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High-intensity interval training vs. yoga in improving binge eating and physical fitness in inactive young females

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Yoga is effective in binge eating disorder (BED) treatment, but it does not seem effective enough to improve low physical fitness. In contrast, high-intensity interval training (HIIT) is effective in improving physical fitness but has never been studied in the context of BED. In the study, 47 young inactive females with mild to moderate BED were recruited and randomly assigned to a HIIT group (HIIT), a Yoga group (YG), or a control group (CG; age, 19.47 ± 0.74, 19.69 ± 0.874, and 19.44 ± 0.63 years; BMI, 21.07 ± 1.66, 21.95 ± 2.67, and 20.68 ± 2.61 kg/m^2, respectively). The intervention groups participated in 8-week specific exercises, while the CG maintained their usual daily activity. Before and after the training, participants were evaluated for BED using the binge eating scale (BES) and for physical fitness. The obtained data were compared within groups and between groups, and a correlation analysis between BES and physical fitness parameters was performed. After the training, the YG presented significant improvements in BES (− 20.25%, $p = 0.006$, $\eta_p^2 = 0.408$), fat mass (FM, − 3.13%, $p = 0.033$, $\eta_p^2 = 0.269$), and maximal oxygen consumption (VO_2max, 11.51%, $p = 0.000$, $\eta_p^2 = 0.601$), whereas the HIIT showed significant improvements in body weight (BW, − 1.78%, $p = 0.006$, $\eta_p^2 = 0.433$), FM (− 3.94%, $p = 0.033$, $\eta_p^2 = 0.285$), and BMI (− 1.80%, $p = 0.006$, $\eta_p^2 = 0.428$), but not in BES. Comparisons between groups revealed that both HIIT and YG had significantly higher VO_2max levels than CG (HIIT 12.82%, $p = 0.006$, $\eta_p^2 = 0.088$; YG: 11.90%, $p = 0.009$, $\eta_p^2 = 0.088$) with no difference between HIIT and YG. Additionally, YG presented significantly lower BES than both HIIT (15.45%, $p = 0.02$, $\eta_p^2 = 0.03$) and CG (11.91%, $p = 0.022$, $\eta_p^2 = 0.03$). In conclusion, Yoga is an effective treatment for BED, but HIIT is not, despite its high efficacy in improving physical fitness.

Keywords High-intensity interval training, Yoga, Young inactive females, Binge eating disorder, Physical fitness

Binge eating disorder (BED) is a psychiatric disorder characterized by recurrent binge eating episodes which are not followed by inappropriate compensatory behaviors[1]. The mean age of BED onset is between 20 and 25 years, and it is more common in women than men, with lifetime prevalences of 3.5% and 2.0%, respectively[2]. BED can occur in individuals who are normal-weight, overweight, and/or obese individuals, and it is generally associated with self-reported insufficient activity[3].

Diet and cognitive behavior therapy are the most common treatments for BED[4], yet individual susceptibility varies widely. People with BED are generally associated with inadequate physical activity and low physical fitness, often accompanies by depression and anxiety[5]. As a result, physical exercise has recently gained much attention

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for its potential benefits in improving both BED[6] and physical fitness[7,8]. Yoga is a typical low- to moderate-intensity exercise[9] that is scalable for many fitness levels and considered safe for special populations[10]. Yoga has been shown to significantly improve binge eating behaviors and reduce food preoccupation[11,12]. Recent studies have shown that Yoga could induce positive changes in various psychophysiological markers in individuals with obesity, alleviating physical limitations and chronic pain[13,14]. The influence of Yoga on BED is believed to be related to increased body awareness and body reactivity[15]. Consequently, Yoga has been preliminarily considered an additional treatment option in multimodal psychiatric treatment programs[15]. However, Yoga may be too low in intensity to improve physical fitness[16] in individuals with BED, especially those with obesity and metabolic syndrome.

High-intensity interval training (HIIT) is a form of high intensity physical exercise that involves repeated short bursts of intense exercise interspersed brief recovery periods[17]. Extensive evidence has shown the effectiveness of HIIT in improving physiological functions and physical fitness in both young and the elderly[18], as well as in both healthy and sick individuals[19]. HIIT has also been shown to benefit appetite regulation[20], promote spontaneous modulation of food choices, and regulate dietary intake[21]. Therefore, it is plausible to assume that HIIT might be helpful for individuals with BED in terms of both physical fitness and binge eating. However, evidence also suggests that moderate to vigorous physical activity is directly associated with increased food intake compared to general activity level[22]. This can perpetuate a cycle of binge eating and excessive exercise, contributing to overall physical and psychological distress.

Previous studies on overweight and obese adults have shown that HIIT could potentially offer comparable or greater benefits than moderate-intensity continuous training (MICT) in improving adherence, enjoyment, affective responses, quality of life, anxiety, and depression[23]. Yet, to our knowledge, no study to date has compared the effects of HIIT and Yoga on improving BED and physical fitness. The present study applied HIIT and Yoga in two groups of young inactive females with mild to moderate binge eating (BE). As the participants were young, with slightly lower physical fitness than average general and in the early stage of binge eating, we hypothesize that HIIT may be more effective than Yoga in improving physical fitness, such as body composition and aerobic capacity, and thereby reducing binge eating scores to a level comparable to that induced by Yoga. Thus, HIIT might be a potential alternative for the physical treatment of BE, comparable to Yoga.

Methods

Participants

A total of 384 young female university students were recruited through campus posters. The reason of only including females in the study is that BED occurs more often in female than in male. The inclusion criteria were: (1) volunteer participation in the study; (2) a mild to moderate binge eating problem, defined as a binge eating score (BES) of $18 < BES < 27$ (evaluated by a clinician); (3) the BE problem was not being treated by a clinical physician or psychiatrist; and (4) physically inactive, defined as metabolic equivalent minutes (MET) < 600 MET/week (assessed with an accelerometer, New Lifestyles NL-2000). The exclusion criteria were: (1) several binge eating problems, BES > 27 (7 students were excluded); (2) physically active, MET > 600 MET/week (272 students were excluded); (3) the binge eating problem was treated by a clinical physician or psychiatrist (10 students were excluded); (4) other acute or chronic diseases such as cardiorespiratory disease or diabetes (3 students were excluded); and (5) inability to complete the study (45 students were excluded).

According to Cohen classification, effect size (d) of 0.2 is considered small, 0.5 is medium, and larger than 0.8 is large[24]. Additionally, according to Serdar[25], the larger the effect size, the smaller the required sample size. In the present study, a medium effect size of 0.52 was selected to achieve a medium sample size, which was deemed appropriate considering both the time-consuming process of recruiting enough participants and financial constraints, as well as ensuring statistical reliability in the outcomes. Accordingly, with the effect size of 0.52, a calculated sample size of 39 with $\alpha = 0.05$ and power = 0.8 was obtained. Ultimately, 47 individuals completed the study, exceeding the calculated sample size.

Using a R software (version 4.0.0, https://www.r-project.org/), the 47 participants were randomly assigned to the HIIT group (HIIT, $n = 15$), the Yoga group (YG, $n = 16$), and the control group (CG, $n = 16$, Table 1). Anthropology data of the participants, including height, body weight, body mass index (BMI), and BES as well as maximal oxygen consumption (VO_2max) were measured and statistically analyzed. No significant difference was observed in any parameter between the groups.

				ANOVA		
	HIIT	YG	CG	F	*p*	Reference value
Age (year)	19.47 (0.74)	19.69 (0.87)	19.44 (0.63)	0.520	0.598	18.00–22.00[35]
Body weight (kg)	56.26 (5.49)	57.75 (5.82)	55.32 (8.27)	0.540	0.587	51.37 (6.86)[34]
Fat mass (kg)	17.51 (2.50)	18.88 (3.22)	17.25 (3.97)	1.112	0.338	11.68 (3.83)[34]
BMI (kg/m^2)	21.07 (1.66)	21.95 (2.67)	20.68 (2.61)	1.196	0.312	17.20–23.90[35]
VO_2max (ml/kg/min)	34.87 (4.94)	34.75 (3.82)	34.25 (2.46)	0.114	0.893	38.70 (6.30)[36]
BES	22.13 (3.46)	23.75 (4.25)	21.25 (3.30)	1.588	0.216	

Table 1. Biometric data of the participant and reference values. *HIIT* high-intensity group ($n = 15$), *YG* Yoga group ($n = 16$), *CG* control group ($n = 16$). Data are expressed as mean (standard deviation).

This study was approved by the local Sports Science Experimental Ethics Committee at Beijing Sport University (BSU2021170H) and was conducted in accordance with the Declaration of Helsinki. All the participants provided their written informed consent, and the privacy of the participants was guaranteed.

Experimental procedures

The total experimental period was 11 weeks, and the procedures are shown in Table 2. In the first week, BES and physical activity level were evaluated, followed in the second week by measurements of the basic biometric data of all the participants, including height, body weight, body composition, BMI, fat mass, and VO_2max. During 3–10 week, the HIIT and Yoga training programs were conducted. Participants were instructed to avoid participating in any forms of regular physical exercise for three months prior to the study. During the last week (week 11), biometric tests, BES, and VO_2max were repeated for all participants.

Measurements

BES test: the test was conducted using the website of https://psychology-tools.com/binge-eating-scale/ in a quiet room. The BES was developed by Gormally[26] and consists of 16 items, each with 3 to 4 options. Each option is assigned a score of 0, 1, 2, or 3 (0 indicates that there is no binge eating problem, 3 reflects a severe binge eating problem). The total score of the scale ranges from 0 to 46, with a higher total score indicating more severe in binge eating problems. No binge eating was defined as a BES score ≤ 17, mild to moderate binge eating as a BES score between 18 and 26, and severe binge eating as a BES score of 27 or higher[27].

MET test: Metabolic Equivalent of Task (MET) level or activity level was evaluated over 6 consecutive days using an accelerator (New Lifestyles NL-2000, USA), worn for no less than 10 h per day from the moment of waking until going into bed, except during swimming and bathing. Participants needed to have an activity level of less than 600 MET.

Biometric test: the participants' height was measured using a stadiometer (Jianmin, China), body weight was measured using a weight scale (Jianmin, China), and BMI was calculated as body weight/height^2 (kg/m^2). Body composition was measured using the dual energy X-ray absorptiometry (Lunar iDXA, GE Healthcare, USA). Weight and body composition measurements were performed in the morning after overnight fasting.

VO_2max test: the test was conducted on a treadmill (H/P/Cosmos, Germany) with a Meta Max3B gas metabolism meter (Cortex, Germany). Participants followed a Modified Bruce protocol, and the test was stopped when any three of the four following criteria (exhaustion criteria)[28] were met: (1) O_2 uptake reached a plateau despite increased workload; (2) respiratory exchange ratio ≥ 1.15; (3) HR within $\pm 5\%$ of age-predicted maximum (207–0.7 × age), and (4) inability to continue exercising.

Interventions

HIIT module: the participants engaged in treadmill training under the supervision of an exercise physiologist. The HIIT protocol began with a 5-min regular warm-up, followed by four repetitions of 3 min of brisk running at 90% VO_2max intensity with 2 min of active recovery at 50% VO_2max, and 5 min of cooling down between repetitions, totally about 30 min per day[29]. Participants were instructed to avoid any form of aerobic exercise outside of the specific exercise intervention. HIIT was conducted three times a week for 8 weeks.

Yoga module: Yoga practice was conducted under the instruction of two professional Yoga instructors. Each session lasted 60 min and was held three times a week. A session consisted of 5 min of meditation and breathing, 45 min of asanas, and 10 min of relaxation. If participants were unable to perform a specific pose, they were allowed to perform a similar but easier pose. Details of the Yoga practice are shown in Table 3.

Statistics

Statistical analysis was conducted using the Statistical Package for the Social Sciences (SPSS, V.25.0, IBM Corporation, USA). Comparisons of variables before training between groups were analyzed using analysis of variance (ANOVA).Body composition, VO_2max, and BES were analyzed using 2 (Time: pre- and post-) × 3 (Conditions: HIIT, YG, and CG) repeated measures analysis of variance. Effect sizes were calculated for Time (M post-test − M pre-test/Pooled SD) and Condition (MYG − MHIIT/Pooled SD post-test; MYG − MCG/Pooled SD post-test; MHIIT − MCG/Pooled SD post-test). Correlation analyses were conducted using the Spearman's rank correlation coefficient to explore the relationship between BES and other parameters. Descriptive statistics were presented as mean (standard deviation) and/or ranges (minimum - maximum). Statistical significance was set at $p \leq 0.05$.

Results

After the specific training, the YG group presented significantly lower BES [F (2, 10.323) = 7.112, $p = 0.006$, $\eta_p^2 = 0.408$] and fat mass [F (2, 5.525) = 3.025, $p = 0.033$, $\eta_p^2 = 0.269$], whereas the group HIIT showed

Week	Biometric test	BES test	MET test	VO_2max test	HIIT or yoga
1		x	x		
2	x			x	
3–10					x
11	x	x		x	

Table 2. Experimental procedures.

Stage	Contents	During and repetitions
Beginning/preparation	Meditation and Pranayama (abdominal breathing)	5 min
Warm-up	Stretching muscles of upper limbs and neck, Sun Salutation (Surya Namaskar)	5 min
Major part/Asanas	1. Standing asanas: Mountain Pose (Tadasana), Tree Pose (Vrksasana), Phantom Chair Pose (Utkatasana), Standing Forward Bend (Uttanasana), Warrior I (Virabhadrasana I), Warrior II (Virabhadrasana II), Warrior III (Virabhadrasana III), Crescent Pose (Anjaneyansana), Triangle Pose (Trikonasana), Extended Triangle Pose (Utthita Parsvakonasana).	All poses were practiced once, totally around 40 min
	2. Semi-standing asanas (palm and foot support): Latch Pose (Parighasana), Cat Pose (Marjaryasana), Cow Pose (Bitilasana), Plank Pose (Phalakasana), Side Plank Pose (Vasisthasana), Half-moon Pose (Ardha Chandrasana).	
	3. Seated asanas: Staff Pose (Dandasana), Seated Forward Bend Pose (Paschimottanasana), Hero Pose (Virasana), Butterfly Pose (Baddha Konasana), Seated Twist Pose (Marichyasana), Boat Pose (Paripurna Navasana), Half Pinal Twist Pose (Vakrasana), Seated Forward Bend (Paschimottanasnana), Marichi Pose (Marichyasana).	
	4. Supine and lying asanas: Bow Pose (Dhanurasana), Bridge Pose (Setu Bandha Sarvangasana), Locust Pose (Salabhasana), Child Pose (Balasana), Reclined Butterfly Pose (Supta Baddha Konasana)."	
Ending/Relaxation	Stretching muscles of lower limbs and hip, Corpse Pose (Shavasana)	10 min

Table 3. Yoga module.

Variable	Group	Pre	Post	*p*	*p*		
					YG vs. HIIT	YG vs. CG	HIIT vs. CG
Body weight (kg)	HIIT	56.26 (5.49)	55.26 (5.23)	0.006	0.896	0.505	0.432
	YG	57.75 (5.82)	57.31 (5.87)	0.361			
	CG	55.32 (8.27)	55.52 (8.11)	0.373			
Fat mass (kg)	HIIT	17.51 (2.50)	16.82 (2.03)	0.033	0.138	0.686	0.123
	YG	18.88 (3.22)	18.29 (3.29)	0.033			
	CG	17.25 (3.97)	17.31 (4.17)	0.690			
BMI (kg/m^2)	HIIT	21.07 (1.66)	20.69 (1.50)	0.006	0.116	0.916	0.370
	YG	21.95 (2.67)	21.80 (2.84)	0.411			
	CG	20.68 (2.61)	20.76 (2.57)	0.348			
VO_2max (ml/kg/min)	HIIT	34.87 (4.94)	39.07 (5.50)	0.000	0.836	0.009	0.006
	YG	34.75 (3.82)	38.75 (3.80)	0.000			
	CG	34.25 (2.46)	34.63 (3.16)	0.333			
BES	HIIT	22.13 (3.46)	22.40 (4.50)	0.797	0.020	0.022	0.998
	YG	23.75 (4.25)	18.94 (6.46)	0.006			
	CG	21.25 (3.30)	21.50 (2.10)	0.348			

Table 4. Results and comparisons of body composition, VO_2max, and BES. Data are presented as mean (standard deviation). *Pre* pre-training values, *Post* post-training values, *HIIT* high-intensity group ($n=15$), *YG* Yoga group ($n=16$), *CG* control group ($n=16$).

significant reductions in all three parameters of body composition, including body weight [$F(2, 10.692)=2.973$, $p=0.006$, $\eta_p^2=0.433$], fat mass [$F(2,5.598)=3.025$, $p=0.033$, $\eta_p^2=0.285$], and BMI [$F(2, 10.486)=3.011$, $p=0.006$, $\eta_p^2=0.428$], but not in BES (Table 4). Additionally, after the training, both groups showed significant improvements in VO_2max [HIIT: $F(2, 37.646)=10.666$, $p=0.000$, $\eta_p^2=0.729$; YG: $F(2, 22.588)=10.666$, $p=0.000$, $\eta_p^2=0.601$]; however, no significant difference was observed in VO_2max between the two groups post training (Table 4).

Comparisons between groups revealed that the YG group had significantly lower BES scores than both the HIIT group [$F(2, 44)=3.829$, $p=0.020$, $\eta_p^2=0.030$] and the CG group [$F(2 ,44)=3.829$, $p=0.022$, $\eta_p^2=0.030$], whereas the HIIT group showed no significant difference in BES scores compared with the CG group. Moreover, no significant difference was observed in any parameter of body composition between the HIIT and YG groups (Table 4). Correlation analysis revealed a significant correlation only between BES and body weight in the HIIT group ($r=0{,}692$, $p=0.004$; Table 5).

Discussion

The study, for the first time, evaluated the effects of high-intensity interval training (HIIT) on improving BED and physical fitness in young inactive females and compared these effects with those of Yoga. The results showed that while HIIT did not induce significant improvement in BED, it did significantly improve physical fitness. In contrast, Yoga led to significant improvements in both BED and VO_2max. These results indicate that Yoga is an optimal treatment for BED, most likely through psychiatric regulation, whereas HIIT was not effective in improving BED through physical fitness, even in young females with mild to moderate BED.

Group	Body weight (kg)		Fat mass (kg)		BMI (kg/m^2)		VO_2max (ml/kg/min)	
	r	*p*	*r*	*p*	*r*	*p*	*r*	*p*
HIIT	0.692	0.004	0.370	0.175	0.353	0.196	0.324	0.239
YG	− 0.264	0.324	0.034	0.900	0.119	0.662	0.013	0.960
CG	− 0.055	0.840	0.223	0.407	− 0.045	0.870	− 0.186	0.490

Table 5. Correlation analysis of BES with body composition and VO_2max. *HIIT* high-intensity group ($n = 15$), *YG* Yoga group ($n = 16$), *CG* control group ($n = 16$).

HIIT is a time-efficient strategy that elicits physiological and psychological adaptations linked to improved physical fitness and metabolic health, making it particularly effective for individuals with overweight and obesity. It improves body composition, glucose and lipid metabolism, blood pressure, and cardiorespiratory fitness[30,31]. Consistent with previous observation, the 8-week high-intensity interval training program in this study led to significant improvement in physical fitness (VO_2max) and body composition, including reductions in body weight, fat mass, and BMI. Evidence has also suggested a relationship between BED and body mass index (BMI) and obesity in both clinical and non-clinical populations[32,33]. This relationship holds true even in young inactive females with mild to moderate BE, who often have slightly higher body weight, fat mass[34], and BMI[35], but lower VO_2max[36] compared to age-matched healthy girls. HIIT has been shown to improve body composition in both healthy and BED patients[37,38].

However, despite the significant improvement in physical fitness observed in this study, HIIT did not lead to a corresponding improvement in BED. Additionally, correlation analysis revealed that in the HIIT group, BES did not present significant correlation with most physical fitness parameters. These results suggest that BED cannot be rectified solely through improvement in physical fitness. This may be due to the adverse effects of HIIT on eating habits, as vigorous physical activity is directly associated with binge eating and increased appetite. Previous study, have indicated that while high-intensity exercise can increase energy expenditure and improve metabolic health, potentially aiding in weight management (a concern for individuals with BED[39]), HIIT does not to induce compensatory increase in energy intake compared to moderate-intensity exercise[40].

Evidence has shown that high-intensity exercise is associated with mood improvements and reductions in depressive symptoms, common co-occurring factors in BED[41]. Intense physical activity can serve as a stress-relieving outlet, potentially reducing the likelihood of using binge eating as a coping mechanism for stress and negative emotions[42]. However, this study revealed that HIIT did not significantly improve BED. Although psychiatric parameters such as mood, self-esteem, self-image, depression, binge eating frequency were not individually evaluated, self-image and food intake behavior were assessed through the integrative BES parameter. In the HIIT group, BES was only significantly correlated with body weight and not with any other physical fitness parameter. These results indicate that high-intensity interval training did not function as a stress- or depression-relieving outlet in this context.

The 8-week Yoga intervention significantly improved BED, consistent with previous studies where Yoga led to significant reductions in BES[43] and the frequency of binge eating episodes[12]. Individuals with BED are often accompanied by anxiety, depression, and guilt[44,45], and low- to moderate intensity physical exercise has been shown to reduce the severity of anxiety and depression[46,47]. Yoga is believed to enhance body awareness, body image, body connection, and other aspects that are particularly helpful in reducing binge eating[48]. In this study, despite significant improvement in BES and a reduction in fat mass, no significant correlation was observed between BES and any physical fitness parameter. These results suggest that the significant improvement in BES induced by Yoga, a typical low- to moderate intensity exercise, is not associated with physical fitness improvement but with psychiatric regulation. However, the study did not demonstrate a direct correlation between BES and fat mass or any other physiological parameters in the Yoga group, reinforcing the notion that BED is primarily a psychiatric disorder[15].

Conclusions

This present study revealed that HIIT cannot effectively improve binge eating, while Yoga can. In contrast, Yoga only induced significant improvement in VO_2max, whereas HIIT significantly improved all physical fitness parameters. We concluded that Yoga, rather than HIIT, is the optimal physical treatment for the psychiatric disorder of BED.

Limitations

The interpretation of the current results should be approached with caution due to several limitations. Firstly, the sample size was small, and the participants were limited to young inactive young females. Secondly, the 8-week physical training may not capture long-term training effects. Additionally, the study did not include diet control, which could be a confounding factor. Finally, the study did not assess mood along with BED symptoms, making it difficult to fully interpret some results, particularly the findings of the correlation analysis between BED and body composition. Future research should include a more diverse sample, extend the training period, use objective measures of dietary intake and physical activity, and assess mood to further examine the risks and potential benefits of HIIT for BED, the conditions for its application, even the possibility of combining Yoga with other therapeutic interventions for a holistic approach to managing BED.

Data availability

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request (ss.mao@bsu.edu.cn).

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Study concept and design: HML, CJL, CQY, JGY and SSM. Acquisition, analysis, or interpretation of data: all authors. Drafting of the manuscript: HML, CJL, YHS, JGY and SSM. Critical revision of the manuscript for important intellectual content: all authors. Statistical analysis: HML, CJL. Administrative, technical, or material support: LZ, CQY and SSM. Study supervision: SSM.

Declarations

Competing interests
The authors declare no competing interests.

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