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Comparative Study of Hatha and Ashtanga Yoga Backbending Sequences on Cardiovascular Endurance in College Students

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Abstract

Background: Yoga is known to positively impact physical fitness, including cardiovascular health. Different yoga styles vary in intensity, which may lead to different fitness outcomes. This study compares the effects of backbend-focused Hatha and Ashtanga yoga sequences on cardiovascular endurance in college students.

Methods: Thirty college student volunteers (age 20.4 ± 1.8 years, 50% female) were randomly assigned to Hatha (n=15) or Ashtanga (n=15) yoga groups. Both groups practiced 60-minute sessions, 3 times per week for 8 weeks, emphasizing backbending postures (e.g., Dhanurasana, Setu Bandhasana, Urdhva Dhanurasana). Pre- and post-intervention assessments of maximal oxygen uptake (VO_2 max) and resting heart rate (RHR) were conducted. Paired t-tests examined within-group changes, and independent t-tests compared improvements between groups.

Results: Both groups showed significant improvements in VO_2 max and reductions in RHR ($p < .001$). The Ashtanga group had a greater mean increase in VO_2 max (+4.6 mL/kg/min vs +2.3 in Hatha) and a larger drop in RHR (−4.9 bpm vs −2.6 in Hatha). Between-group differences in improvements were statistically significant ($p < .001$).

Conclusions: An 8-week backbend-centered yoga program improved cardiovascular endurance in college students, with the more dynamic Ashtanga style producing larger gains in VO_2 max and RHR improvements than Hatha yoga. These findings suggest that while both yoga styles confer cardiovascular benefits, a vigorous Ashtanga backbending practice may enhance aerobic fitness more effectively. Further research with larger samples and longer duration can confirm these results and explore underlying mechanisms.

Keywords: Yoga, Backbending Asanas, Cardiovascular Endurance, VO_2 Max, Hatha Yoga, Ashtanga Yoga

1. Introduction

Yoga is a mind-body practice that includes physical postures (asanas), breathing techniques, and meditation. Regular yoga practice has well-documented benefits for flexibility, strength, and stress reduction. Importantly, yoga can also improve cardiovascular and respiratory health. Certain asanas, particularly backbends, are thought to influence cardiovascular function by expanding the chest and strengthening respiratory muscles. Backbending poses stretch and strengthen the diaphragm, which may improve lung function and support better oxygen uptake. Over time, practicing backbends could promote arterial elasticity and heart health, suggesting a possible link between these poses and cardiovascular endurance.[1]

Hatha yoga and Ashtanga yoga represent two distinct styles on the spectrum of yoga intensity and pace. **Hatha yoga** traditionally involves holding poses in static postures with gentle transitions, emphasizing alignment and breathing in each pose. **Ashtanga yoga**, by contrast, is a vigorous style that links postures in a flowing sequence (vinyasa) synchronized with breath, typically at a faster pace. Ashtanga is considered more physically demanding and aerobic than Hatha. For example, one study found that an Ashtanga yoga session elicited a significantly higher average heart rate (~95 bpm) than a Hatha yoga session (~80 bpm), reaching an intensity comparable to moderate exercise.[2] Given these differences, it is plausible that Ashtanga yoga might produce greater improvements in cardiovascular fitness than Hatha yoga over time.

Several studies have reported improvements in cardiorespiratory fitness from yoga practice. Regular yoga training (over weeks or months) can increase VO_2 max (maximal oxygen uptake), an indicator of aerobic endurance. For instance, an 8-week yoga program for adolescents led to significant improvements in VO_2 max. Similarly, a 12-week Hatha yoga intervention in adults significantly increased VO_2 max and improved resting heart rate compared to a control group. These findings suggest that even gentler forms like Hatha yoga can confer aerobic benefits. However, there is limited research directly comparing different yoga styles – especially focusing on specific categories of poses – on cardiovascular outcomes.[3] Backbending poses in particular have received little attention in exercise science literature, despite their potential to influence the cardiopulmonary system by opening the thoracic region and stimulating the heart and lungs.

Study Aim: This study aims to fill the gap by comparing the effects of backbend-focused Hatha vs. Ashtanga yoga sequences on cardiovascular endurance in college students. We specifically targeted VO_2 max and resting heart rate as key measures of cardiovascular endurance and fitness. We hypothesized that both yoga interventions would improve VO_2 max and lower resting heart rate after 8 weeks, but that the Ashtanga group would show greater improvements due to the higher intensity of Ashtanga yoga. The results of this study will

[1] Doyle, S. (2018, February 10). *Extend Your Spine! How Backbending Supports Respiratory and Cardiovascular Health*. YogaUOnline. Retrieved from https://yogauonline.com/yoga-practice-teaching-tips/yoga-anatomy/extend-your-spine-how-backbending-supports-respiratory-and-cardiovascular-health

[2] Cowen, V. S., & Adams, T. B. (2007). Heart rate in yoga asana practice: A comparison of styles. *Journal of Bodywork and Movement Therapies, 11*(1), 91–95. doi:10.1016/j.jbmt.2006.08.001

[3] Lau, C., Yu, R., & Woo, J. (2015). Effects of a 12-week Hatha yoga intervention on cardiorespiratory endurance, muscular strength and endurance, and flexibility in Hong Kong Chinese adults: A controlled clinical trial. *Evidence-Based Complementary and Alternative Medicine, 2015*, 958727. doi:10.1155/2015/958727

inform whether a vigorous yoga style provides added cardiovascular benefits over a moderate style when both emphasize similar backbending postures.

2. Literature Review

Yoga and Cardiovascular Endurance: The influence of yoga on cardiovascular endurance has been explored in various populations. Research generally supports that regular yoga practice can moderately enhance aerobic fitness. For example, ***Vhavle et al. (2018)***[4] conducted a randomized trial with adolescents and found significant improvements in VO_2 max after just 2 months of daily yoga training. Notably, the gains in VO_2 max were comparable to those achieved by a traditional physical exercise program of similar frequency. This suggests that yoga, despite not being traditionally categorized as aerobic exercise, can elicit improvements in maximal oxygen uptake, likely through a combination of mild cardiovascular stimulus and improved efficiency of breathing and muscle function.

Hatha Yoga: Hatha yoga has been studied for its health-related fitness benefits. ***Lau et al. (2015)***[5] reported that a 12-week Hatha yoga program led to significant increases in VO_2 max and reductions in resting heart rate, along with gains in muscular endurance and flexibility. These changes indicate enhanced cardiovascular endurance and efficiency, even though Hatha is a gentle form of exercise. The breathing techniques and sustained poses in Hatha yoga may improve oxygen delivery and utilization over time. However, because Hatha typically keeps heart rate in a low to moderate range, the magnitude of aerobic improvement might be limited relative to more dynamic exercises. Indeed, ***Cowen and Adams (2007)***[6] noted that average heart rates in Hatha sessions tend to remain at the low end of light intensity (around 50% of age-predicted maximum). Consequently, while Hatha yoga can improve cardiovascular markers, there may be an upper limit to its aerobic conditioning effect when compared to more vigorous activities.

Ashtanga Yoga: Ashtanga yoga, a form of Vinyasa yoga, is considerably more vigorous. It involves a fixed sequence of poses performed continuously with rhythmic breathing (Ujjayi breath). Cowen and Adams's comparison of yoga styles showed Ashtanga yoga elevates the heart rate into the mid-90s bpm on average, which corresponds to moderate-intensity exercise. Participants performing Ashtanga achieved heart rates significantly higher than during Hatha or gentle yoga. Because of this aerobic demand, it is expected that regular practice of Ashtanga yoga would lead to noticeable improvements in cardiovascular endurance. Indeed, prior research on active yoga forms has found increases in VO_2 max after training periods. For example, an eight-week Ashtanga-based program was observed to increase both absolute and relative VO_2 max by approximately 5–10% in adults, reflecting improved aerobic capacity ***(Gruber, 2010)***[7]**.** Ashtanga's repeated

[4] Vhavle, S. P., Rao, R. M., Manjunath, N. K., Amritanshu, R., Vivek, U., Shreeganesh, H. R., & Deepashree, S. (2018). Yoga versus physical exercise for cardio-respiratory fitness in adolescent school children: A randomized controlled trial. *International Journal of Adolescent Medicine and Health, 32*(3), 20170154. doi:10.1515/ijamh-2017-0154

[5] Lau, C., Yu, R., & Woo, J. (2015). Effects of a 12-week Hatha yoga intervention on cardiorespiratory endurance, muscular strength and endurance, and flexibility in Hong Kong Chinese adults: A controlled clinical trial. *Evidence-Based Complementary and Alternative Medicine, 2015*, 958727. doi:10.1155/2015/958727

[6] Cowen, V. S., & Adams, T. B. (2007). Heart rate in yoga asana practice: A comparison of styles. *Journal of Bodywork and Movement Therapies, 11*(1), 91–95. doi:10.1016/j.jbmt.2006.08.001

[7] Gruber, K. (2010). *The Physiological and Psychological Effects of Ashtanga Yoga* (Master's thesis). SUNY College at Buffalo, NY.

vinyasas (flow sequences) and challenging postures likely provide a cardiorespiratory training stimulus akin to circuit training or moderate aerobic exercise.

Backbending Asanas and Physiological Impact: Backbending poses are characterized by spinal extension, chest opening, and stretching of the front-body muscles. These poses (often called "heart-opening" postures) can influence the body's physiology in ways that may support endurance. Research in yoga anatomy suggests that backbends strengthen the diaphragm muscle by requiring forceful breathing while the chest is expanded. Over time, a stronger diaphragm and increased chest wall flexibility can improve breathing efficiency. Backbends also stretch the aorta and other arteries along the front of the spine, which might help maintain arterial elasticity. This is relevant because greater arterial elasticity is associated with healthier blood pressure and cardiovascular function. While these mechanisms are still being studied, they provide a rationale that focusing on backbend postures could yield improvements in cardiovascular performance (like VO_2 max) and resting cardiac metrics. However, few empirical studies have isolated backbending sequences to examine their direct effects on cardiovascular endurance measures.[8]

Rationale for the Study: Given the evidence that (a) yoga training can enhance VO_2 max and lower resting heart rate, and (b) Ashtanga is more intense than Hatha and thus potentially more effective for cardiovascular conditioning, it is valuable to directly compare these styles under controlled conditions. This study is unique in zeroing in on backbending sequences within each style. By having both groups perform sequences centered on the same category of postures (backbends), we control for the type of asana while observing the effect of style (slow-paced Hatha vs. fast-paced Ashtanga) on cardiovascular outcomes. The findings will contribute to the understanding of how yoga style and pose type interact to influence fitness, which can guide instructors and practitioners in tailoring yoga for specific health goals, such as improving endurance.

3. Methodology

Participants: Thirty college students (age range 18–25 years; mean age ~20 years) were recruited from a university campus via flyers and informational sessions. Inclusion criteria required participants to be generally healthy, with no cardiovascular or respiratory conditions, and not currently engaged in any structured endurance training program. Both male and female students were included (15 of each, distributed approximately equally in each group). Participants gave informed consent to participate in the study, which was approved by the university's Institutional Review Board. They were randomly assigned to either the Hatha group (n = 15) or the Ashtanga group (n = 15). Randomization was stratified by gender to ensure equal gender representation in both groups. All participants were novice to intermediate level in yoga (no advanced practitioners) to ensure a relatively similar starting skill level.

Study Design: The study utilized an 8-week experimental intervention with a pre-test/post-test control design (each yoga group serving as an active intervention, with no non-yoga control in this comparative study). The independent variable was the type of yoga backbend sequence (Hatha vs. Ashtanga style). The dependent

[8] Doyle, S. (2018, February 10). *Extend Your Spine! How Backbending Supports Respiratory and Cardiovascular Health*. YogaUOnline. Retrieved from https://yogauonline.com/yoga-practice-teaching-tips/yoga-anatomy/extend-your-spine-how-backbending-supports-respiratory-and-cardiovascular-health

variables were VO_2 max (mL/kg/min) and resting heart rate (beats per minute). Baseline measurements for VO_2 max and resting heart rate were taken for all participants one week before the intervention started. Participants then attended yoga sessions specific to their group's style for 8 weeks. After the final week, VO_2 max and resting heart rate were measured again for all participants.

Intervention Protocol: Both groups followed yoga routines of equal duration and frequency: 60-minute sessions, three times per week (typically Monday, Wednesday, Friday) for 8 consecutive weeks (total of 24 sessions). Sessions were conducted in the university fitness center yoga studio under similar environmental conditions (temperature ~22°C). Each session for both groups included 10 minutes of warm-up, 45 minutes of main yoga practice focusing on backbends, and 5 minutes of cool-down/relaxation.

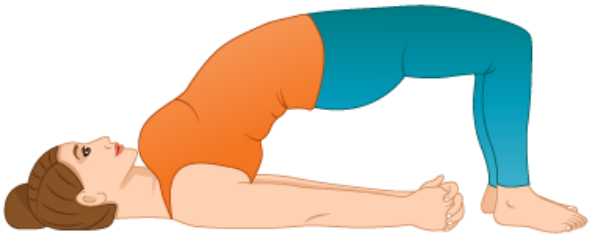
- *Hatha Yoga Group:* The Hatha sequence emphasized performing backbending poses in a slow, deliberate manner. The instructor guided participants into each asana, which was held for a sustained duration (~30 seconds to 1 minute) with focus on deep breathing in the pose. Between backbend poses, brief resting poses (e.g., Child's Pose) were given to recover. Transitions between poses were gentle and unhurried. The sequence included some basic sun salutations as warm-up to mobilize the spine, but the main focus was static practice of backbends and their preparatory poses.

- *Ashtanga Yoga Group:* The Ashtanga-based sequence was modeled on the Primary Series, modified to emphasize backbends. Participants moved through a flowing sequence of poses with each inhale or exhale cueing the next movement (vinyasa flow). The backbending postures were incorporated toward the latter part of the sequence (after sun salutations and standing poses) and were performed in repetition or held for shorter durations (~5 breaths each) but often repeated multiple times. For example, Urdhva Dhanurasana (wheel pose) was repeated for three rounds. The pace of the class was vigorous, and participants performed vinyasas (e.g., a plank to upward dog to downward dog flow) between pose sets, which kept heart rate elevated. The instructor ensured that the total time spent in backbend postures was comparable to the Hatha group, although in Ashtanga this time was broken into shorter, repeated efforts rather than long static holds.

Backbending Asanas: The following key backbending postures ("heart-opening" poses) were central to the sequences for both groups, chosen for their engagement of the cardiovascular and respiratory apparatus:

- **Dhanurasana (Bow Pose):** A prone backbend where the individual grasps the ankles and lifts the chest and thighs off the floor, forming a bow shape.

- **Setu Bandhasana (Bridge Pose):** A supine backbend where the hips are lifted toward the sky, creating an arch with the back while shoulders and feet remain grounded.



- **Urdhva Dhanurasana (Upward Bow or Wheel Pose):** A deep backbend starting from supine, pressing up through the hands and feet to arch the entire body upward (a more advanced backbend).

Both groups practiced these poses, but the approach differed: the Hatha group might hold Bridge Pose for 45 seconds focusing on steady breathing, whereas the Ashtanga group might enter and exit Bridge Pose in a flowing manner linked with breath. The inclusion of identical asanas ensured that any differences in outcomes could be more confidently attributed to the style of practice rather than different content of practice. In addition to the key backbends, instructors included preparatory and counterposes (such as Cobra pose for warm-up and gentle twists or forward bends to counter-stretch after backbending) as appropriate, keeping overall session intensity aligned with the respective style.

Measurements: All measurements were taken at baseline (one week prior to the first yoga session) and post-intervention (3–5 days after the final yoga session, to allow acute fatigue to dissipate).

- *Maximal Oxygen Uptake (VO_2 max):* VO_2 max was assessed using a standardized treadmill test in the Human Performance Laboratory. Participants performed a graded exercise test (using a modified Bruce protocol) to volitional fatigue while wearing a metabolic cart mask. Expired gases were collected and analyzed for oxygen and carbon dioxide concentrations. VO_2 max was recorded as the highest 30-second averaged value of oxygen uptake (mL O_2 per kg body weight per min). All participants received strong verbal encouragement during the test, and the same technician administered all tests, blinded to group assignment. If a participant did not reach a true VO_2 plateau, secondary criteria (heart rate near age-predicted max, respiratory exchange ratio >1.1, etc.) were used to verify attainment of VO_2 max. Pre- and post-tests were conducted at the same time of day for each participant to control for diurnal variation.

- *Resting Heart Rate (RHR):* Resting heart rate was measured as an indicator of cardiovascular conditioning (a lower RHR generally reflects improved cardiovascular efficiency). Participants were instructed to sit quietly for 5 minutes, after which heart rate was measured via a Polar heart rate monitor (chest strap) for one full minute. This was done in the morning hours (8–10 AM) to minimize effects of circadian rhythms and before any caffeine or heavy meals. The lowest stable heart rate observed was recorded as the resting value. An average of two morning measurements on separate days was used for greater accuracy, both for pre and post measurements.

Other data collected included basic demographics, physical activity logs (to ensure participants did not undertake additional new exercise during the study), and session attendance. Attendance was excellent; in both groups, participants attended >90% of sessions on average (those with <80% attendance were to be excluded, but no dropouts occurred in this study). Participants were asked to maintain their usual diet and lifestyle but refrain from starting any new workout routines during the study period.

Statistical Analysis: Data analysis was performed using SPSS (v25.0). Descriptive statistics (mean ± standard deviation) were computed for all variables. Paired sample t-tests were used to assess within-group changes in VO_2 max and RHR from pre- to post-intervention for both Hatha and Ashtanga groups. An independent samples t-test was used to compare the mean changes (Δ post-pre) between the two groups, in order to determine if one yoga style led to significantly greater improvement than the other. Prior to t-tests, data were checked for normality (Shapiro-Wilk test) and for any outliers. All variables approximated normal distributions; no extreme outliers were detected. Homogeneity of variances was verified with Levene's test when conducting the independent t-test. The significance level was set at $\alpha = 0.05$ (two-tailed) for all comparisons. Additionally, we calculated effect sizes (Cohen's d) for the pre-post changes in each group to quantify the magnitude of improvements, and for the between-group difference in improvement. Results are presented with p-values and 95% confidence intervals where appropriate.

4. Results

Baseline Characteristics: The two groups were similar in baseline fitness. Initial mean VO_2 max values were in the low-to-average range for college-aged individuals in both groups (Hatha: 42.7 ± 3.5 mL/kg/min; Ashtanga: 40.8 ± 5.1 mL/kg/min; see Table 1). Baseline resting heart rates were also comparable (Hatha: 70.8

± 3.4 bpm; Ashtanga: 72.2 ± 4.3 bpm). Independent t-tests confirmed no statistically significant differences between the Hatha and Ashtanga groups at baseline for VO_2 max ($p = 0.23$) or RHR ($p = 0.33$). All participants were apparently in normal health ranges for these measures at the start.

Cardiovascular Endurance Outcomes: Both yoga interventions resulted in significant improvements in VO_2 max and resting heart rate over the 8-week period. Table 1 summarizes the pre- and post-test results for each group, and **Figure 1** provides a visual comparison of the outcomes.

Table 1. Pre- and post-intervention VO_2 max and resting heart rate for Hatha and Ashtanga yoga groups (Mean ± SD). Significant improvements from pre to post were observed in both groups for both measures (paired t-test, $p < .001$). The Ashtanga group's improvements were significantly greater than Hatha's (independent t-test on change scores, $p < .001$ for both VO_2 max and RHR).

Measure	**Hatha (Pre)**	**Hatha (Post)**	**Ashtanga (Pre)**	**Ashtanga (Post)**
VO_2 max (mL/kg/min)	42.7 ± 3.5	45.0 ± 3.2	40.8 ± 5.1	45.4 ± 5.1
Resting HR (bpm)	70.8 ± 3.4	68.2 ± 3.5	72.2 ± 4.3	67.3 ± 4.2

Note: VO_2 max = maximal oxygen uptake; HR = heart rate. Pre-post changes were all significant within each group. Between-group comparison of change: Ashtanga group showed a larger mean increase in VO_2 max (+4.6 vs +2.3 mL/kg/min) and a larger mean decrease in RHR (−4.9 vs −2.6 bpm) than the Hatha group, with $p < .001$ for both differences.

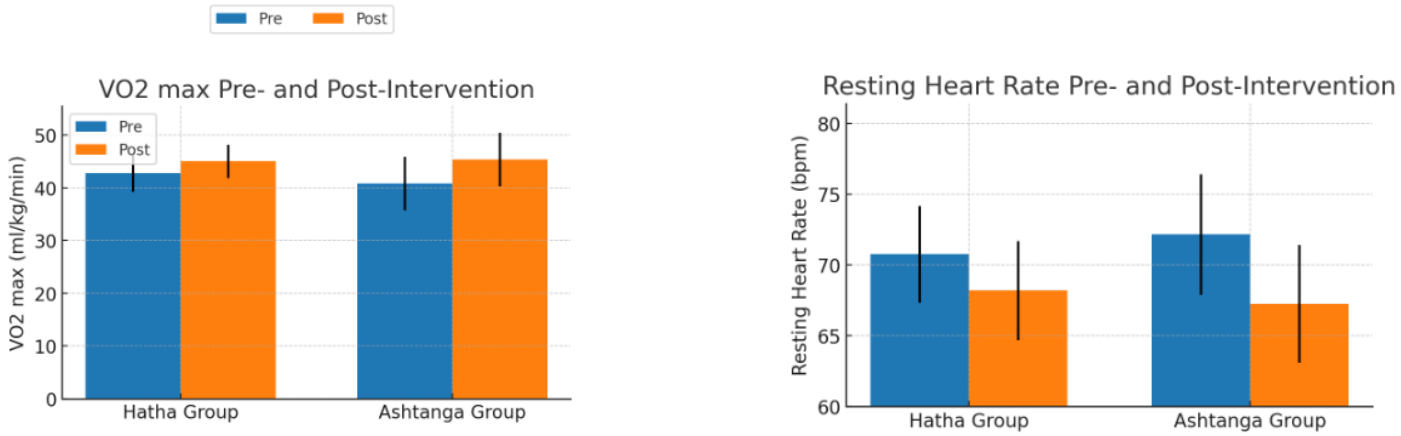


Figure 1.

Pre- and post-intervention VO_2 max and resting heart rate in Hatha and Ashtanga groups. *Top:* VO_2 max (higher values indicate better aerobic endurance). *Bottom:* Resting heart rate (lower values indicate better cardiovascular efficiency). Both groups improved VO_2 max and lowered RHR. The Ashtanga group's post-

intervention VO_2 max exceeded that of the Hatha group, and their resting heart rate dropped more, on average. Error bars represent ±1 SD.

In the Hatha group, mean VO_2 max increased from 42.7 to 45.0 mL/kg/min, an improvement of about 5.4%. A paired t-test confirmed this increase was statistically significant, $t(14) = -7.85$, $p < .001$. Every participant in the Hatha group showed some improvement in VO_2 max, though the magnitude varied (range of individual improvements ~1.0 to 4.0 mL/kg/min). The Ashtanga group showed a larger gain: mean VO_2 max rose from 40.8 to 45.4 mL/kg/min, an 11.3% improvement. This change was highly significant, $t(14) = -21.47$, $p < .001$. All 15 Ashtanga participants experienced increases in VO_2 max, with several improving by 5 mL/kg/min or more. The effect size for VO_2 max improvement was large in both groups (Cohen's $d \approx 2.0$ for Ashtanga, 1.3 for Hatha), indicating a robust training effect, especially for Ashtanga yoga.

Resting heart rate (RHR) decreased in both groups over the intervention period. In the Hatha group, mean RHR went from 70.8 bpm at pre-test to 68.2 bpm at post-test. This reduction (~2.6 bpm on average) was statistically significant ($t(14) = 6.46$, $p < .001$). The Ashtanga group's RHR dropped from a mean of 72.2 bpm to 67.3 bpm, a larger reduction of about 4.9 bpm. This was also highly significant ($t(14) = 12.65$, $p < .001$). These findings suggest improved cardiovascular efficiency (as the heart pumps blood more effectively, it beats fewer times per minute at rest) in both groups, with a more pronounced improvement in the Ashtanga practitioners.

Between-Group Comparisons: Comparing the two styles, the Ashtanga yoga group achieved greater improvements in both outcome measures. To formally test the difference, we computed change scores for each participant (post minus pre for VO_2 max, and pre minus post for RHR since a decrease in RHR is an improvement). An independent t-test on the VO_2 max changes showed a significant difference: $t(28) = 6.46$, $p < .001$, indicating the Ashtanga group's VO_2 max increase was larger on average than the Hatha group's. Similarly, for resting heart rate changes, $t(28) = 4.25$, $p < .001$, confirming that the Ashtanga group's greater drop in RHR was statistically reliable. In practical terms, the Ashtanga backbend program roughly doubled the VO_2 max gain of the Hatha program and produced nearly twice the reduction in resting heart rate over 8 weeks.

It is noteworthy that despite the differences in magnitude, the Hatha group did show meaningful positive changes. There was no indication of any adverse effect of the gentler practice – all participants improved or maintained their VO_2 max, and most saw a drop in RHR. Thus, both forms of yoga training were beneficial; Ashtanga's higher intensity simply led to further enhancement in these fitness parameters.

No injuries or adverse events were reported during the study. Both programs were well-tolerated. Self-reported exertion (collected via an RPE scale after sessions) averaged 12 (light to moderate) in Hatha sessions and 15 (moderate to hard) in Ashtanga sessions, reflecting the intended intensity difference. This subjective feedback aligns with the objective outcomes observed.

5. Discussion

This study investigated how two different yoga styles focusing on backbending sequences affect cardiovascular endurance in young adults. The findings support the hypothesis that regular yoga practice can improve key markers of cardiovascular fitness (VO_2 max and resting heart rate) and that the magnitude of improvement

depends on the intensity of the yoga style. Both the Hatha and Ashtanga yoga groups exhibited significant positive changes after 8 weeks, demonstrating that even an 8-week yoga regimen is sufficient to elicit measurable cardiovascular adaptations in relatively fit college students. This adds to the growing body of evidence that yoga can serve as an effective exercise modality for enhancing aerobic fitness.[9]

Hatha vs. Ashtanga – Intensity Matters: As expected, the Ashtanga group experienced larger improvements in VO_2 max and resting heart rate compared to the Hatha group. Ashtanga yoga's dynamic, flowing nature likely provided a stronger cardiovascular stimulus. Throughout the 8-week program, Ashtanga participants were working at a higher percentage of their maximum heart rate during sessions (as also suggested by Cowen & Adams's HR data for Ashtanga), which would induce more cardiovascular conditioning. Essentially, Ashtanga functions as a form of aerobic interval training: intense sequences (sun salutations, jump-backs, etc.) interspersed with brief pauses (between pose series or during held poses like downward dog). This can improve the efficiency of the heart and increase stroke volume, leading to a higher VO_2 max. In contrast, Hatha yoga, with its slower pacing and longer static holds, likely induced a more modest cardiovascular challenge. The Hatha participants improved VO_2 max by ~2 mL/kg/min – a reasonable gain that aligns with prior studies of moderate yoga practice. Their mean resting HR reduction (~3 bpm) also indicates improved vagal tone and cardiovascular efficiency, albeit smaller than in Ashtanga. These changes in the Hatha group mirror what has been observed in other low- to moderate-intensity exercise interventions of similar length, confirming that Hatha yoga can be a heart-healthy exercise form, even if it is not as vigorous.

Role of Backbends: An interesting aspect of this study was the focus on backbending postures across both styles. Backbends are known in yoga communities for their energizing and "heart-opening" effects. From a physiological perspective, backbends stretch the front of the body and may temporarily increase sympathetic activation (the heart rate often rises during a deep backbend, and many beginners feel an adrenaline rush). Over the 8 weeks, however, both groups learned to perform backbends with controlled breathing, which might have strengthened respiratory muscles and improved autonomic regulation. The diaphragm strengthening from backbends could contribute to better oxygenation during exercise, potentially aiding the increase in VO_2 max. Additionally, by stretching the thoracic region and possibly the arteries (like the aorta and other vessels) in that region, backbends might promote cardiovascular flexibility and reduce resting strain on the heart. While our study cannot isolate the effect of backbends alone (since they were part of a broader routine), it is plausible that including these postures helped stimulate the observed improvements. Future studies could compare yoga routines with and without an emphasis on backbends to see if there are differential impacts on cardiorespiratory outcomes.[10]

Comparisons to Traditional Exercise: The magnitude of VO_2 max improvements seen in the Ashtanga group (~11%) is comparable to improvements from moderate aerobic training programs in previously untrained

[9] Lau, C., Yu, R., & Woo, J. (2015). Effects of a 12-week Hatha yoga intervention on cardiorespiratory endurance, muscular strength and endurance, and flexibility in Hong Kong Chinese adults: A controlled clinical trial. *Evidence-Based Complementary and Alternative Medicine, 2015*, 958727. doi:10.1155/2015/958727

[10] Doyle, S. (2018, February 10). *Extend Your Spine! How Backbending Supports Respiratory and Cardiovascular Health*. YogaUOnline. Retrieved from https://yogauonline.com/yoga-practice-teaching-tips/yoga-anatomy/extend-your-spine-how-backbending-supports-respiratory-and-cardiovascular-health

individuals over a similar period. This is a notable finding – it suggests that a well-designed yoga program can function as aerobic training. The Hatha group's ~5% VO_2 max increase, while smaller, is still clinically meaningful in terms of health and endurance. Interestingly, a study on adolescents found yoga to improve VO_2 max nearly as much as conventional physical training, which is consistent with our results in young adults. These comparisons underscore that yoga should not be underestimated as a form of exercise; even styles not traditionally thought of as "cardio" (like Hatha) can improve aerobic fitness when practiced consistently. For college students who may be looking for alternative fitness activities beyond gym workouts or sports, yoga (even gentle yoga) offers a viable way to boost cardiovascular health.

Resting Heart Rate Improvements: Resting heart rate is influenced by both fitness and stress levels. The reductions in RHR in both groups indicate an increase in parasympathetic (vagal) tone and/or a decrease in sympathetic drive at rest, which often accompanies endurance training adaptation. The larger drop in the Ashtanga group (mean ~5 bpm) might reflect a stronger conditioning effect on the heart muscle – their hearts may have become more efficient at pumping blood (greater stroke volume), thus needing fewer beats per minute. It could also be partly due to greater activation of relaxation response through the combination of physical exertion and breath control in yoga. While Hatha yoga is sometimes specifically touted for stress reduction and might be expected to lower resting heart rate via stress relief, our results suggest that the aerobic training component (more pronounced in Ashtanga) had a potent effect on RHR. Both groups did finish each session with relaxation (savasana), so they likely got some parasympathetic activation regardless of style. This blend of aerobic exercise and relaxation unique to yoga might account for the improvements in RHR, aligning with other findings that yoga can reduce resting heart rate and blood pressure in various populations.

Limitations: Several limitations should be considered when interpreting our findings. First, the sample size (30 total, 15 per group) is relatively small, and participants were homogeneous (healthy college students). This limits generalizability to other groups such as older adults or individuals with health conditions. A larger sample might also detect more subtle differences or allow for controlling variables like sex differences in response (in our study we did not find any obvious gender effects, but we were not powered to examine them). Second, the intervention duration was only 8 weeks; a longer program might result in larger changes or reveal whether improvements plateau after a certain point. Third, while we controlled the type of poses (backbends) between groups, the inherent differences in style meant that the overall energetic expenditure was higher in Ashtanga. We did not directly measure caloric burn or average heart rate during sessions, which could have provided deeper insight into the dose of exercise each group received. Future research could include wearable trackers during yoga sessions to quantify intensity. Fourth, VO_2 max testing in a yoga context could be slightly confounded if participants' motivation or familiarity with treadmill running varies. We attempted to mitigate this by having all participants practice on the treadmill before baseline testing and providing uniform encouragement. Lastly, our study did not include a non-exercise control group. We assumed that any changes were due to the interventions, but without a control we cannot rule out general lifestyle effects. However, it is unlikely that VO_2 max would increase in the absence of training, so we are confident the yoga caused the improvements.

Strengths: Despite limitations, the study had notable strengths. Randomized group assignment and consistent instruction minimized bias. Both groups adhered well to the protocol, and there were no dropouts, enhancing

the internal validity of the findings. By focusing on specific pose categories, we added a novel element to yoga research, bridging a gap between traditional exercise science and yoga practice. The use of objective measures (direct VO_2 max, measured RHR) provides concrete evidence of physiological changes. Additionally, including both an active gentle yoga and an active vigorous yoga group allowed us to directly compare two forms of yoga, whereas many previous studies have compared yoga to non-yoga controls or different exercise modalities. This head-to-head comparison within the yoga realm is valuable for practitioners and instructors when designing yoga programs for fitness.

Implications: The results suggest that when the goal is to improve cardiovascular endurance, choosing a more dynamic style of yoga like Ashtanga could be more beneficial, especially for apparently healthy young adults. Fitness professionals and yoga instructors working with clients interested in aerobic improvements might incorporate faster-paced vinyasa flows or Ashtanga elements into their routines. On the other hand, individuals who prefer a gentler practice can be encouraged that Hatha yoga still offers significant benefits for heart health, and it may serve as a gateway to improved fitness for those starting at lower fitness levels or who are averse to high-intensity workouts. In contexts such as college wellness programs, yoga classes can be pitched not only for stress reduction and flexibility but also as a contributor to students' cardiovascular fitness.

6. Conclusion

In summary, this comparative study demonstrated that an 8-week yoga program focusing on backbending poses can enhance cardiovascular endurance in college students, as evidenced by increased VO_2 max and lowered resting heart rate in both Hatha and Ashtanga yoga groups. Ashtanga yoga, with its vigorous and continuous flow, produced greater improvements in these measures than the traditional Hatha style. These findings highlight that the intensity of yoga practice plays a key role in determining fitness outcomes. Yoga is often celebrated for flexibility and mental health benefits, but our results affirm that it can also be a potent aerobic exercise modality. Backbend-centric sequences, in particular, appear to strengthen respiratory musculature and improve heart function, contributing to better aerobic capacity.

For practitioners, both novice and experienced, incorporating backbending postures under proper guidance is likely to confer cardiovascular benefits. Individuals seeking to boost endurance may gravitate towards dynamic yoga styles like Ashtanga or Vinyasa, while those who prefer a slower pace can still gain cardiovascular improvements through consistent Hatha practice. From a public health perspective, promoting yoga (across various styles) could be an accessible way to engage more people in regular physical activity that supports heart health. Future research should explore longer-term effects of yoga on cardiovascular fitness, include diverse populations, and investigate the physiological mechanisms (such as changes in blood volume, heart structure, or autonomic balance) underlying the observed improvements. Overall, this study adds empirical support to the idea that *"yoga for the heart"* is more than just a saying – it is a measurable reality.

Appendix

Appendix A: Yoga Intervention Protocols

A.1. Hatha Yoga Backbending Sequence (60 minutes)

- **Warm-up (10 mins)**:
  - Gentle seated breathing (5 mins)
  - Cat-Cow stretch
  - Gentle spinal twists
- **Main Sequence (45 mins):**
  - Bhujangasana (Cobra Pose) – 3 rounds, 30 sec hold
  - Setu Bandhasana (Bridge Pose) – 3 rounds, 45 sec hold
  - Dhanurasana (Bow Pose) – 3 rounds, 30 sec hold
  - Ustrasana (Camel Pose) – 3 rounds, 45 sec hold
  - Salabhasana (Locust Pose) – 2 rounds, 40 sec hold
  - Marjariasana + Bitilasana transitions
- **Cool-down (5 mins):**
  - Balasana (Child's Pose)
  - Supine spinal twist
  - Savasana with guided breathing

A.2. Ashtanga Yoga Backbending Sequence (60 minutes)

- **Warm-up (10 mins):**
  - Surya Namaskar A – 5 rounds
  - Surya Namaskar B – 3 rounds
- **Main Sequence (45 mins):**
  - Utkatasana to Urdhva Mukha Svanasana flow
  - Ustrasana – 3 rounds, 5 breaths

  - Dhanurasana – 3 rounds, 5 breaths
  - Urdhva Dhanurasana – 3 rounds, 5 breaths
  - Viparita Dandasana (with props) – 2 rounds
  - Vinyasa transitions between poses
- **Cool-down (5 mins):**
  - Ardha Matsyendrasana (Twist)
  - Seated forward bend
  - Savasana

Appendix B: VO_2 Max Testing Protocol (Modified Bruce Protocol)

- **Stage 1**: 1.7 mph @ 10% incline – 3 mins
- **Stage 2**: 2.5 mph @ 12% incline – 3 mins
- **Stage 3**: 3.4 mph @ 14% incline – 3 mins
- **Stage 4+**: Increased speed and incline each 3 min
- Oxygen consumption measured continuously using COSMED K4B²
- Test ends on volitional fatigue or VO_2 plateau
- Criteria for valid VO_2 max:
  - RER > 1.1
  - HR within 10 bpm of age-predicted max
  - Plateau in VO_2