

Yoga Breathing, Heart Rate Variability, and Functional Capacity in University Students

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Abstract

Background: University students experience academic and lifestyle demands that may affect autonomic regulation and cardiorespiratory health. Yoga breathing, or pranayama, may influence these physiological domains, but the available evidence remains heterogeneous.

Objective: To summarise evidence on yoga breathing interventions and outcomes related to heart rate variability (HRV) and functional capacity in university students and comparable young adults.

Methods: A preliminary review was conducted using records identified from PubMed, Scopus, Web of Science, and Google Scholar on August 1, 2026. Two reviewers independently screened titles, abstracts, and full texts, with disagreements resolved through discussion or consultation with a third reviewer. Six studies were included. Interventions comprised standalone pranayama and multicomponent yoga programmes. Findings were narratively synthesised because of substantial heterogeneity in interventions, study designs, and outcome measures. No formal risk of bias assessment was performed.

Results: Slow pranayama reduced heart rate from 76.60 ± 5.15 to 73.66 ± 3.90 beats/min ($p < 0.001$) in one controlled study. Other studies reported significant changes in selected HRV, cardiovascular, respiratory, six-minute walk, and maximal oxygen uptake outcomes. An acute crossover study reported increased SDNN and low-frequency power ($p < 0.05$), whereas a 12-week controlled programme reported improved VO₂max. Effect estimates and confidence intervals were inconsistently reported.

Conclusion: Available evidence suggests that yoga breathing may be associated with changes in selected autonomic, cardiorespiratory, and functional outcomes. However, heterogeneity, the absence of formal risk of bias appraisal, and inconsistent reporting limit certainty regarding effectiveness.

Keywords

Breathing Exercises; Heart Rate Variability; Autonomic Nervous System; Exercise Tolerance; Students

Introduction

University students are exposed to academic, social, and lifestyle demands that may influence psychological wellbeing and physiological health.¹⁻³ Studies among Indonesian university students have reported symptoms of depression, anxiety, and stress, highlighting the need for accessible strategies that may support student wellbeing.¹ Similar concerns have been documented internationally, with anxiety and depressive symptoms representing important health issues in university populations.² In addition to psychosocial demands, insufficient physical activity and prolonged sedentary behaviour remain relevant concerns among students and may coexist with elevated perceived stress.³ These factors may collectively influence cardiovascular autonomic regulation and cardiorespiratory health.⁴⁻⁶

Heart rate variability (HRV) represents variation in the time intervals between successive normal heartbeats and provides information regarding cardiac autonomic modulation.⁷ However, HRV should not be interpreted as a direct or universal measure of overall autonomic balance because its values are influenced by age, physical activity, respiration, body position, recording duration, and environmental and methodological conditions.⁴ Different HRV indices also represent distinct characteristics of cardiac rhythm regulation.⁴ For example, the standard deviation of normal-to-normal intervals (SDNN) reflects overall variability within the recording period, whereas the root mean square of successive differences and high-frequency power are commonly examined as indices of vagally mediated cardiac modulation under appropriate measurement conditions.⁴ Accordingly, interpretation of HRV outcomes requires consideration of the specific metric, respiratory conditions, and measurement procedures rather than reliance on a single index as evidence of sympathetic or parasympathetic predominance.⁴

Functional capacity represents another relevant dimension of physiological health in young adults. Measures such as the six-minute walk test (6MWT) and maximal oxygen uptake (VO₂max) provide information about the integrated ability of cardiovascular, respiratory, and musculoskeletal systems to support physical activity.^{8,9} Cardiorespiratory fitness established during young adulthood is relevant to long-term health, while regular physical activity remains important for maintaining physiological function and overall wellbeing.¹⁰ Nevertheless, university students may encounter barriers to regular exercise, including academic workload, time constraints, and sedentary study routines.³ Therefore, complementary approaches that are feasible, require limited resources, and can be adapted to university environments warrant further investigation.⁵

Yoga breathing, commonly referred to as pranayama, encompasses voluntary breathing techniques that differ in breathing rate, depth, rhythm, nostril involvement, and duration.¹¹ These techniques include slow and controlled breathing patterns as well as rapid or forceful manoeuvres, and their physiological effects should not be assumed to be equivalent.^{11,12} Slow and voluntarily controlled breathing has been associated with changes in cardiovascular and HRV measures, although the magnitude and persistence of these effects vary according to the intervention protocol, study population, and measurement procedures.^{5,6,11} Broader evidence has also suggested that slow-paced breathing may influence selected HRV and cardiovascular outcomes in nonclinical

populations.^{5,6} However, such findings should not be interpreted as evidence that all pranayama techniques produce identical physiological responses or that changes in individual HRV indices represent a uniform autonomic effect.^{4,12}

The potential relevance of yoga breathing extends beyond cardiac autonomic measures. Controlled breathing may influence respiratory patterns and selected cardiovascular outcomes, while repeated practice within structured programmes may also be associated with changes in physical or cardiorespiratory performance.^{11,13} Nevertheless, the available evidence is heterogeneous. Some interventions evaluate standalone pranayama techniques, whereas others incorporate breathing practice into broader yoga programmes that may include physical postures, relaxation, or chanting. Similarly, the reported outcomes include direct HRV indices, cardiovascular and respiratory variables, 6MWT performance, and VO₂max. These measures represent related but distinct physiological domains and should not be treated as interchangeable indicators of autonomic function or functional capacity.^{4,10}

The studies identified in the present review illustrate this fragmentation of the available evidence. Some investigations primarily evaluated direct HRV outcomes or cardiovascular and respiratory variables, whereas others examined functional capacity through walking performance or VO₂max.^{12,14–18} Importantly, evidence from separate studies addressing these domains does not establish that yoga breathing simultaneously improves autonomic regulation and functional capacity within the same student population. Among the six included studies, no study concurrently evaluated direct HRV and functional capacity as primary outcome domains within the same cohort.^{12,14–18} Therefore, the present review does not assume a direct relationship between these outcomes but instead provides a descriptive synthesis of the evidence available across the two domains.

Interpretation of the evidence is further complicated by substantial variation in participant characteristics, study design, intervention composition, breathing technique, intervention duration, and outcome measurement.^{12,14–18} Acute physiological responses during a single breathing session should also be distinguished from changes observed after repeated practice.^{16,17} Likewise, findings from multicomponent yoga programmes cannot be attributed exclusively to pranayama when other intervention components may have contributed to the observed outcomes.^{14,17} These distinctions are essential to avoid overinterpreting individual findings or presenting heterogeneous evidence as a uniform estimate of intervention effectiveness.

Accordingly, this preliminary review aimed to summarise the available evidence on yoga breathing interventions and outcomes related to HRV and functional capacity among university students and comparable young adults. The review specifically distinguishes direct HRV outcomes from cardiovascular and respiratory surrogate measures and from functional capacity outcomes, while also considering differences in intervention type and study design. Given the heterogeneity of the included evidence and the absence of formal risk of bias appraisal, the findings are intended to provide a cautious descriptive overview rather than a definitive estimate of intervention effectiveness. The review also identifies methodological considerations and evidence gaps that should be addressed in future controlled studies and more comprehensive evidence syntheses.

Methods

This preliminary review was conducted to summarise the available evidence on yoga breathing interventions and outcomes related to heart rate variability (HRV) and functional capacity among university students and comparable young adults. The review was designed as a structured preliminary evidence synthesis and was not intended to constitute a completed systematic review. Although multiple bibliographic and academic information sources were searched and a documented selection process was applied, the review did not include all methodological procedures required for a fully reproducible systematic review, particularly a formal risk of bias assessment. Therefore, the findings were synthesised narratively and should be interpreted as preliminary evidence rather than as a definitive estimate of intervention effectiveness.

The review question was structured according to the Population, Intervention, Comparator, Outcomes, and Study design framework. The population comprised university students or comparable healthy young adults, generally aged 17 to 28 years. The intervention consisted of structured yoga breathing or pranayama, either as a standalone intervention or as a defined component of a broader yoga programme. Comparators included no intervention, a control condition, an alternative breathing condition, or within-participant preintervention and postintervention comparisons, depending on the study design. The primary outcome domains were direct HRV measures and functional capacity measures, including six-minute walk distance and maximal oxygen uptake (VO₂max). Cardiovascular and respiratory variables, including heart rate, blood pressure, respiratory rate, pulse pressure, and peak expiratory flow rate, were considered related physiological outcomes and were analysed separately from direct HRV and functional capacity outcomes.

The literature search was conducted on August 1, 2026. Four information sources were used: PubMed through pubmed.ncbi.nlm.nih.gov, Scopus through scopus.com, Web of Science through webofscience.com, and Google Scholar through scholar.google.com. Studies published between 2013 and 2026 in English or Indonesian were considered. The search was limited to primary research studies. Review articles, editorials, conference abstracts, and theses or dissertations without peer review were not eligible for inclusion.

The search strategy combined terms related to pranayama or yoga breathing, physiological outcomes, and the target population. The core search strategy included the following concepts:

(pranayama OR “yoga breathing” OR “alternate nostril breathing” OR Bhastrika OR Bhramari OR Kapalabhati OR “Nadi Shuddhi” OR Nadishodhana OR “Anulom Vilom”) AND (“heart rate variability” OR HRV OR “autonomic function” OR “autonomic nervous system” OR “cardiac autonomic” OR “functional capacity” OR “six-minute walk” OR 6MWT OR VO₂max OR “cardiorespiratory fitness” OR “exercise capacity”) AND (“university student” OR “college student” OR “medical student” OR “nursing student” OR “young adult”).

For PubMed, the search terms were adapted using title and abstract field restrictions where applicable. Equivalent keyword combinations were adapted for Scopus and Web of Science according to the syntax and search functions of each platform. Google Scholar was used as an additional academic information source. The complete database-specific search strings and detailed yields for each individual source were not retained in a form that permits full replication. This limitation is acknowledged, and the present review is therefore classified as a preliminary review rather than a systematic review.^{19,20}

Studies were eligible when they enrolled university students or comparable healthy young adults aged approximately 17 to 28 years; implemented structured pranayama or yoga breathing either as a standalone intervention or as a defined component of a broader yoga programme; and reported quantitative findings for at least one prespecified outcome domain. Eligible designs included randomised controlled studies, controlled experimental or quasi-experimental studies, crossover studies, and prospective single-arm preintervention and postintervention studies. Studies were excluded when participants primarily had diagnosed cardiovascular, respiratory, or psychiatric conditions; the intervention consisted exclusively of an acute single session without a structured training period; the study did not report extractable quantitative outcome data; or the publication was not a primary research article.

One acute crossover study was retained because it directly examined HRV responses during nostril-regulated yoga breathing. Its findings were analysed separately from repeated interventions and were interpreted as immediate physiological responses rather than evidence of long-term training adaptation.¹⁶ This distinction was maintained throughout the synthesis to avoid combining acute effects with outcomes observed after repeated intervention exposure.

The process of study identification, screening, eligibility assessment, and inclusion is presented in Figure 1.

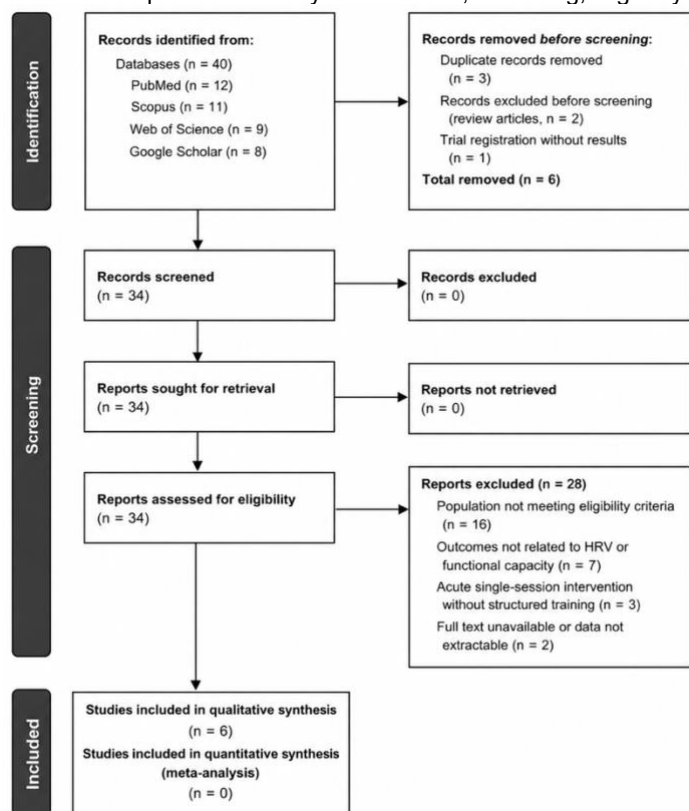


Figure 1. Flow of Study Identification, Screening, Eligibility Assessment, and Inclusion

A total of 40 records were identified from the selected information sources. Three duplicate or overlapping records were removed. In addition, two review articles and one trial registration without reported study results were excluded before screening. Therefore, 34 records remained for further assessment.

Two reviewers independently assessed the identified records and subsequently evaluated the potentially eligible reports against the predefined inclusion and exclusion criteria. All 34 records proceeded to the eligibility assessment stage. Twenty-eight reports were excluded because the study population did not meet the eligibility criteria, including studies involving populations other than university students or comparable young adults ($n = 16$); the reported outcomes were unrelated to HRV or functional capacity ($n = 7$); the intervention consisted only of an acute single session without a structured training period and was not retained for the relevant training-effect synthesis ($n = 3$); or the full text was unavailable or the required data could not be extracted ($n = 2$). Six studies were included in the final narrative synthesis.

Differences in screening decisions between the two reviewers were resolved through discussion. When agreement could not be reached, the final decision was referred to a third reviewer, identified as a senior researcher or supervisor. No formal calibration exercise before screening was documented. The selection process shown in Figure 1 is presented as a transparent description of the documented review process and should not be interpreted as evidence that the review fulfilled all methodological requirements of a PRISMA-compliant systematic review.¹⁹

Data extraction was performed by two reviewers. The extraction process was not conducted independently in duplicate. The information extracted from each included study comprised the author and publication year, study design, participant characteristics, country, sample size, intervention type and duration, comparator where applicable, outcome domain, and principal quantitative findings, including reported p values. Extracted data were discussed between the reviewers, and discrepancies identified during the extraction process were resolved through consensus.

The six included studies were checked against the corresponding original publications to confirm key study characteristics, including study design, participant characteristics, sample size, intervention, duration, and principal findings. During this verification process, an incorrect citation was identified for the study previously listed as Bal et al. 2021. The characteristics reported in the evidence table, including 108 university students, a 12-week intervention, and findings related to $VO_{2\max}$, corresponded to Anand et al. 2018.¹⁸ Therefore, the citation was corrected to Anand et al. 2018, and this correction was applied consistently throughout the manuscript, including Table 1 and the reference list.

A formal risk of bias or methodological quality assessment was not performed for the included studies. Consequently, the individual study findings were not weighted according to methodological quality or internal validity. This limitation affects the certainty of the narrative synthesis and is considered in the interpretation of the findings. The absence of formal methodological appraisal is one of the reasons why the present article should be interpreted as a preliminary review rather than a systematic review.

No protocol was registered in PROSPERO or another review registry. According to the information confirmed by the authors, a formal written review protocol was not prepared before the review was conducted. Consequently, no prospectively documented protocol or formal record of methodological deviations was available for comparison. This limitation is reported transparently.

Because the included studies differed substantially in intervention composition, breathing technique, intervention duration, participant characteristics, study design, and outcome measurement, meta-analysis was not performed. The findings were

synthesised narratively and organised into four predefined categories: direct HRV outcomes, cardiovascular and respiratory surrogate outcomes, functional capacity outcomes, and acute versus repeated intervention effects. Standalone pranayama interventions were also distinguished from multicomponent yoga programmes to avoid attributing the effects of broader interventions exclusively to breathing practice.

For each included study, the synthesis distinguished within-group changes from between-group findings whenever these data were reported in the original publication. Numerical changes and *p* values were reported descriptively when available. Confidence intervals and standardised effect estimates were not calculated retrospectively when they were not reported in the original publication or could not be extracted reliably. The synthesis therefore focused on the nature and direction of the reported findings while avoiding interpretation of the number of statistically significant results as evidence of a common or uniform intervention effect.

Results

The study identification, screening, eligibility assessment, and inclusion process is presented in Figure 1. A total of 40 records were identified from the selected information sources. After duplicate or overlapping records and ineligible publication types were removed, 34 reports underwent eligibility assessment. Of these, 28 reports were excluded according to the predefined criteria, resulting in six studies included in the final narrative synthesis. The included studies were published between 2013 and 2024 and were conducted in India, Bangladesh, and the United States.^{12,14–18}

The characteristics of the included studies are summarised in Table 1. The evidence comprised three controlled studies,^{12,15,18} two uncontrolled preintervention and postintervention studies,^{14,17} and one randomised crossover study.¹⁶ The interventions ranged from standalone slow or fast pranayama and alternate nostril breathing to multicomponent yoga programmes incorporating controlled breathing with asana or chanting. Intervention exposure ranged from a single acute session to programmes lasting four to twelve weeks or comprising 30 intervention sessions.

Table 1. Characteristics and Principal Findings of the Included Studies

Study	Study design	Participants	Intervention and duration	Outcome domain	Main reported findings
Sharma et al. 2013 ¹²	Three arm randomised controlled study	90 health care students, aged 18 to 25 years, India	Fast pranayama: Kapalabhati, Bhastrika, and Kukkuriya. Slow pranayama: Nadishodhana, Savitri, and Pranava. Control group. Thirty minutes per session, three times weekly for 12 weeks	Cardiovascular surrogate outcomes	Slow pranayama was associated with significant reductions in heart rate, diastolic blood pressure, mean arterial pressure, and double product. Heart rate decreased from 76.60 ± 5.15 to 73.66 ± 3.90 beats/min ($p < 0.001$). The fast pranayama group showed downward trends in several cardiovascular measures, although these changes were not reported as statistically significant.
Akhtar et al. 2013 ¹⁴	Single arm preintervention and postintervention study	30 physiotherapy students, aged 18 to 22 years, India	Multicomponent yoga programme involving asana, pranayama, and Omkar chanting. One hour per session for 30 sessions	Functional capacity	Six minute walk distance increased significantly. Rating of perceived exertion and recovery time decreased. Because the study had no parallel control group and used a multicomponent intervention, the observed changes cannot be attributed specifically to pranayama.
Jahan et al. 2021 ¹⁵	Two arm randomised experimental study	100 first year medical students, aged 18 to 20 years, Bangladesh; 50 intervention and 50 control participants	Alternate nostril breathing for 4 weeks	Cardiovascular and respiratory surrogate outcomes	Compared with the control group, pulse rate, respiratory rate, and diastolic blood pressure decreased significantly. Pulse pressure and peak expiratory flow rate increased significantly.
Telles et al. 2024 ¹⁶	Randomised crossover study	47 experienced yoga practitioners; mean age 26.3 years, India	Acute single session under four conditions: suryabhedan, chandrabhedan, breath awareness, and quiet rest	Direct HRV	SDNN and low frequency power increased significantly during both suryabhedan and chandrabhedan pranayama conditions ($p < 0.05$). These findings represent acute physiological responses and were analysed separately from repeated training effects.
Tay and Baldwin 2015 ¹⁷	Pilot preintervention and postintervention study without a control group	13 to 14 university students, aged 18 to 22 years, United States	Weekly vinyasa yoga sessions for 10 weeks with emphasis on controlled breathing during the yoga sequence	Direct HRV	SDNN increased significantly at the first and third assessment sessions ($p < 0.05$). Low frequency power and percentage low frequency power increased significantly at the third session. Low frequency power increased from 1348 ± 1468 ms ² to 3796 ± 3456 ms ² . Mean heart rate did not change significantly.
Anand et al. 2018 ¹⁸	Two arm randomised controlled study	108 university students, aged 17 to 28 years, India; 54 intervention and 54 control participants	Anuloma Viloma and Bhastrika pranayama for 12 weeks	Functional capacity and physical fitness	Physical fitness parameters improved significantly in the intervention group, including VO ₂ max. Improvements in flexibility and muscular strength were also reported. Mental health parameters improved but were not statistically significant compared with the control group.

Note: HRV, heart rate variability; SDNN, standard deviation of normal to normal intervals; VO₂max, maximal oxygen uptake.

As shown in Table 1, substantial heterogeneity was observed across the six studies. The differences involved participant characteristics, study design, intervention composition, breathing technique, duration of exposure, comparator conditions, and outcome measurement. Two studies evaluated direct HRV outcomes,^{16,17} two assessed cardiovascular or respiratory surrogate outcomes,^{12,15} and two evaluated functional capacity or related physical fitness outcomes.^{14,18} These differences precluded quantitative pooling and therefore no meta-analysis was performed.

Two studies provided direct evidence on HRV.^{16,17} Telles et al. evaluated immediate responses to nostril-regulated yoga breathing in 47 experienced yoga practitioners using a randomised crossover design.¹⁶ The study compared suryabhedan pranayama, chandrabhedan pranayama, breath awareness, and quiet rest. Statistically significant increases in SDNN and low frequency power were reported during both pranayama conditions, with $p < 0.05$. Because this study evaluated responses during an acute intervention, the findings were considered separately from changes observed following repeated exposure.

Tay and Baldwin examined HRV changes among 13 to 14 university students participating in a 10-week vinyasa yoga programme that incorporated controlled breathing throughout the yoga sequence.¹⁷ SDNN increased significantly at selected assessment sessions, and low frequency power increased significantly by the third assessment. Low frequency power increased from $1348 \pm 1468 \text{ ms}^2$ to $3796 \pm 3456 \text{ ms}^2$, whereas mean heart rate did not change significantly. Because the intervention included a broader yoga programme rather than standalone pranayama, the observed HRV changes cannot be attributed exclusively to breathing practice.

The two HRV studies therefore represented different intervention contexts and exposure periods. Telles et al. reported acute physiological responses during a single breathing session, whereas Tay and Baldwin assessed changes associated with repeated participation in a multicomponent yoga programme.^{16,17} Consequently, these findings were not interpreted as directly comparable estimates of a common intervention effect.

Two studies assessed cardiovascular and respiratory variables that were related to, but distinct from, direct measures of HRV.^{12,15} Sharma et al. compared fast pranayama, slow pranayama, and a control condition among 90 health care students over 12 weeks.¹² In the slow pranayama group, mean heart rate decreased from 76.60 ± 5.15 to 73.66 ± 3.90 beats/min ($p < 0.001$). Significant reductions in diastolic blood pressure, mean arterial pressure, and double product were also reported. In contrast, the fast pranayama group showed downward trends in several cardiovascular variables, although these changes were not reported as statistically significant.

Jahan et al. evaluated four weeks of alternate nostril breathing among 100 first-year medical students in a controlled experimental study.¹⁵ Compared with the control group, the intervention was associated with significant reductions in pulse rate, respiratory rate, and diastolic blood pressure. Significant increases were also reported in pulse pressure and peak expiratory flow rate. These outcomes were considered cardiovascular and respiratory surrogate measures and were not interpreted as direct evidence of changes in cardiac autonomic modulation.

Functional capacity and related physical fitness outcomes were reported in two studies.^{14,18} Akhtar et al. assessed 30 physiotherapy students before and after 30 sessions of a multicomponent yoga programme involving asana, pranayama, and Omkar chanting.¹⁴ Six-minute walk distance increased significantly, whereas rating of perceived exertion and recovery time decreased. However, because the study used a single-arm preintervention and postintervention design without a parallel control group, the observed changes cannot be attributed specifically to pranayama or separated from potential repeated-testing effects.

Anand et al. evaluated 108 university students aged 17 to 28 years using a two-arm controlled design, with 54 participants in the intervention group and 54 in the control group.¹⁸ The intervention consisted of Anuloma Viloma and Bhastrika pranayama practised over 12 weeks. Significant improvements in physical fitness parameters, including VO₂max, were reported in the intervention group. Improvements in flexibility and muscular strength were also observed, whereas changes in mental health parameters were not statistically significant compared with the control group.

Overall, the six included studies reported statistically significant changes in selected HRV indices, cardiovascular and respiratory variables, six-minute walk performance, VO₂max, and other physical fitness parameters. However, the findings were heterogeneous and varied according to intervention type, study design, duration, comparator, and outcome definition. Acute responses were distinguished from repeated intervention effects, and multicomponent yoga programmes were not interpreted as evidence of effects attributable exclusively to pranayama.

Effect estimates and confidence intervals were not consistently available across the included studies, and the reporting of within-group and between-group findings was also variable. Therefore, the results provide a descriptive synthesis of the reported findings rather than a pooled estimate of effectiveness. The observed changes should be interpreted cautiously because no formal risk of bias assessment was conducted and the methodological quality of individual studies was not incorporated into the synthesis.

Discussion

This preliminary review summarised evidence from six studies examining yoga breathing and related yoga based interventions among university students and comparable young adults. The findings indicated that selected heart rate variability (HRV), cardiovascular, respiratory, and functional capacity outcomes changed following either acute or repeated breathing based interventions. However, the evidence did not support a single or uniform estimate of effectiveness because the included studies differed substantially in intervention type, duration, study design, participant characteristics, and outcome definitions. In addition, direct HRV outcomes, cardiovascular and respiratory surrogate measures, and functional capacity outcomes represented distinct physiological domains and should not be interpreted as interchangeable indicators of the same intervention effect.

The findings related to HRV require particularly cautious interpretation. Telles et al. reported acute changes in SDNN and low frequency (LF) power during nostril regulated breathing, whereas Tay and Baldwin reported changes in selected HRV indices following repeated participation in a multicomponent vinyasa yoga programme.^{16,17} These findings suggest that breathing based practices may be associated with measurable changes in cardiac rhythm dynamics, but the two studies evaluated fundamentally different exposures. The acute crossover study cannot demonstrate sustained physiological adaptation, whereas the multicomponent intervention does not allow the observed changes to be attributed exclusively to pranayama. Consequently, the available evidence does not establish that yoga breathing consistently improves HRV across university populations.

Interpretation of frequency domain HRV findings also requires methodological caution. LF power should not be interpreted as a specific or isolated marker of parasympathetic activity because it reflects complex physiological influences and may vary according to respiratory pattern, recording conditions, and analytical procedures.⁴ Changes in LF power observed during or after breathing interventions should therefore be interpreted in conjunction with other HRV indices and the methodological context of the measurement. Similarly, increases in SDNN indicate changes in overall variability during the relevant recording period but do not

independently establish a specific autonomic mechanism. The present findings therefore support the observation of changes in selected HRV metrics rather than a definitive conclusion regarding sympathetic or parasympathetic dominance.

The cardiovascular and respiratory findings provide additional but indirect evidence of physiological responses to breathing interventions. Sharma et al. reported reductions in heart rate and selected blood pressure related measures following slow pranayama, whereas Jahan et al. observed changes in pulse rate, respiratory rate, diastolic blood pressure, pulse pressure, and peak expiratory flow rate following alternate nostril breathing.^{12,15} These outcomes are consistent with the possibility that controlled breathing may influence cardiorespiratory regulation. Nevertheless, they should not be considered substitutes for direct HRV measures. Furthermore, differences between slow and fast pranayama in the study by Sharma et al. indicate that breathing techniques may not produce equivalent physiological responses. This heterogeneity is important because the term pranayama encompasses multiple techniques that differ in breathing frequency, depth, rhythm, and respiratory manoeuvre.

Functional capacity findings were also heterogeneous. Akhtar et al. reported improved six minute walk performance following a multicomponent yoga programme, whereas Anand et al. reported improvements in VO₂max and other physical fitness parameters after 12 weeks of Anuloma Viloma and Bhastrika pranayama.^{14,18} The findings suggest that repeated breathing based or yoga interventions may be associated with changes in physical performance among young adults. However, the interpretation differs between the two studies. The uncontrolled design used by Akhtar et al. limits causal inference, while the intervention in that study also included asana and Omkar chanting. In contrast, the controlled design used by Anand et al. provides a comparative framework, although the findings remain specific to the studied intervention and population. The current evidence therefore does not establish that changes in functional capacity result from a common mechanism across all yoga breathing practices.

An important feature of the present synthesis is the separation of acute responses from repeated intervention effects. Immediate physiological changes observed during a single breathing session may reflect transient responses to altered respiratory patterns rather than longer term adaptation. Conversely, changes observed after several weeks of practice may reflect cumulative exposure but can also be influenced by adherence, cointerventions, repeated testing, or changes in participant behaviour. Similarly, standalone pranayama should be distinguished from multicomponent yoga programmes because the latter may combine breathing with physical postures, relaxation, meditation, or vocal practices. Failure to make these distinctions could result in an overstatement of the evidence for pranayama as an isolated intervention.

The heterogeneity of the included studies also explains why a quantitative synthesis was not considered appropriate. The studies differed in study design, sample size, participant characteristics, intervention composition, duration, comparator conditions, and outcome measurement. Effect estimates and confidence intervals were not consistently available, and within group and between group findings were not reported uniformly. A pooled analysis under these conditions could create an appearance of precision that is not supported by the underlying evidence. The present narrative approach therefore prioritised transparent description of individual study findings and the identification of major sources of heterogeneity.

Several methodological limitations should be considered when interpreting this review. Although multiple information sources were searched and two reviewers participated in study selection and data extraction, the complete database specific search strategies and detailed yield from each source were not retained in a fully reproducible form. The data extraction process was also not performed independently in duplicate, and no formal calibration exercise was documented. Most importantly, no formal risk of bias or methodological quality assessment was undertaken. As a result, the internal validity and certainty of the individual study findings could not be systematically evaluated or incorporated into the synthesis. These limitations prevent the review from being considered a fully reproducible systematic review and support its classification as a preliminary review.

Despite these limitations, the review provides a structured overview of an evidence base that is fragmented across autonomic, cardiovascular, respiratory, and functional outcomes. The findings highlight several priorities for future research. Controlled studies should clearly define the pranayama technique, frequency, session duration, intervention period, and comparator condition. HRV protocols should report recording procedures and analytical methods in sufficient detail to support interpretation.⁴ Future studies examining functional capacity should also distinguish between within group changes and between group effects and report effect estimates and confidence intervals whenever appropriate. Studies designed to investigate both autonomic and functional outcomes within the same cohort would be particularly valuable because the currently included evidence does not directly establish a relationship between changes in HRV and functional capacity.

From a practical perspective, yoga breathing may represent a feasible complementary practice for university settings because it generally requires limited equipment and can potentially be incorporated into existing health promotion activities. However, the current evidence is insufficient to support a definitive implementation recommendation or to specify an optimal breathing technique, intensity, or duration. Any application in university settings should therefore be regarded as conditional and subject to further evaluation rather than as an established evidence based intervention.

Overall, the available evidence indicates that yoga breathing and related yoga based interventions have been associated with changes in selected physiological and functional outcomes among university aged populations. However, substantial heterogeneity, inconsistent reporting of effect magnitude and uncertainty, limited comparability between acute and repeated interventions, and the absence of formal risk of bias assessment substantially limit the certainty of these findings. More rigorous controlled studies and reproducible systematic evidence syntheses are required before stronger conclusions can be drawn regarding the effectiveness of specific yoga breathing interventions on HRV or functional capacity.

Conclusion

This preliminary review identified six studies examining yoga breathing and related yoga based interventions in university students and comparable young adults. The included studies reported changes in selected HRV indices, cardiovascular and respiratory variables, six minute walk performance, VO₂max, and other physical fitness outcomes. However, these findings arose from heterogeneous interventions, study designs, participant populations, and outcome measures.

The available evidence does not support a single or definitive estimate of intervention effectiveness. Acute physiological responses should be distinguished from changes observed after repeated practice, and findings from multicomponent yoga programmes cannot be attributed exclusively to pranayama. In addition, cardiovascular and respiratory variables should not be interpreted as direct substitutes for HRV outcomes, and the currently available studies do not establish a direct relationship between changes in autonomic regulation and functional capacity.

The findings therefore suggest that yoga breathing may be associated with changes in selected autonomic, cardiorespiratory, and functional outcomes, but the certainty of this evidence remains limited. The absence of formal risk of bias

assessment, incomplete reproducibility of the search strategy, inconsistent reporting of effect estimates and confidence intervals, and substantial methodological heterogeneity require cautious interpretation.

Yoga breathing may have potential as a complementary practice in university health promotion, but the current evidence is insufficient to support a definitive recommendation regarding its implementation, optimal technique, intensity, or duration. Future controlled studies should use clearly defined interventions, appropriate comparators, standardised outcome assessment, and transparent reporting of effect magnitude and uncertainty. More rigorous and reproducible systematic evidence syntheses are also required to determine the effectiveness of specific yoga breathing interventions on HRV and functional capacity.

Author Contribution

I Wayan Namun Pebriana: Conceptualization, methodology, literature search, data extraction, writing original draft, and manuscript revision.

I Putu Kharismawan Aritama: Methodological guidance, interpretation of findings, supervision, and writing review and editing.

Komang Githa Pradnyamitha Dewi: Data extraction, narrative synthesis, manuscript editing, and writing review and editing.

All authors have read and approved the final version of the manuscript.

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Conflict of Interest Statement

The authors declare no conflicts of interest related to this study.

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Ethics Statement

This study was a preliminary review based on previously published research and did not involve direct participation of human subjects, animals, or the collection of identifiable personal data. Therefore, formal ethical approval was not required.

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