 categories: easy, moderately difficult, and difficult. The participants were required to respond to only items specific to their level of functioning. The maximum total score on this scale is 50 points, and the minimum is 1 point. Higher scores indicate better shoulder girdle function.

Assessment of the maximal aerobic capacity and ventilatory threshold

For the arm-crank exercise test, an arm ergometer (ANGIO with a chair, Lode, Groningen, The Netherlands) and a gas analyzer (Vmax 29c Exercise Testing System) were used. Gas was collected using a mask connected to the gas sampling line and analyzed breath by breath. The test protocol included a warm-up preceding the test; the resistance was increased in a ramp mode of 15 W/min. Throughout the test, the participants were required to maintain the ergometer speed at 60 rpm until they could not maintain it (ie, the speed dropped to < 50 rpm) or stopped voluntarily. The intervals between the test initiation and the participant's exhaustion, maximum power, and VO_2peak were recorded. Their all-out point was the point at which they met 2 of the following 3 standard conditions: their VO_2 reached a plateau with increasing exercise power, their respiratory exchange ratio exceeded 1.1, or their heart rate reached 85% of the estimated maximum heart rate for someone their age (formula: 220 – age).[20]

This study combined the V-slope and ventilatory equivalence methods to determine the participants' ventilatory threshold (Tvent) values.[20] The V-slope method, which is commonly used to determine Tvent, involves plotting the relationship between VCO_2 and VO_2. Tvent is determined from the slopes of the curves for these parameters during the increasing movement mode and by identifying an evident offset point. The ventilation equivalence mode is defined as the exercise intensity point at which the oxygen equivalent (minute ventilation [VE]/VO_2) sharply increases but the carbon dioxide equivalent (VE/VCO_2) does not, indicating Tvent. If the V-slope method fails, the ventilation equivalent method should be used to determine Tvent.

Evaluation of HRV

Throughout the exercise test, electrocardiography (ECG) data were recorded to analyze the participants' HRV activity. The HRV activity at the end of the maximal-intensity exercise period and the 10-min recovery period were recorded to measure the rates of HRV activity recovery during PSC and ISC. A miniature physiological signal recorder (TD3; Taiwan Telemedicine Device Company) was used to obtain ECG (lead II) data throughout the test. HRV is a measure of the fluctuation in time intervals between successive heartbeats (R-R interval in ECG); it indicates the interplay between sympathetic activity and parasympathetic activity. The TD3 recorder processes HRV data in 32-s (unit) intervals for high frequency and low frequency spectrum analysis. Units of 5 min were used for spectrum analysis to monitor the change in overall ANS activity (high-intensity exercise period vs 10-min recovery period). For spectrum analysis, the collected R-R interval ECG signals were subjected to fast Fourier transform through frequency domain analysis. The parameters used in the main analysis were the total power (TP) —a marker of ANS activity, low-frequency power (LF) —a marker of both sympathetic and parasympathetic modulation, high-frequency power (HF) —a marker of parasympathetic activity, LF%—a marker of sympathetic activity, HF%—a marker of sympathetic inhibition, and LF/HF ratio—a marker of the sympathovagal balance.[21] For further details on HRV analysis methods, please refer to previous reports.[11,12,22]

Assessment of sleep quality

The Pittsburgh Sleep Quality Index (PSQI) is widely used for measuring the overall sleep quality of an individual in the month preceding the measurement.[23] This questionnaire comprises 19 items, which assess the following 7 indicators:

sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbance, sleeping medication use, and daytime dysfunction. Each indicator has a unique scoring standard and is scored from 0 to 3 points. The total score ranges from 0 to 21 points. A total score (for the 7 indicators) of > 5 indicates poor sleep quality, whereas a total score of ≤ 5 indicates good sleep quality.

Statistical analysis

The requisite sample size was derived using the G-Power 3.1.9.4 software. Predicated on an a priori power analysis for a repeated-measures ANOVA and leveraging an effect size of .60 [24], with a set power at .80 and alpha of .05, the indicated minimum sample size stood at 24. A sample size of 40 participants was considered appropriate for this study. Repeated-measures analysis of variance was used to analyze the pretest and posttest data corresponding to the PSC period (week 1 vs week 4) and ISC period (week 4 vs week 8; time effect) and to explore the group×time interactions of various parameters in the cupping and sham groups. The following parameters were analyzed: subjective perception (DASH, FLEX-SF, and PSQI data) and objective physiological response (maximal exercise performance and HRV activity). Performance was measured in terms of peak power, exercise test duration, peak heart rate, VO_2peak, and Tvent. Statistical analyses were performed using PASW Statistics (version 23.0; SPSS Inc., Chicago, IL, USA). The level of significance was set at $P < .05$, and tendency was analyzed at $.05 < P < .09$.

Results

Effects of dry cupping on the upper-extremity function of baseball players

After 4 weeks of cupping during PSC, the participants' scores on the DASH questionnaire for upper-extremity disability and exercise disability were not significantly changed (time effect). Furthermore, no significant changes were noted in their scores on the FLEX-SF questionnaire (Table 1). In addition, no significant difference was discovered in the group×time interaction effect after 4-week cupping; this result was consistent with the participants' scores on the DASH and FLEX-SF questionnaires.

After 4 weeks of cupping during ISC, no significant changes were noted in the participants' upper-extremity disability or shoulder disability (time effect). Furthermore, no significant difference in shoulder disability (FLEX-SF) or exercise disability (DASHe) was discovered in the group×time interaction effect. Although the group×time interaction effect for upper-extremity disability (DASHs) exhibited significant difference ($P = .045$), no significant changes were noted in the cupping group; however, a decreasing trend in DASHs was observed in the sham group (Table 1). This finding may be attributable to factors unrelated to cupping during the ISC period

Table 1. Upper-extremity function after short-term regular cupping ($n = 40$).

Upper extremity function	Group	Pre-test	Post-test	P (F) value	
				Time	Group × time
Preseason conditioning (1-4 weeks)					
DASHs	Sham (n=20)	4.19±1.03	4.07±0.88	0.774	0.925
	Cupping (n=20)	3.03±1.03	2.81±0.88	(0.084)	(0.009)
DASHe	Sham (n=20)	4.38±1.99	6.56±2.28	0.594	0.340
	Cupping (n=20)	5.31±1.99	4.69±2.28	(0.288)	(0.934)
FLEX-SF	Sham (n=20)	45.95±1.37	45.35±1.22	0.604	0.951
	Cupping (n=20)	45.95±1.41	45.47±1.25	(0.274)	(0.004)

In-season conditioning (4-8 weeks)

DASHs	Sham (n=20)	4.07±0.88	2.10±0.72	0.066	0.045
	Cupping (n=20)	2.81±0.88	2.89±0.72	(3.587)	(4.285)
DASHe	Sham (n=20)	6.56±2.28	5.31±2.13	0.692	0.692
	Cupping (n=20)	4.69±2.28	4.69±2.13	(0.160)	(0.160)
FLEX-SF	Sham (n=20)	45.68±1.24	46.32±1.19	0.285	0.738
	Cupping (n=20)	45.7±1.21	46.9±1.16	(1.177)	(0.113)

Note: DASH: Disabilities of the Arm, Shoulder, and Hand; DASHs: a disability/symptom unit; DASHe: highly skilled exercise; FLEX-SF: Flexilevel Scale of Shoulder Function.

Data are presented in terms of the mean ± standard error of the mean (s.e.m.).

Effects of dry cupping on exercise performance and aerobic capacity

Cupping during PSC led to no significant changes in most parameters of the maximal exercise test (time effect); only the peak heart rate decreased significantly (P = .041; Table 2). No significant difference was discovered in the group×time interaction effect for any exercise parameter. Compared with the sham group, the cupping group exhibited increasing trends for VO_2max (P = .069) and peak ventilation (P = .078), but neither difference was significant. Furthermore, no significant difference was noted in the time or group×time interaction effect for Tvent (anaerobic threshold) during PSC (Table 2).

Cupping during ISC led to a significant increase in only peak ventilation (time effect; P = .025; Table 2). Upward trends were noted in exercise duration (P = .086), peak power (P = .074), and VO_2peak (P = .068), but the changes were nonsignificant. No significant difference was found in the group×time interaction effect for any exercise parameter, the time effect for Tvent, or the group×time interaction effect for Tvent (Table 2).

Effects of dry cupping on the rate of recovery of HRV activity after the incremental exercise test

Four weeks of cupping during PSC led to no significant changes in the 10-min recovery rate (time×trial interaction effect) of any HRV parameter after high-intensity exercise (Table 3). However, when the between-group difference in HRV recovery was considered (time×trial×group), 4-week cupping was found to significantly improve the rate of LF recovery after intense exercise; the rate was significantly higher in the cupping group than in the sham group (P = .013; Fig. 3; Table 3). A similar, but nonsignificant, trend was noted in the rate of TP recovery (time×trial×group interaction effect; P = .061). However, the rate of HF recovery (time×group interaction effect) was significantly lower in the cupping group than in the sham group (P = .05; Table 3).

Table 2. Participants' performance in the arm-crank exercise test after short-term cupping.

	Group / Parameters	Sham (n=20)		Cupping (n=20)		P (F) value	
		Pre-test	Post-test	Pre-test	Post-test	Time	Group × time
Preseason Conditioning	***Stress test***						
	Duration (s)	423.2±16.6	430.1±18.7	423.2±16.6	445.5±18.7	0.141	0.433
	Peak power	102.8±4.1	104.3±4.6	102.5±4.1	108.4±4.6	0.123	0.343
	VO_{2peak} (ml/kg/min)	22.16±1.29	20.45±1.14	20.57±1.29	21.40±1.14	0.519	0.069
	HRpeak (bpm)	149.9±4.1	142.9±4.6	150.7±4.1	147.8±4.6	0.041	0.375
	VEpeak (L/min)	59.36±3.78	58.00±4.29	51.80±3.78	60.26±4.29	0.197	0.078
	Tvent						
	VO_2 (ml/kg/min)	10.02±0.46	9.86±0.50	9.33±0.46	10.01±0.50	0.484	0.261
	Workload (Watt)	52.55±2.25	55.00±2.65	51.05±2.25	56.65±2.65	0.081	0.487
	HR (bpm)	109.4±3.2	109.4±3.8	111.0±3.2	108.7±3.8	0.659	0.659
In-season Conditioning	***Stress test***						
	Duration (s)	430.1±18.7	454.0±17.6	445.5±18.7	457.6±17.6	0.086	0.566
	Peak power	104.3±4.6	110.6±4.3	108.4±4.6	111.0±4.3	0.074	0.447
	VO_{2peak} (ml/kg/min)	20.45±1.14	21.79±1.42	21.40±1.14	22.78±1.42	0.068	0.975
	HRpeak (bpm)	142.9±4.6	147.2±4.3	147.8±4.6	153.3±4.3	0.124	0.854
	VEpeak (L/min)	58.00±4.26	67.68±4.87	61.44±4.37	65.45±5.00	0.025	0.339
	Tvent						
	VO_2 (ml/kg/min)	9.86±0.50	9.93±0.54	10.01±0.50	11.03±0.54	0.139	0.196
	Workload (Watt)	55.00±2.65	51.45±2.61	56.65±2.65	56.95±2.61	0.512	0.438
	HR (bpm)	109.4±3.8	104.3±2.9	108.7±3.8	111.5±2.9	0.682	0.157

Note: VO_2: oxygen consumption; HR: heart rate; VE: minute ventilation; Tvent: ventilatory threshold.
Data are presented in terms of the mean ± s.e.m.

Table 3. HRV activity recovery after the maximal exercise test during PSC and ISC.

	HRV	week (trial)	Sham (n=20)		Dry cupping (n=20)		P value		
			End of exercise	10 min recovery	End of exercise	10 min recovery	Time × trial	Time × group	Time × trial × group
Preseason Conditioning (1-4 weeks)	TP	1st	4.75±0.18	6.66±0.21	4.95±0.19	6.33±0.22	0.141	0.091	0.061
	[ln(ms^2)]	4th	4.90±0.17	6.76±0.21	4.80±0.18	6.58±0.22			
	LF	1st	3.17±0.24	5.94±0.23	3.37±0.25	5.60±0.24	0.292	0.285	0.013
	[ln(ms^2)]	4th	3.37±0.24	5.97±0.22	3.22±0.25	5.86±0.23			
	HF	1st	1.31±0.24	4.88±0.25	1.80±0.26	4.55±0.26	0.506	0.050	0.149
	[ln(ms^2)]	4th	1.56±0.22	4.99±0.25	1.49±0.23	4.61±0.26			
	LF/HF	1st	1.86±0.13	1.07±0.17	1.57±0.13	1.05±0.18	0.994	0.108	0.841
	(ln ratio)	4th	1.81±0.12	0.99±0.16	1.74±0.13	1.25±0.17			
	LF%	1st	67.4±3.0	69.3±3.0	64.5±3.2	69.0±3.2	0.960	0.360	0.731
		4th	66.5±3.2	67.2±2.9	66.1±3.4	71.6±3.0			
In-season Conditioning (4-8 weeks)	TP	4th	4.90±0.17	6.76±0.21	4.82±0.17	6.57±0.21	0.647	0.221	0.194
	[ln(ms^2)]	8th	5.00±0.24	7.13±0.20	4.74±0.24	6.36±0.20			
	LF	4th	3.37±0.24	5.97±0.22	3.24±0.24	5.87±0.22	0.246	0.793	0.555
	[ln(ms^2)]	8th	3.40±0.33	6.34±0.20	3.02±0.33	5.76±0.20			
	HF	4th	1.56±0.21	4.99±0.24	1.50±0.21	4.56±0.24	0.890	0.071	0.247
	[ln(ms^2)]	8th	1.52±0.33	5.22±0.25	1.30±0.33	4.15±0.25			
	LF/HF	4th	1.81±0.12	0.99±0.16	1.75±0.12	1.31±0.16	0.121	0.004	0.317
	(ln ratio)	8th	1.88±0.13	1.13±0.14	1.72±0.13	1.61±0.14			
	LF%	4th	66.5±3.3	67.2±2.9	66.0±3.3	72.8±2.9	0.050	0.037	0.481
		8th	65.4±3.3	70.0±2.5	63.1±3.3	78.1±2.5			

Noe: HRV: heart rate variability; TP: total power; LF: low-frequency power; HF: high-frequency power; LF/HF: ratio of LF to HF; LF%: LF in normalized unit. Data are presented in terms of the mean ± s.e.m.

Cupping during ISC significantly improved the rate of LF% recovery after intense exercise (time×trial interaction effect; *P* = .05; Fig. 4A; Table 3). The rate of LF% recovery was significantly higher in the cupping group than in the sham group (time×group interaction effect; *P* = .037; Fig. 4B). Furthermore, LF/HF activity 10 min after intense exercise was significantly higher in the cupping group than in the sham group (time×group interaction effect; *P* = .004; Table 3).

Effects of dry cupping on sleep quality during PSC and ISC

After 4 weeks of cupping during PSC, no significant difference was observed in the time effect or group×time interaction effect for the total PSQI score (Table 4). However, significant improvement was noted in the participants' daytime dysfunction (C7 index) score (time effect; *P* = .012). Notably, the degree of improvement was significantly higher in the cupping group than in the sham (group×time interaction effect; *P* = .026). Furthermore, the cupping group exhibited greater improvement trend in sleep latency (C2 index) compared with the sham group (*P* = .060); however, the group×time interaction effect was nonsignificant.

Cupping during ISC led to significant improvements in sleep quality (total PSQI score), sleep latency, and sleep disturbance (time effect; Table 4). However, no significant between-group difference was noted in the group×time interaction effect for any PSQI component.

Table 4. Effects of cupping on sleep quality during PSC and ISC.

	Group / PSQI	Sham (n=20)		Dry cupping (n=20)		P (F) value	
		Baseline	4th week	Baseline	4th week	Time	Group × time
Preseason Conditioning	C1	0.95±0.06	0.90±0.11	0.90±0.06	0.65±0.11	0.109	0.281
	C2	1.55±0.30	2.10±0.25	1.70±0.30	1.45±0.25	0.472	0.060
	C3	1.05±0.18	1.15±0.15	1.20±0.18	1.25±0.15	0.560	0.846
	C4	0.00±0.13	0.05±0.08	0.32±0.13	0.11±0.08	0.422	0.196
	C5	5.20±0.81	6.00±0.96	5.85±0.81	6.00±0.96	0.435	0.593
	C6	0	0	0	0	N/A	N/A
	C7	1.35±0.23	1.30±0.27	1.55±0.23	0.80±0.27	0.012	0.026
	Total	10.10±1.18	11.50±1.28	11.50±1.18	10.25±1.28	0.928	0.118
In-season Conditioning	C1	0.90±0.11	0.75±0.11	0.65±0.11	0.70±0.11	0.531	0.214
	C2	2.10±0.25	1.40±0.27	1.45±0.25	1.05±0.27	0.001	0.329
	C3	1.15±0.15	1.30±0.14	1.25±0.15	1.25±0.14	0.542	0.542
	C4	0.05±0.08	0.10±0.06	0.11±0.08	0.05±0.06	1.000	0.492
	C5	6.00±0.96	4.30±0.85	6.00±0.96	5.60±0.85	0.028	0.165
	C6	0	0	0	0	N/A	N/A
	C7	1.30±0.27	0.85±0.26	0.80±0.27	0.85±0.26	0.320	0.216
	Total	11.5±1.28	8.75±1.13	10.25±1.28	9.50±1.13	0.011	0.137

PSQI, Pittsburgh Sleep Quality Index; C1, sleep quality; C2, sleep latency; C3, sleep duration; C4, habitual sleep efficiency; C5, sleep disturbances; C6, sleep medication; C7, daytime dysfunction; N/A, not available.
Data are presented in terms of the mean ± s.e.m.

Discussions

This study investigated the effects of cupping on athletes during PSC and ISC periods. The findings revealed that regular cupping can improve the quality of sleep during PSC and improve the rate of HRV activity recovery after intense exercise. Cupping accelerated the recovery of both sympathetic and parasympathetic modulation during PSC but only that of sympathetic activity during ISC. However, cupping exerted no significant effects on the participants' perceived upper-extremity function, shoulder function, or aerobic capacity. The present study clarifies the effects of cupping during PSC and ISC on athletes' upper-extremity function, aerobic capacity, ANS activity and recovery rate, and sleep quality.

This study revealed that cupping did not exert a significant effect on the participants' upper-extremity function or shoulder function during PSC or ISC (Table 1). This finding differs from the previous studies, Chen et al (2017) demonstrated that cupping during the recovery period after strenuous exercise resulted in immediate alleviation of muscle fatigue.[11] Similarly, Hou et al (2021) reported that cupping significantly reduced fatigue induced by continuous curling of the biceps.[10] A comprehensive review of the literature confirmed that cupping enhances blood flow, increases the oxygenated hemoglobin level in the treated area, facilitates metabolite elimination, and reduces pain, all of which make cupping a promising intervention for musculoskeletal and sports rehabilitation.[8] The discrepancy between the present and previous studies may be attributable to the absence of evident functional impairment in the participants' upper extremities. This inference is supported by the participants' scores on the DASH and FLEX-SF questionnaires. In the present study, the participants' scores on the DASH questionnaire (maximum score: 100 points) ranged from approximately 3 to 6 points. Their scores on the FLEX-SF questionnaire (maximum score 50 points) ranged from 45 to 46 points. Because of the existence of a ceiling effect, this study was unlikely to discover cupping-mediated significant improvements in upper-extremity function and shoulder function.

This study explored the effects of regular cupping on athletes' performance in a maximal exercise test and found no significant group-by-time interaction in peak power, VO_2peak, or Tvent during PSC or ISC (Table 2). This finding is consistent with the study of Chen et al (2017), who investigated the immediate effects of cupping after strenuous exercise, in which no apparent effect was observed on any parameter of the maximal exercise test.[11] In the present study, cupping during PSC tended to increase the cupping group's VO_2peak to higher that of the sham group ($P = .069$). This trend may be attributable to the positive effects cupping on blood flow[15] and the oxygenated hemoglobin level[16] in the treated area. The time effect of cupping during ISC was found to generally result in increases in peak power and VO_2peak ($P = .074$ and .068); however, no such trend was discovered for cupping during PSC. This study speculates that the participants experienced high levels of competition pressure during ISC, likely because of higher morale during ISC than during PSC. However, the aforementioned trend did not achieve statistical significance, and its effect on the participants' actual competition performance might have been limited.

Repeated high-intensity exercise impairs short-term parasympathetic reactivation.[25] HRV parameters are used to analyze the body's stress response during training; these parameters can offer insights into physiological recovery after training.[26] The rate of HRV recovery after exercise is significantly correlated with subsequent exercise performance.[7] Therefore, enhancing the rate of ANS activity recovery after exercise-induced fatigue is crucial for improving exercise performance. Evidence suggests that cupping can restore HRV activity by stimulating the peripheral nervous system to regulate ANS imbalance.[12,13]

Cupping during PSC increased the rate of HRV activity recovery after the maximal exercise test ($P < .05$ for LF and TP; Table 3). As shown in Fig. 3, after 4 weeks of regular cupping, the LF activity of the cupping group was rapidly regained after high-intensity exercise; however, the sham group exhibited no significant change in the rate of LF recovery after high-intensity exercise. As shown in Table 3, cupping during ISC primarily affected the LF/HF ratio ($P = .004$) and LF% ($P = .037$); this finding indicates that cupping influences the rate of recovery of sympathetic activity. The rate of sympathetic activity recovery after high-intensity exercise was significantly higher in week 8 than in week 4 ($P = .050$; Fig. 4A). Furthermore, the rate of LF% recovery was significantly higher in the cupping group than in the sham group ($P = .037$; Fig. 4B). Therefore, cupping significantly enhances the recovery of ANS activity after intense exercise, but the effects of cupping differ between PSC and ISC periods. Cupping improved the rates of recovery of both sympathetic and parasympathetic modulation during PSC but only that of sympathetic activity during ISC. This study postulates that frequent competitions during ISC keep athletes in a state of sympathetic nerve excitement, which results in lower sympathetic activity and a lower recovery rate after high-intensity exercise. Regular cupping can increase the rate of sympathetic activity recovery, as evident from the changes in LF% in the present study, which may contribute to the trend toward improved sports performance during ISC ($P = .074$ for peak power; Table 2).

The present findings revealed that baseball players typically have poor sleep quality: the participants' total PSQI scores consistently exceeded 5 (average score range: 8.75 to 11.5) during both PSC and ISC. The total PSQI score was consistently higher during PSC than during ISC. Sleep quality improved significantly during ISC (total PSQI score decreased; $P = .011$). These findings are consistent with those of other studies.[25,26,27] Mah et al (2018) reported that college athletes frequently have poor sleep quality and exhibit daytime sleepiness and that these individuals experience poorer sleep quality when on campus than when traveling for competitions.[25] The primary contributors to sleep disturbance in elite athletes are training, travel, and competition.[26] Poor sleep negatively affects cognitive function, physical function, and sports performance.[28,29] Although insomnia is primarily treated using medications, the pharmacological approach often entails side effects.[30] Cupping, a nonpharmacological approach, offers a convenient and safe alternative and is supported by studies demonstrating its efficacy in mitigating insomnia symptoms and enhancing sleep quality.[17] In the present study, cupping significantly improved daytime dysfunction during PSC ($P = .026$) and exhibited a tendency to improve sleep latency ($P = .060$). However, the overall improvement in sleep quality during ISC (time effect; $P = .011$) might have stemmed from changes in sleep latency ($P = .001$) and sleep disturbance ($P = .028$), rather than cupping; this observation may be related to competition stress and exercise-induced fatigue.

The present study has some limitations. First, because athletes from the same team were recruited, the sample size was small. Second, although training modes and intensities are similar among athletes on the same team, these similarities were limited to the PSC period. With the beginning of the ISC period, coaches made tactical arrangements and scheduled tasks for key players. Consequently, during ISC, pressure and fatigue levels were likely to vary across the sample. Thus, when assessing the effects of cupping during ISC, this study found it challenging to avoid interference due to the disparities in the participants' physiological or psychological status. Finally, to avoid disrupting the team's normal schedule and competitions, simultaneous cupping and evaluation sessions could not be scheduled. Typically, evaluations were performed the day after each cupping session. Thus, the residual (next day) rather than the immediate effects of cupping were observed.

Conclusion

The present findings revealed that the effects of dry cupping on subjective perceptions and objective physiological responses differ between PSC and ISC periods. Poor sleep quality is prevalent among elite athletes. Cupping was found to mitigate daytime dysfunction and sleep latency during PSC; however, its effects were less pronounced during ISC. During PSC, cupping significantly increased the rate of recovery of both sympathetic and parasympathetic modulation after intense exercise. By contrast, during ISC, cupping increased the rate of recovery of only sympathetic activity. However, cupping did not exert any significant effect on aerobic capacity or perceived upper-extremity function. Further studies are required to determine the effective dosage of cupping that translates into tangible performance benefits.

Declarations

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Author contributions

C.-L.C. and C.-C.C. conceived and designed the study; C.-L.C. and J.-S.T. collecting the data; C.-L.C., J.-S.T., and C.-C.C. contributed in statistical analysis, data interpretation and manuscript drafting and revising. The final version of manuscript for submission was approved by all authors for submission.

Data availability statement

Data will be made available upon reasonable request from the corresponding author.

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Competing Interests Statement

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Ethical statement

The studies involving humans were approved by Human Research Ethics Review Committee of National Cheng Kung University (NCKU HRECF-107-013-2). The studies were conducted in accordance with the institutional requirements. The participants provided their written informed consent to participate in this study.

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Figures

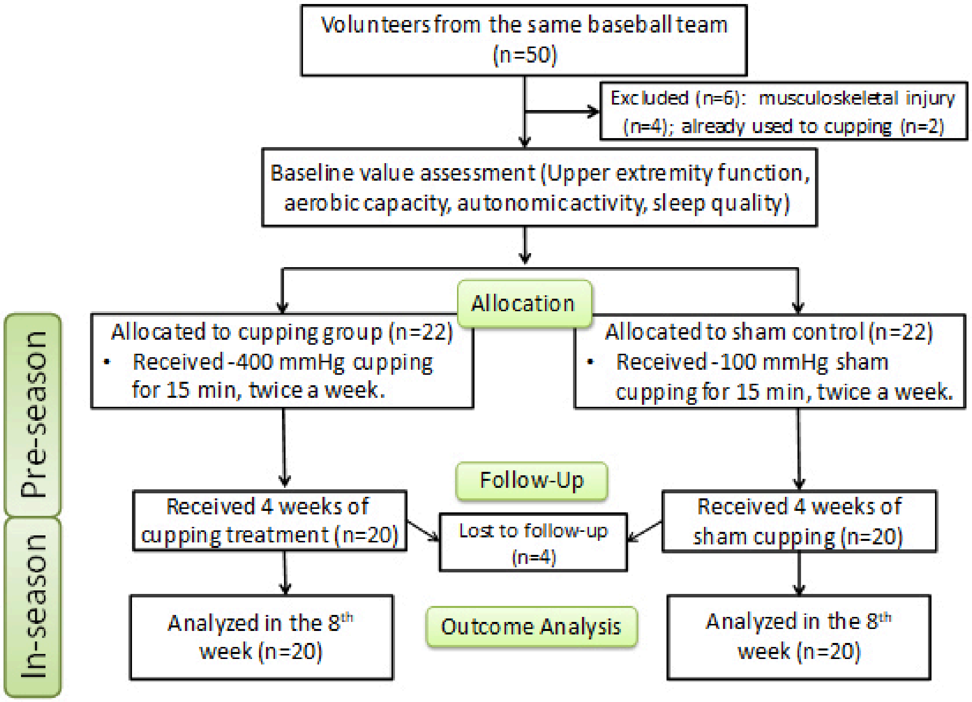

Figure 1

Flowchart depicting the experimental procedure.

Figure 2

Placement of 7 cups for dry cupping on a participant’s upper back and bilateral deltoid muscle.

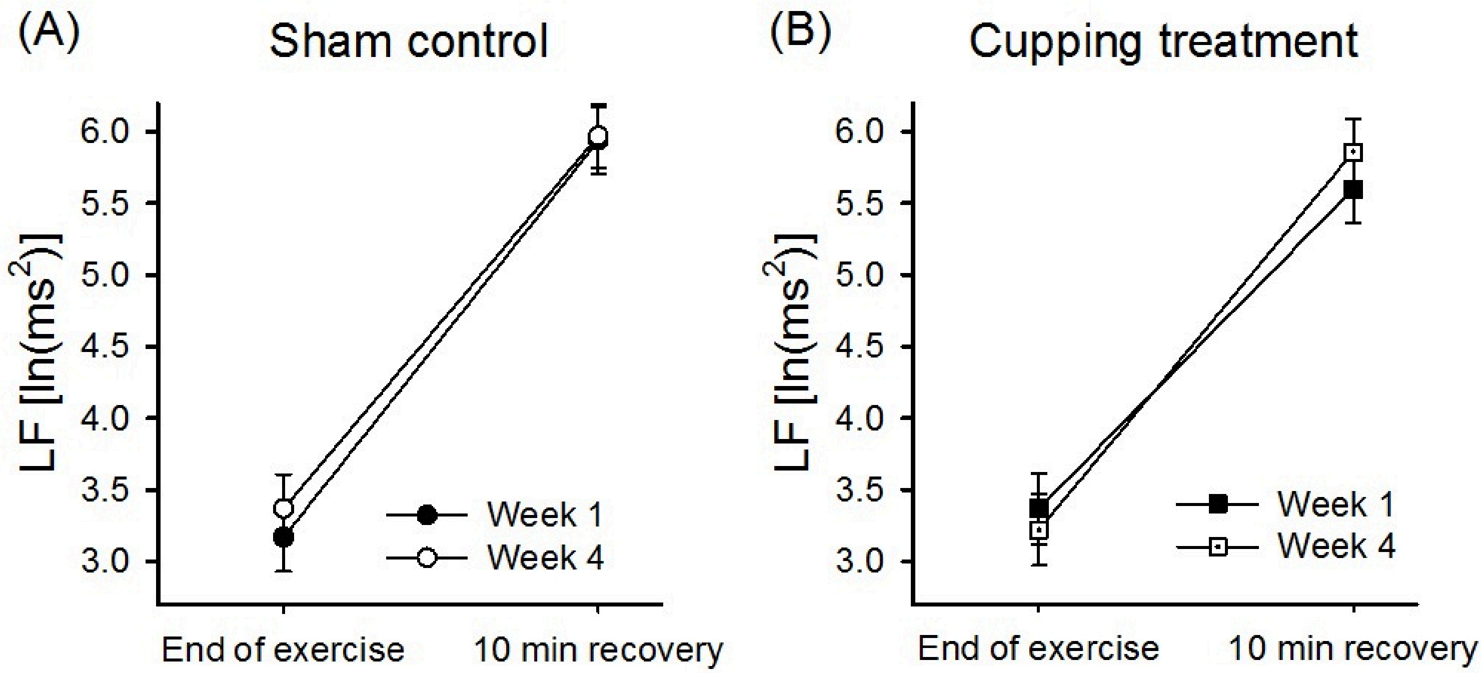

Figure 3

Recovery of LF activity in the cupping and sham groups after intense exercise. After 4 weeks of cupping, the rate of LF recovery was significantly higher in the cupping group than in the sham group (time×trial×group interaction effect; $P = .013$). (A) Sham group's response did not differ between weeks 4 and 1. (B) Cupping group's postexercise recovery rate was significantly better in week 4 than in week 1.

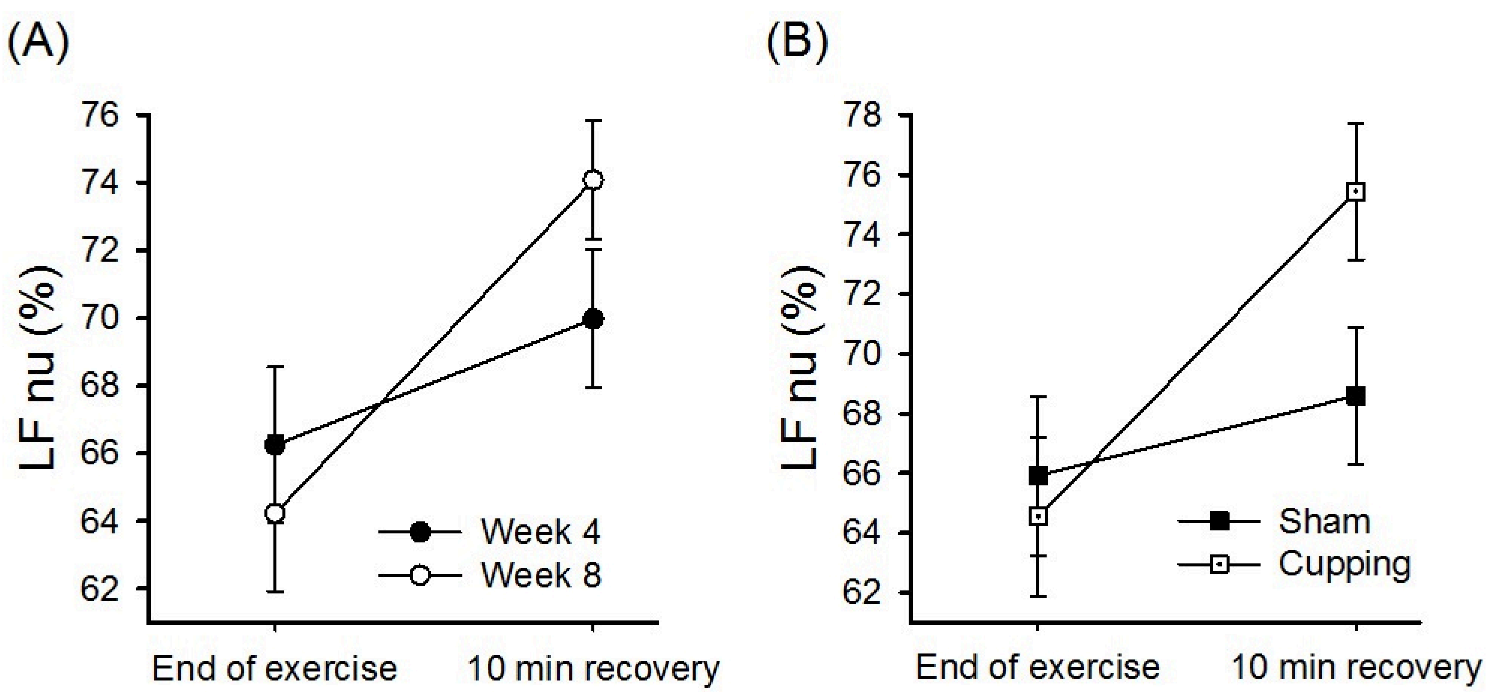

Figure 4

Effects of cupping on postexercise LF% recovery after strenuous exercise. (A) Four-week cupping significantly improved the rate of LF% recovery (time×trial interaction effect; $P = .05$) during ISC. (B) Rate of postexercise LF% recovery was significantly better in the cupping group than in the sham group (group×time interaction effect; $P = .037$).