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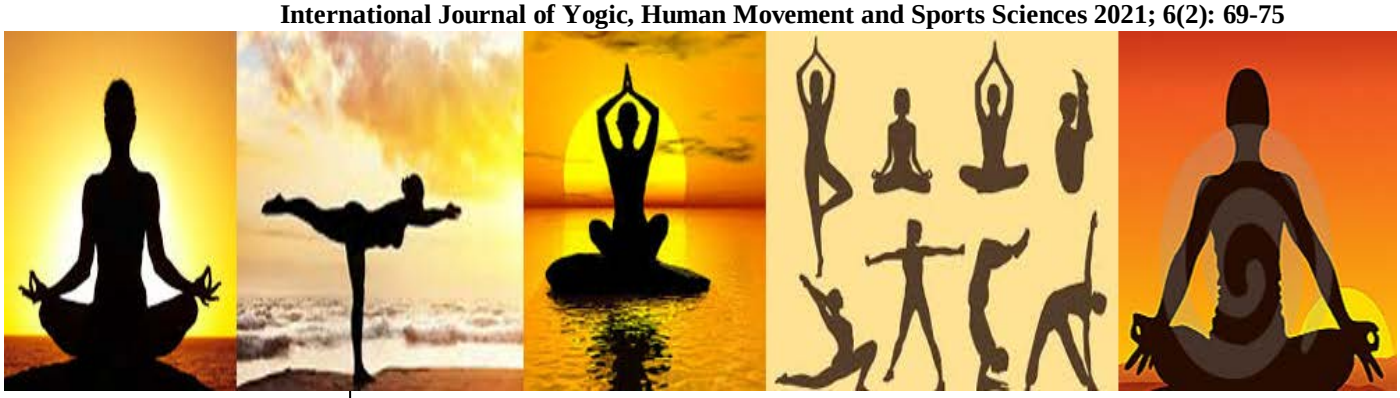

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Effect of obesity yoga therapy on psychological determinants and heart rate variability in obese individuals

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Abstract
Background: Obesity is associated with stress, anxiety, and decreased quality of life an epidemic responsible for metabolic disorders. Yoga a holistic approach is aimed at restoring the abnormalities of body and mind physiology to normal, thereby restoring health. The study aimed to assess the effect of yoga therapy on perceived stress, anxiety, quality of life, and heart rate variability in obese individuals.
Materials and Methods: 60 obese individuals were recruited for the study based on inclusion and exclusion criteria. The study population was divided into case group (n=30) received yoga therapy for 10 days with routine lifestyle and diet, and control group (n=30) followed routine lifestyle and diet. Assessments were done on day 1 and day10 for both groups.
Results: In the post-test assessments of the case group with the control group, there was a significant reduction in scores of perceived stress scale, and Hamilton anxiety rating scale, also reduction in mean HR, LF, LF/HF, and a significant increase in mean R-R variables of HRV in the case group.
Conclusion: Ten days of yoga therapy in obese individuals had a positive effect on perceived stress, anxiety, quality of life, and heart rate variability, indicating parasympathetic dominance. Hence, yoga therapy acts in primary and secondary prevention of obesity-associated stress and anxiety symptoms.

Keywords: Anxiety, heart rate variability, obesity, perceived stress, quality of life, yoga

Introduction
Obesity an epidemic of the 21st century is a causative factor for metabolic disorders and is associated with depression, anxiety, and reduced quality of life [1, 2]. The prevalence of overweight and obesity in Asian countries has increased in the past few decades. Southeast Asia and the western pacific region are facing an epidemic of diseases associated with obesity such as diabetes and cardiovascular diseases (CVD) [1].
In our modern society, obesity coincides with the increase in chronic stress. In the past years, evidence is intensifying that stress plays a role in the development of obesity [3]. Obesity itself can be a stressful status due to the high dominance of weight stigma [4] Obesity has been associated with low levels of quality of life [5] and leads to anxiety [6].
Yoga is an ancient Indian discipline, considered holistic therapy as this system considers the body as a whole. According to yoga, the health of an individual is characterized by good physical health, a balanced state of mind, constructive and social surroundings, and also high spiritual growth; this holistic approach is aimed at restoring the abnormalities of body and mind physiology to normal, thereby restoring health [7]. Yoga has a beneficial effect through direct influence on the autonomic nervous system, improving wellbeing, reducing stress and anxiety. Evidence suggests, asana (physical posture), pranayama (breath regulation), dhyana (meditation), and relaxation practices have been shown to reduce sympathetic activation, regulates the hypothalamic-pituitary-adrenal axis and increase the quality of life by reducing stress and anxiety [8]. Hewett *et al.* (2018) concluded yoga significantly improved perceived stress in sedentary and stressed adults [9]. Chandla *et al.* show that pranayama for six weeks improves anxiety and increases parasympathetic activity [10]. Cramer *et al.* conclude yoga intervention is safe which had moderately strong positive effects on anthropometric variables and quality of life in women with abdominal obesity [11].

Materials and Methods

Study setting and participants

The study was conducted at Sri Dharmasthala Manjunatheshwara (SDM) Yoga and Nature Cure Hospital, Dharmasthala, Dakshina Kannada, India. Participants were screened from a consultation at SDM yoga and nature cure hospital and through a survey at UJIRE town. Participants had their vital signs assessed before the test.

Ethical approval

Approval was obtained from the institutional ethical committee (EC-234). A signed informed consent form was obtained from all the participants after explaining in detail the study intervention and assessments. The study was registered in the Clinical Trials Registry India CTRI/2019/10/021775.

Recruitment and sampling

Out of 210 participants, 60 were selected based on inclusion and exclusion criteria. A sampling of the study population (n=60) was done by computer-generated random numbers into the case (n=30) and control (n=30) groups.

Study design

A concurrent parallel study was conducted. Pre (day one) and post (day ten) data of both the groups were collected. Total (n=60) completed the post-assessments, there were no dropouts during the study period. Participants in, case group received yoga intervention along with their routine lifestyle and diet for 10 days and the control group was asked to follow their routine lifestyle and diet during the period of the study. Figure 1 illustrates the study plan in detail.

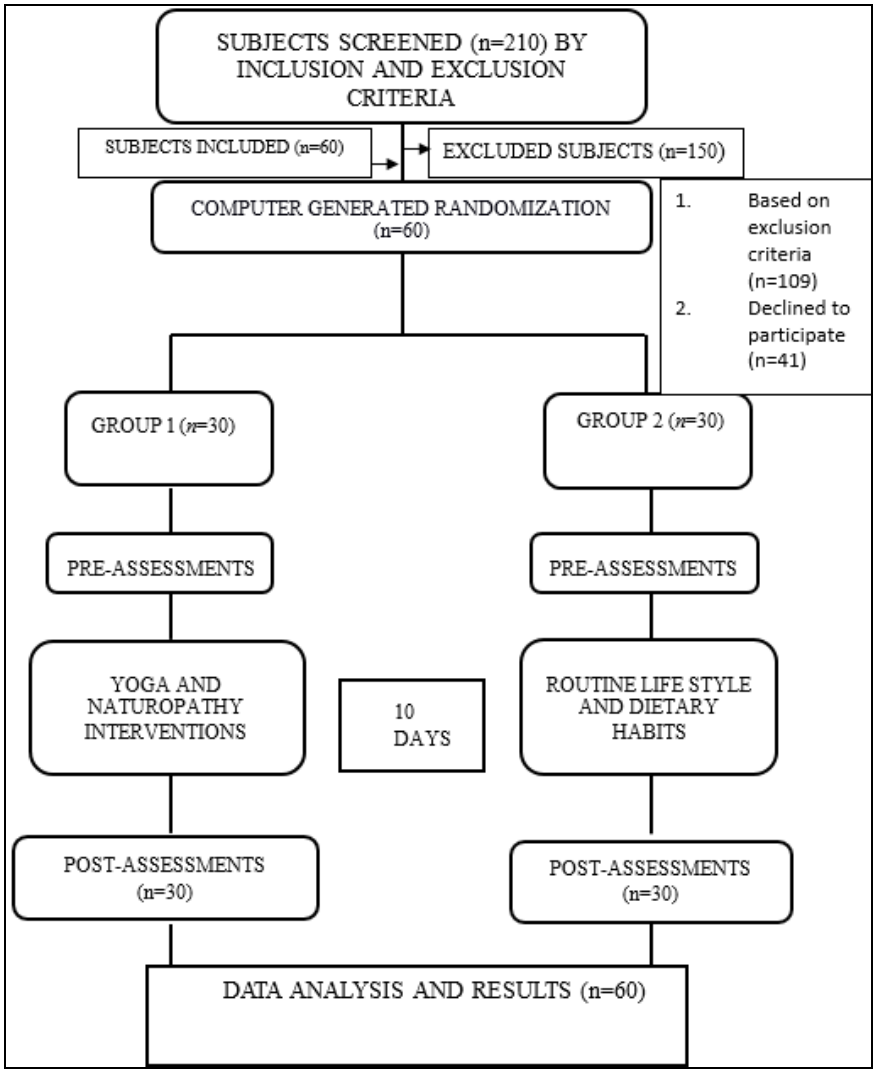


Fig 1: Illustration of the study plan

Data collection process

The data was collected using self-assessment rating scales (PSS, perceived stress scale; HAM-A, Hamilton anxiety rating scale; QLI, Ferrans and Powers quality of life index) and polygraph equipment (BIOPAC, Montana, USA; model no: BSL 4.0 MP 36) for heart rate variability (HRV) spectrum.

Inclusion and exclusion criteria

Inclusion criteria included subjects with age group 18 to 35 years, both male and female gender, and obesity (BMI greater than 30.0 kg/m^2). Exclusion criteria comprised individuals with acute disease (appendicitis, influenza, etc.), recent trauma and injury, cardiovascular disease, and females during menstruation, pregnancy, and lactation.

Intervention

The case group was educated and practiced yoga for one-hour duration each day from six a.m. to seven a.m. for 10 days continuous. Detailed descriptions of the practices are tabulated in Table 1. The Control group did not practice yoga, followed their routine lifestyle during the assessment period.

Table 1: Obesity yoga therapy protocol

S. No	Name of the Practice		Rounds (No. of times repeated)	Duration (Minutes)
1	Sukhasana (Easy posture) and Prarthana mantra chanting (Universal Prayer)		1	1
2	Suryanamaskara		5	10
3	Standing series asana	Ardhachakrasana	1	1
		Trikonasana	1	1
4	Supine series asana	Uttitapadasana	1	1
		Vipareetakarani	1	1
		Naukasana	1	1
		Pavanamuktasana	1	1
5	Prone series asana	Bhujangasana	1	1
		Shalabasana	1	1
		Dhanurasana	1	1
		Navasana	1	1
6	Instant Relaxation Technique (IRT)		1	2
7	Pranayama's	Bhastrika (bellows breathing)	36-50 strokes	3
		Kapalabhati	250-300 strokes	5
		Anulom-vilom (alternate nostril breathing)	20-25	6
		Surya bhedana (Right nostril breathing)	20-25	3
8	Deep Relaxation Technique (DRT)			20
9	Total Duration			60 (1 hour)

Assessments

Perceived stress scale

Items within the scale were designed to trap how unpredictable, uncontrollable, and overloaded respondents find their life, also included several direct queries about current levels of experienced stress. Questions within the PSS asked about feelings and thoughts during the last month, respondents were asked how often they felt a particular way.

Hamilton anxiety rating scale

The scale consisted of 14items, defined by a series of symptoms, and measured both psychic and somatic anxiety.

Ferrans and powers quality of life index

This instrument consisted of two parts: the first measured satisfaction with various aspects of life and the second measured importance of those same aspects. Scores were calculated for overall quality of life in four domains: health and functioning, psychological/ spiritual, social and economic, and family.

Heart rate and heart rate variability spectrum (HRV):

The electrocardiogram (ECG) was recorded pre-test on the 1st day and post-test on the 10th day using standard bipolar limb lead II configuration (BIOPAC, Montana, USA; model NO: BSL 4.0 MP 36). The ECG was digitized using a 12-bit analogue to digital converter point event series of successive R-R intervals (0.6-1.2 seconds), from which the beat-to-beat heart rate series was computed. In time domain analysis the assessments were RMSSD: root mean square of the successive normal sinus RR interval difference, pNN50: percentage of absolute differences between successive normal RR intervals that exceed 50ms, Mean R-R: the successive interval between R-R, HR: Heart rate. In frequency domain analysis the assessments were LF, Low frequency; HF, High frequency; LF/HF, the ratio of low frequency to high frequency.

Statistical analysis

The data collected was analyzed using Statistical Package for Social Sciences (SPSS) version 23.0 and was checked for normality using the Kolmogorov-Smirnov test. The pre and post-data of case and control groups with normal distribution were analyzed by parametric tests, independent t (between groups), and paired t-tests (within-group). Comparison of pre and post-data of case and control groups with not normal distribution were analyzed using non-parametric tests, Mann Whitney u test (between groups), and Wilcoxon signed-rank test (within-group). A p-value of <0.05 was considered statistically significant.

Results

This study was conducted to evaluate whether yoga therapy influenced perceived stress, anxiety, quality of life, and heart rate variability in obese individuals.

Case group: 53% males and 47% females with mean ± SD (standard deviation) age of 26.87±4.55 years and mean BMI (body mass index) of 29.12 kgs (kilograms).

Control group: 40% males and 60% females with mean ± SD age of 28.47±4.59 years and mean BMI of 29.68 kgs.

Table 2: Baseline characteristics of study groups

Variables	Case	Control	x^2 Measure of difference	P Probability value
Age	26.87±4.55[a]	28.47±4.59[a]	1.67 (df=3)	0.65 (NS)
Gender (male, female)	16,14[b]	12,18[b]	1.07 (df=1)	0.30 (NS)
BMI	29.12±2.15[a]	29.68±1.87[a]	1.9	0.28 (NS)

Data presented as [a] mean ± SD, [b] number of participants, df – degrees of freedom, NS- not significant.

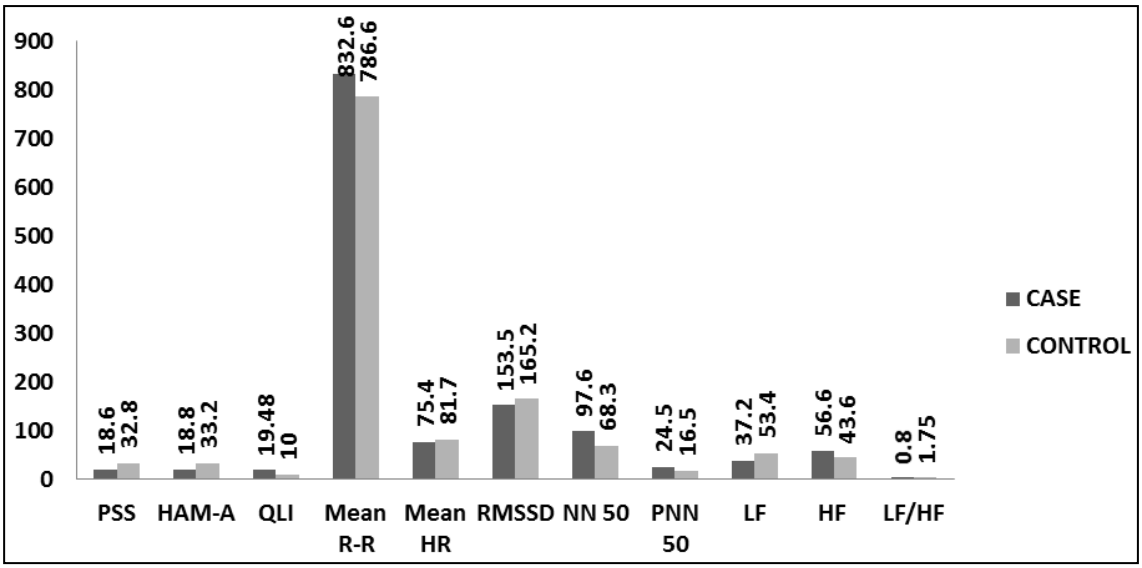
In case group, comparing pre and post assessments there was significant improvement (p<0.0001) in PSS (sample t-test: t=-10.92), HAM-A (t=-12.19), QLI (t=8.94), mean R-R (p=0.0004, t=3.79), mean HR (p=0.0003, t= -3.82), LF (t=-2.91, p=0.005), LF/HF (t=-2.41, p=0.01). RMSSD (t=0.661, p=0.511), NN50 (t=0.95, p=0.343), pNN50 (t=1.71, p=0.087) and HF (t=1.64, p=0.10) were not significant. Table 3. (Sample t-test: t- implies hypothesis testing between means of two groups).

Table 3: Comparison of pre and post-tests within the case group

Variables	Pre-test mean ± SD	Post-test mean ± SD	P Probability value
PSS	30.3±3.3	18.6±4.85	<0.0001**
HAM-A	33.6±4.2	18.8±5.15	<0.0001**
QLI	11.56±1.84	19.48±4.49	<0.0001**
Time-domain			
Mean R-R (s)	740.7±75.98	832.64±108.9	0.0004**
Mean HR (b/min)	86.1±13.49	75.47±7.07	0.0003**
RMSSD (ms)	124.6±169.2	153.5±169.5	0.511
NN50 (ms)	72.63±97.84	97.67±104.9	0.343
pNN50 (ms)	17.95±13.9	24.52±15.3	0.087
Frequency domain			
LF (Hz)	50.34±19.6	37.24±14.9	0.005*
HF (Hz)	47.59±20.28	56.6±22.05	0.10
LF/HF (Hz)	1.54±1.38	0.87±0.64	0.01*

*significant, **highly significant. PSS, Perceived stress Scale; HAM-A, Hamilton Anxiety; QLI, Ferrans and Powers Quality of Life Index; Mean R-R, the successive interval between R-R; HR, Heart rate; RMSSD, root mean square of the successive normal sinus RR interval difference; pNN50, percentage of absolute differences between successive normal RR intervals that exceed 50ms; LF, Low frequency; HF, High frequency; LF/HF, the ratio of low frequency to high frequency. s, seconds; ms, milliseconds; b/min, beats per minute; Hz, hertz.

Post-test comparison between case and control groups revealed, significant changes in PSS (95% confidence interval: CI,-15.5 to -10.97), HAM-A (95% CI, -18.29 to -11.7), QLI (95% CI, 7.06 to 10.04) with p-value <0.001. Also, significant changes in Mean HR (p=0.03) of time domain variable, LF (p=0.0003), HF (p=0.01), LF/HF (p=0.02) of frequency domain variables. The change was not significant in mean RR (p=0.1), RMSSD (p=0.8), NN50 (p=0.2) and pNN50 (p=0.1) in time domain variables of HRV. Table 4; figure 2 illustrate mean changes in the case and control group on the 10th day.



PSS, Perceived stress Scale; HAM-A, Hamilton Anxiety; QLI, Ferrans and Powers Quality of Life Index; Mean R-R, the successive interval between R-R; HR, Heart rate; RMSSD, root mean square of the successive normal sinus RR interval difference; pNN50, percentage of absolute differences between successive normal RR intervals that exceed 50ms; LF, Low frequency; HF, High frequency; LF/HF, the ratio of low frequency to high frequency. Y-axis represents data presented in mean values.

Fig 2: Changes after the 10 days of intervention in case and control group

Table 4: Comparison of post-test variables of case and control groups

Variables	Case mean ± SD	Control mean ± SD	P Probability value
PSS	18.6±4.85	32.87±3.2	<0.0001**
HAM-A	18.8±5.15	33.2±3.6	<0.0001**
QLI	19.48±4.49	10.0±2.01	<0.0001**
Time-domain			
Mean R-R (s)	832.64±108.9	786.6±108.85	0.1
Mean HR (b/min)	75.47±7.07	81.75±13.7	0.03*
RMSSD (ms)	153.5±169.5	165.2±196.2	0.8
NN50 (ms)	97.67±104.9	68.3±85.7	0.2
pNN50 (ms)	24.52±15.3	16.56±21.4	0.1
Frequency domain			
LF (Hz)	37.24±14.9	53.45±17.7	0.0003**
HF (Hz)	56.6±22.05	43.6±17.6	0.01*
LF/HF (Hz)	0.87±0.64	1.75±1.88	0.02*

*Statistically significant; **highly significant. PSS, Perceived stress scale; HAM-A Hamilton Anxiety; QLI, Ferrans and Powers Quality of Life Index; Mean R-R, the successive interval between R-R; HR, Heart rate; RMSSD, root mean square of the successive normal sinus RR interval difference; pNN50, percentage of absolute differences between successive normal RR intervals that exceed 50ms; LF, Low frequency; HF, High frequency; LF/HF, the ratio of low frequency to high frequency. s, seconds; ms, milliseconds; b/min, beats per minute; Hz, hertz.

In the control group, pre and post-data results showed insignificant variation in PSS, HAM-A, and QLI. Short-term HRV measurements of time and frequency domain variables also showed an insignificant difference between pre and post-data. Table 5.

Table 5: Comparison of pre and post-tests within the control group

Variables	Pretest Mean ± SD	Post-test Mean ± SD	P Probability value
PSS	31.23±3.3	32.87±3.2	0.055
HAM-A	32.9±4.2	33.2±3.6	0.767
QLI	10.6±2.1	10.0±2.01	0.262
Time-domain			
Mean R-R (s)	773.2±84.6	786.6±81.75	0.630
Mean HR (b/min)	161.3±69.87	165.2±68.3	0.420
RMSSD (ms)	17.93±105.8	16.56±108.85	0.937
NN50 (ms)	13.49±188.08	13.7±196.2	0.945
pNN50 (ms)	91.75±22.7	85.7±21.4	0.810
Frequency domain			
LF (Hz)	52.33±44.83	53.45±43.6	0.823
HF (Hz)	2.30±21.9	1.75±17.7	0.812
LF/HF (Hz)	22.16±3.13	17.6±1.88	0.412

PSS, Perceived stress Scale; HAM-A, Hamilton Anxiety; QLI, Ferrans and Powers Quality of Life Index; Mean R-R, the successive interval between R-R; HR, Heart rate; RMSSD, root mean square of the successive normal sinus RR interval difference; pNN50, percentage of absolute differences between successive normal RR intervals that exceed 50ms; LF, Low frequency; HF, High frequency; LF/HF, the ratio of low frequency to high frequency. s, seconds; ms, milliseconds; b/min, beats per minute; Hz, hertz.

Discussion

The study aimed to evaluate the effect of yoga therapy on obese individuals. In the present study, following yoga therapy, there was a significant reduction in PSS, HAM-A, Mean HR, LF, and LF/HF ratio and a significant increase in QLI, Mean RR, and insignificant increase in RMSSD, NN50, pNN50, and HF in the case group. These results of this study are suggestive of a sympathovagal balance.

In this study, the comparison of post-test variables in case and control groups, the mean scores of PSS significantly decreased in the case group. In the studies by Woodyard C and Tyagi A, the sympathetic region of the hypothalamus is inhibited by yoga. The hypothalamic-pituitary-adrenal (HPA) axis and the sympathetic activity are downregulated and the autonomic regulatory reflex mechanism associated with stress is restored promoting stress relief and relaxation [12, 13]. A clinical trial on adult obese individuals states, reduced levels of perceived stress are associated with lower cortisol secretion, which contributes to a reduction of obesity, adoption to healthier dietary habits, and subsequent loss of weight [14]. In the present study following yoga therapy (YT) for ten days, the stress levels decreased significantly in obese individuals.

HAM-A scales mean score of anxiety decreased significantly in the case group. In an explorative review article, yoga practices inhibit the areas responsible for fear, aggressiveness, and rage; stimulate the rewarding pleasure centres in the median forebrain and other areas leading to a state of bliss and pleasure. This inhibition leads to lower anxiety, pulse, rate of respiration, and cardiac output [12]. The Hamilton Rating Scale for Anxiety is a widely used measure for assessing anxiety in research [15]. The current study specified ten days of YT resulted in the reduction of the anxiety scores in the case group, indicating reduced symptoms of psychic and somatic anxiety.

The mean overall scores of QLI increased significantly in the case group in aspect to the improved person's satisfaction of life towards health and functioning, psychological/ spiritual, social and economic, and family, by reducing stress, anxiety, and weight in obese individuals. A study with a large sample

size (yoga experienced minimum one month n=298) by Telles *et al.*, reported higher outcomes in four out of six aspects in quality of life (enjoyment in physical activities, ability to work, self-esteem, and social satisfaction) in yoga experienced group compared to the yoga naïve [16].

The HRV variables in the time domain, Mean RR showed a significant increase, Mean HR reduced significantly, RMSSD insignificantly decreased, NN50 and pNN50 insignificantly increased in the case group. According to Lanfranchi PA and Somers high variability of the RR interval is a recognized index of the ability of the cardiovascular system to cope with environmental challenges [17]. A decrease in the heart rate could be due to increased vagal tone or due to sympathetic withdrawal, which reflects efficient vagal activity and flexible autonomic regulation [13]. An increase in RMSSD suggests parasympathetic predominance states McCall T [18]. Following YT insignificant reduction in RMSSD could be associated with parasympathetic saturation but Altini M states that this is not necessarily bad, considering HR can assist figure out the findings [19]. An increase in the NN50 and pNN50 count in time domain analysis of HRV is indicative of parasympathetic activity reported by Telles S *et al.* [20]. The changes in the time domain suggest obese individuals cope with environmental challenges in this study following YT in the case group.

In the frequency-domain variables, LF and LF/HF power significantly reduced, HF power significantly increased in the case group. A meta-analysis and review of literature by Kim HG *et al.* states, low parasympathetic activity variation in HRV is characterized by a decrease in the HF (lower HF power is correlated with stress, anxiety, and decrease quality of life) and an increase in the LF [21]. A short-term effect of integrated yoga revealed that SDNN, RMSSD, mean HR were significantly developed and LF, LF/HF ratio significantly reduced after one month of yoga practice, indicating a shift towards parasympathetic dominance. The study concluded that yoga intervention significantly reduced anxiety and perceived stress and shift towards parasympathetic dominance in heart rate variability [22], whereas in this study the results were obtained with ten days of the interventions indicating parasympathetic dominance from the outcome of HRV results, leading to reduced HR and decreased sympathetic activation. The ability of yoga to influence autonomic function has been the subject, suggest that yoga practices reduce autonomic arousal and assist stress-related disorders according to a bibliometric analysis [23]. Effects of yoga on autonomic function may be due to resonance effects produced by changes in respiration or by other mechanisms such as rhythmical skeletal muscle tension during various yoga postures that lead to vagal dominance and enhanced baroreflex gain without corresponding changes in HRV.

Further research with a larger population and sample size are needed to examine the influence on autonomic variables, as well as studies with a longer duration of interventions and/or practices with long-term follow-up compared to an active control group and a range of assessment approaches.

Conclusion

This ten-day intervention study found a significant effect on perceived stress, anxiety, quality of life, and heart rate variability in obese individuals. Perceived stress and anxiety levels reduced whereas the quality of life and heart rate variability improved in the experimental group. The results suggest a parasympathetic dominance in obese individuals. From this study, it's evident; yoga manages the stress and anxiety associated with obesity.

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