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Original Article

Physiology Section

Impact of *Makarasana* on Cardiovascular Parameters: A Prospective Interventional Study

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ABSTRACT

Introduction: *Makarasana*, a yogic posture also known as the crocodile pose on elbows, is a gentle backbend practised in yoga for its potential physiological benefits, including enhanced breathing, digestive function and purported effects on spiritual and emotional wellbeing.

Aim: To study the changes in Heart Rate (HR), blood pressure, and Heart Rate Variability (HRV) during *Makarasana* in healthy young adults.

Materials and Methods: A prospective interventional study was conducted involving 80 healthy students aged 18-25 years in the Department of Physiology, Faculty of Medicine and Health Sciences, SGT University at Budhera, Gurugram, Haryana, India over 12 months from April 2023 to March 2024. This study aimed to investigate the effects of *Makarasana* on cardiovascular parameters. Baseline measurements of Pulse Rate (PR) and Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP) were recorded in the *Shavasana* posture (lying flat on the back), followed by *Makarasana* practised for 15 minutes daily over three consecutive days. Changes in cardiovascular parameters were assessed using Physio Pac HRV analytic equipment and a digital Omron sphygmomanometer. Continuous data were expressed as mean±SD, while discrete data were expressed as numbers and percentages. The t-test was applied, considering p-value <0.05 significant at the 95% confidence interval.

Results: Participants' ages ranged from 18 to 25 years, with a mean±SD of 20.15±1.9 years; 25 were males (31%), and 55 were females (69%). *Makarasana* done for 15 minutes revealed statistically significant decrease in SBP, DBP and MAP on day 1, day 2 (non significant decrease in MAP) and day 3 (non significant decrease in DBP) and a decrease in SBP (from 108.82±6.71 to 105.8±6.7 mmHg, p-value <0.01) during *Makarasana*. DBP and Mean Arterial Pressure (MAP) showed non significant differences. Analysis of HRV parameters—Low Frequency (LF), High Frequency (HF), and LF/HF ratio—showed no significant changes between the two poses.

Conclusion: The cardiovascular parameters are significantly influenced by *Makarasana*. The postural holding of *Makarasana* particularly enhances the PR.

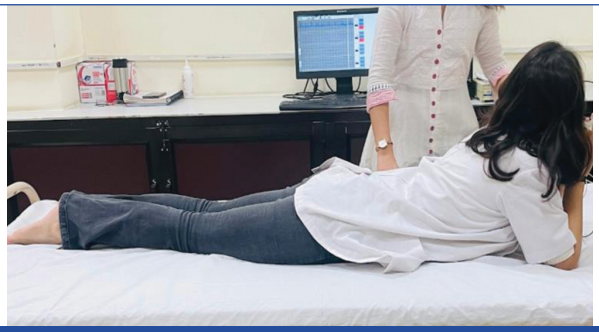
Keywords: Diastolic blood pressure, Heart rate variability, Mean arterial pressure, Systolic blood pressure, Yogic posture

INTRODUCTION

Yoga is a holistic practice that integrates physical postures, synchronised breathing, relaxation and meditation to promote overall wellbeing. Research has shown that yoga positively impacts cardiovascular health [1-3], leading to improved HRV, reduced blood pressure and enhanced overall cardiovascular function, particularly when combined with healthy dietary and lifestyle habits [4]. Asanas are body postures that may stabilise both the body and the mind. One can hold these postures for a period while remaining relaxed, steady, comfortable and motionless. There are potential mechanisms for these yogic poses that may influence cardiovascular responses while performing them. Yoga practice is thought to improve cardiovascular disease-related outcomes through two primary mechanisms: vagal stimulation and activation of the parasympathetic nervous system [5]. The ultimate goal of yoga is to awaken man's evolutionary energy, known as kundalini shakti. Practising yoga poses stimulates the activation of the chakras, dispersing kundalini energy throughout the body. Other postures assist in cleansing and regulating the nadis, promoting the circulation of prana throughout the body. The fundamental objective of yogic postures is to maintain equilibrium among physical and mental forces [6].

Makarasana on elbows (crocodile pose on elbows) is a gentle backbend yoga pose suitable for beginners. The light pressure applied to the lower back, throat and abdomen helps to regulate the digestive tract, opens the Vishuddhi Chakra (the throat chakra), and alleviates stiffness in the low er back, respectively. In addition to stimulating the stomach organs and improving breathing without putting pressure on the chest or rib cage, the supported neck also relieves pressure on the upper and middle back, directing focus towards the lower back [7]. *Makarasana* exerts pressure on the abdomen and lower back while allowing the mind to concentrate on breathing. All of these factors contribute to digestive strength. It has been said to awaken the 'kundalini chakra,' which has a positive effect on the mind [7].

As we stretch our head and chin up with the support of the elbows, the diaphragm experiences a stretch, which alleviates any congestion in the air passages and enhances respiratory rhythm. Given these beneficial qualities, the pose has been included among heart-opener yoga poses and can be beneficial for dyspnoea and chronic obstructive pulmonary disease [8]. Supporting the elbows with a blanket can serve as an alternative practice for those who cannot balance on their elbows for an extended duration. Meanwhile, the reverse pressure from the ground through the elbows stimulates the neck region and the stretched neck has a gentle impact on the throat [Table/Fig-1]. This practice can be included to open and



[Table/Fig-1]: *"Makarasana"* pose.

stimulate the throat chakra, which is believed to promote spiritual and emotional health.

In the literature review, authors found a gap: there was no singular study focused on an individual asana that indicates physiological variation during *Makarasana*. Previously conducted studies [9-11] have combined *Makarasana* with other postures and pranayama for short durations. They observed the combined effect of *Makarasana* with other yogic practices, while present study primarily focused on the physiological changes in cardiovascular parameters while holding the *Makarasana* pose. With this background, the present study aimed to investigate the changes in heart rate, MAP, blood pressure and HRV during *Makarasana* in healthy young adults.

MATERIALS AND METHODS

This was a prospective interventional study conducted with 80 healthy students from the Department of Physiology, Faculty of Medicine and Health Sciences, SGT University, Gurugram, Haryana, India, over a period of 12 months from April 2023 to March 2024. The study was approved by the Institutional Ethics Committee (IEC no. SEC/FMHS/S/29/04/23-04).

Inclusion criteria: First and second-year students of medical and paramedical courses aged between 18 and 25 years were included in the study.

Exclusion criteria: Individuals with history of neurological disorders or vertigo, cardiovascular abnormalities, chronic medication use, tobacco addiction, diabetes mellitus, hypertension, chronic illnesses, or if they were athletes were excluded from the study.

Sample size: Out of 120 students, 40 who had a SBP of less than 100 mmHg were excluded. A total of 80 students were enrolled in the study.

Data collection: Baseline readings were taken before *Shavasana* (pulse rate, SBP, DBP and MAP). Individuals performed the *Shavasana* pose for 15 minutes. During this period, HRV parameters (LF, HF and LF/HF ratio) were measured for 15 minutes. At the end of *Shavasana*, the pulse rate, SBP, DBP and MAP were recorded. The leads were then removed and the individuals were asked to change from *Shavasana* to *Makarasana*. A rest of five minutes was given. Before starting *Makarasana*, the pulse rate, SBP, DBP and MAP were recorded (pre). The individuals performed *Makarasana* and held the posture for 15 minutes, with HRV measured continuously for that duration (LF, HF, LF/HF ratio). At the end of *Makarasana*, the pulse rate, SBP, DBP and MAP were recorded (post). HRV parameters were recorded using the Physio Pac HRV analytic equipment, while blood pressure was measured using a digital Omron sphygmomanometer, and MAP was calculated at the end of each posture.

The same sequence of asanas was repeated for three consecutive days. The mean value for each parameter was taken after 15 minutes of holding the posture, with data collected immediately after the intervention on each of the three days. All parameters were assessed before starting the posture and immediately after holding it for 15 minutes.

STATISTICAL ANALYSIS

Statistical analysis was performed using Statistical Package for the Social Sciences (SPSS) software version 29.0 was used. A paired t-test was applied for comparisons within the same asana group, while an unpaired t-test was utilised to analyse the data between *Shavasana* and *Makarasana*. The level of significance considered in the present study was set at 0.05.

RESULTS

The mean age ranged from 18 to 25 years, with a mean age of 20.15±1.9 years. A total of 52 students fell in the age group ≤20 years, while 28 subjects were in the age group >20 years. The mean height was 163.52±9.89 cm. A total of 54 individuals had a height ≤165 cm, and 26 individuals had a height >165 cm. The mean BMI was found to be 21.57±2.13 kg/m^2. Six individuals had a BMI <18.5, 70 individuals had a BMI between 18.5 and 24.9, and four individuals had a BMI between 25.0 and 29.9 [Table/Fig-2].

Basic characteristics		n (%)/M±SD
Age (years): Mean±SD		20.15±1.9
≤20		52 (65)
>20		28 (35)
Gender	Males	25 (31)
	Females	55 (69)
Height (cm): Mean±SD		163.52±9.89
≤165		54 (67.5)
>165		26 (32.5)
Weight (kg): Mean±SD		58.1±9.66
≤60		58 (72.5)
>60		22 (27.5)
BMI (kg/m^2): Mean±SD		21.57±2.13
<18.5		6 (7.5)
18.5-24.9		70 (87.5)
25.0-29.9		4 (5)

[Table/Fig-2]: Basic characteristics.

A comparison of SBP, DBP, MAP and PR at day 1, day 2, and day 3 before and after holding the *Shavasana* pose for 15 minutes showed a statistically significant reduction in SBP, DBP and MAP on day 1 and day 3 (p-value≤0.05), while the PR slightly decreased across all days but did not show statistically significant changes [Table/Fig-3].

On comparison of SBP, DBP, MAP and PR at day 1, day 2, and day 3 before and after holding the *Makarasana* pose for 15 minutes, there was a significant reduction in SBP across all three days (p-value=0.001). DBP and MAP also significantly decreased on day 1, but their changes were not significant on day 2 (MAP) and day 3 (DBP). PR showed no significant change on days 1 and 3, but dropped significantly on day 2 (p-value=0.001) [Table/Fig-4].

The [Table/Fig-5] compares p-values between *Shavasana* and *Makarasana* across different days for pre and post- posture holding measurements of blood pressure and PR. All p-values are above 0.05, indicating no statistically significant differences between days 1, 2, and 3 for any of the parameters (SBP, DBP, MAP, PR), either before or after the pose. This suggests that the effects of *Shavasana* were consistent across the three days, with no significant day-to-day variation.

Parameters	Day 1		p-value	Day 2		p-value	Day 3		p-value
	Pre	Post		Pre	Post		Pre	Post	
SBP (mmHg)	109.02±8.98	106.51±8.5	0.001**	109.02±7.7	106.12±7.3	0.06	109.63±8.14	106.16±7.95	0.001**
DBP (mmHg)	69.15±7.08	66.71±7.48	0.02**	69.2±6.38	65.55±5.98	0.01**	68.83±5.29	66.66±6.13	0.001**
MAP (mmHg)	82.43±6.17	80.13±6.54	0.001**	82.38±5.8	79.07±5.29	0.02**	82.43±5.18	79.81±5.68	0.001**
PR (beats/min)	74.75±10.35	72.38±9.43	0.99	73.91±10.76	72.73±10.45	0.99	76.04±10.04	74.88±9.14	0.98

[Table/Fig-3]: Comparison of Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), Mean Arterial Pressure (MAP), and Pulse Rate (PR) at day 1, day 2, and day 3 before and after holding the *Shavasana* pose for 15 minutes.
**indicates significance at the level of p≤0.05, t-test

Parameters	Day 1		p-value	Day 2		p-value	Day 3		p-value
	Pre	Post		Pre	Post		Pre	Post	
SBP (mmHg)	108.98±9.32	101.37±8.21	0.001**	108.66±7.53	100.5±7.39	0.001**	109.51±8.14	102.77±8.46	0.001**
DBP (mmHg)	70.92±5.91	65.11±6.92	0.001**	71.13±4.53	65.02±5.04	0.001**	71.42±6.52	65.88±6.14	0.15
MAP (mmHg)	83.61±5.92	77.19±6.03	0.001**	83.64±4.51	76.84±4.7	0.17	84.11±5.87	78.09±5.6	0.001**
PR (beats/min)	79.28±11.81	78.29±10.22	0.87	80.53±10.99	77.95±10.21	0.001**	81.15±9.13	78.98±8.81	0.99

[Table/Fig-4]: Comparison of Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), Mean Arterial Pressure (MAP), and Pulse Rate (PR) at day 1, day 2, and day 3 before and after holding the *makarasana* pose for 15 minutes.
**indicates significance at the level of p≤0.05, t-test

Parameters	Pre			Post		
	Day 1 vs 2	Day 2 vs 3	Day 3 vs 1	Day 1 vs 2	Day 2 vs 3	Day 3 vs 1
SBP (mmHg)	0.32	0.78	0.77	0.62	0.35	0.57
DBP (mmHg)	0.35	0.59	0.55	0.96	0.96	0.35
MAP (mmHg)	0.36	0.36	0.32	0.96	0.94	0.55
PR (beats/min)	0.72	0.97	0.82	0.51	0.96	0.99

[Table/Fig-5]: Comparison of p-value of Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), Mean Arterial Pressure (MAP), and pulse during the *Shavasana* pose for 15 minutes.
t-test applied

The [Table/Fig-6] shows the p-values comparing HRV parameters (LF, HF, LF/HF) across days during the *Shavasana* pose. LF values showed significant differences between day 1 vs day 2 (p-value=0.001) and day 3 vs day 1 (p-value=0.006). In contrast, HF and LF/HF ratios showed no significant differences across days (p-value >0.05).

The [Table/Fig-7] presents the p-values comparing cardiovascular parameters (SBP, DBP, MAP, PR) across different days during the *Makarasana* pose. All p-values for both pre- and postintervention comparisons are above 0.05, indicating no statistically significant differences between Day 1, Day 2, and Day 3.

The [Table/Fig-8] compares HRV parameters (LF, HF, LF/HF) across days during the *Makarasana* pose. A significant difference was found in LF values between day 3 and day 1 (p-value=0.001). However, HF and LF/HF ratios showed no significant differences across all day comparisons (p-value >0.05).

The [Table/Fig-9] compares *Shavasana* and *Makarasana* in terms of their effects on cardiovascular parameters (SBP, DBP, MAP and PR) at day 1, day 2 and day 3, both before (Pre) and after (Post) holding the posture. Most pre- and postintervention p-values are above 0.05, indicating no significant difference between the two poses. However, a significant difference was observed in post-SBP on Day 2 (p-value=0.003), suggesting that *Makarasana* may have reduced SBP more effectively than *Shavasana* on that day. All other measures, including PR and MAP, showed no significant variation between the two poses across the three days.

The [Table/Fig-10] compares *Shavasana* and *Makarasana* in terms of HRV parameters (LF, HF, LF/HF) across day 1, day 2, and day 3. All p-values are greater than 0.05, indicating no statistically significant differences when applying the t-test between the two poses for any of the parameters on any day.

DISCUSSION

The comparison of cardiovascular parameters (PR, SBP, DBP, MAP) between *Shavasana* and *Makarasana* observed a non significant increase in PR after *Makarasana* compared to *Shavasana*, which contrasts with other previously conducted studies [10-12] that have

HRV parameters	Day 1	Day 2	Day 3	Day 1 vs 2	Day 2 vs 3	Day 3 vs 1
				p-value	p-value	p-value
LF	69.8±33.16	51±35.03	48.3±35.37	0.001**	0.4	0.006**
HF	6.3±2.21	6.03±2.46	6.17±2.47	0.71	0.44	0.66
LF/HF	11.18±5.9	8.34±5.7	7.38±4.92	0.99	0.71	0.28

[Table/Fig-6]: Comparison of p-value of LF, HF, LF/HF during the *Shavasana* pose for 15 minutes.
**indicates significance at the level of p≤0.05, t-test

Parameters	pre			Post		
	Day 1 vs 2	Day 2 vs 3	Day 3 vs 1	Day 1 vs 2	Day 2 vs 3	Day 3 vs 1
SBP (mmHg)	0.52	0.94	0.66	0.82	0.99	0.94
DBP (mmHg)	0.47	0.53	0.67	0.38	0.91	0.82
MAP (mmHg)	0.34	0.75	0.73	0.62	0.99	0.93
PR (beats/min)	0.77	0.59	0.92	0.47	0.75	0.65

[Table/Fig-7]: Comparison p-value of Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), Mean Arterial Pressure (MAP), and Pulse Rate (PR) during the *makarasana* pose for 15 minutes.
t-test applied

HRV parameters	Day 1	Day 2	Day 3	Day 1 vs 2	Day 2 vs 3	Day 3 vs 1
				p-value	p-value	p-value
LF	60.6±35.75	54.1±34.60	42±32.06	0.92	0.99	0.001**
HF	5.5±1.75	6.3±2.97	5.9±2.18	0.96	0.91	0.49
LF/HF	10.99±6.74	8.34±4.74	7.01±4.81	0.99	0.94	0.26

[Table/Fig-8]: Comparison p-value of LF, HF, LF/HF during the makarasana pose for 15 minutes.
**indicates significance at the level of p≤0.05, t-test

Parameters	Pre			Post		
	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3
SBP (mmHg)	0.33	0.45	0.36	0.99	0.003**	0.99
DBP (mmHg)	0.93	0.98	0.99	0.87	0.58	0.67
MAP (mmHg)	0.83	0.89	0.96	0.99	0.99	0.95
PR (beats/min)	0.99	0.99	0.99	0.99	0.99	0.14

[Table/Fig-9]: Comparison of *Shavasana* with makarasana before and after holding the posture at day 1, day 2, and day 3, respectively.
**indicates significance at the level of p≤0.05, t-test

HRV parameters	Day 1	Day 2	Day 3
LF	0.86	0.77	0.87
HF	0.98	0.72	0.72
LF/HF	0.39	0.44	0.56

[Table/Fig-10]: Comparison of *Shavasana* with makarasana before and after holding the posture at day 1, day 2, and day 3, respectively.
t-test applied

found a decrease in PR. A possible reason for this discrepancy could be that those studies investigated multiple asanas in a single session. Although on day 1, day 2 and day 3 PR were decreasing but it was statistically non significant. Similar results were observed in a study conducted on normotensive adults who were assessed for brachial blood pressure (SBP and DBP) after performing eight weeks of Hatha yoga [13,14].

Further studies have also investigated the effect of Bikram yoga (a set sequence of 26 asanas including *Makarasana*, Shashankasana, and *Shavasana*, along with two breathing exercises performed in a heated environment for 90 minutes with instructional dialogue) on resting heart rate, SBP and DBP. These studies have primarily been conducted with normotensive participants and, as expected, all reported no significant change over time [14-17].

The clinical trial conducted by Hewett ZL et al., further confirms that resting heart rate and blood pressure remain unchanged in healthy participants [16]. In contrast, findings from studies on Bikram yoga in an unhealthy population of older obese individuals revealed significant changes and strengthened the recommendation to examine cardiometabolic adaptations in unhealthy populations [18].

DBP and MAP were statistically non significant, whereas SBP was highly significant. A probable reason for this could be the decreased systemic vascular resistance, wherein both the sympathetic nervous system and the renin-angiotensin system appear to play a role. Decreased sympathetic reactivity also affects the kidneys, the most influential factor in blood pressure regulation [19]. These findings correlate with a shift in the balance of components of the autonomic nervous system towards parasympathetic activity. The findings of the present study are in concordance with a study conducted by Devasena I and Narhare P [20].

[Table/Fig-8] compares day 1 vs day 2, day 2 vs day 3, and day 3 vs day 1 HRV frequency domain—LF, HF, and LF/HF ratio—while holding the *Makarasana* pose. There was a statistically significant decrease in LF (day 3 vs day 1). LF represents sympathetic activity or a mix of sympathetic and vagal activity. The significant reduction in LF power spectrum may be attributed to inhibition of the hypothalamus's posterior or sympathetic area, optimising the body's sympathetic response to stressful stimuli. This also helps restore the autonomic regulatory reflex mechanism associated with stress. The study results are consistent with findings from various authors. The results of the study conducted by Vinay AV et al., on healthy male volunteers aged 30-60 years practising yoga for a month also coincide with present study [21]. LF power is more closely related to stretch-induced changes in the firing of the baroreceptor afferents rather than the tonic discharge in baroreceptor afferents [22]. Another study involving 100 volunteers comparing yoga and swimming also yielded results similar to present study [11].

The HF or respiratory band reflects parasympathetic activity and is referred to as the respiratory band because it corresponds to heart rate variations related to the respiratory cycle. The LF/HF ratio measures the sympathovagal balance. The fact that physiological therapies like yoga, exercise and meditation always generate reciprocal changes in sympathetic and parasympathetic nerve activity allows for proper interpretation of the LF/HF ratio [23,24].

The comparison of HRV frequency domain—LF, HF and LF/HF ratio—between *Shavasana* and *Makarasana* poses showed a statistically non significant decrease in LF and LF/HF and an increase in HF power. The possible reasons for these non significant results could be the short duration of the study. The results from the study conducted by Vinay AV et al., on healthy male volunteers aged 30-60 years practising yoga for a month were significant [21].

Limitation(s)

The author recognised that a major limitation of the study was that it was a single-centre study. Due to the uniform student population, the analysis was not powered to control for multiple potential confounders. However, authors did not control for age and gender; nonetheless, the majority of responders were of the same age group.

CONCLUSION(S)

The study's results suggest that the *Makarasana* posture causes significant shifts in cardiovascular parameters, particularly affecting SBP and PR compared to *Shavasana*, which aligns with a shift towards parasympathetic activity, as observed in previous studies. However, no significant differences were noted in the HRV frequency domains among the yoga poses under investigation. The functional cardiac changes during *Makarasana* can be further studied using invasive techniques to better understand the cardiovascular changes.

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