

Selecting and Sequencing Pranayama Techniques for Adolescent Practice: A Narrative Review of Protocol Design, Dosage and Safety

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ABSTRACT

Background: Pranayama is delivered to adolescents in a growing number of programs, yet the reasoning that produces any particular protocol is seldom visible in published reports. A protocol names its techniques and its total dose; the grounds on which those techniques were chosen, the order in which they were introduced, and the accommodations made for participants who could not practice on a given day generally remain outside the record.

Objective: This review examines how the current literature supports the selection, ordering, dosage and safe delivery of pranayama techniques in adolescent populations and proposes a reporting framework for protocol design.

Approach: A narrative review of indexed literature covering the physiological profiles of widely used techniques, systematic reviews of yoga and pranayama trials, module development methodology, adverse event reporting and adolescent participation research.

Findings: Four techniques recur across adolescent programs: Anulom Vilom, Bhastrika, Kapalabhati and Bhramari. Their autonomic signatures diverge sharply, with slow regulated breathing raising vagally mediated heart rate variability and forceful techniques producing sympathetic dominance. Many trials combine slow and fast practices within a single protocol. The contribution of any individual technique remains difficult to isolate. Program dosage clusters well below what skill acquisition arguments would predict, averaging roughly seventeen sessions across one to six weeks in the pranayama trial literature. Safety data place yoga broadly on a level with conventional exercise, while adverse events attach more often to forceful techniques than to slow ones. Guidance on practicing during menstruation reaches the field mainly through traditional and practitioner channels rather than through trial protocols, even as menstruation is documented as a substantial influence on adolescent participation in physical activity.

Conclusion: Existing evidence supports an explicit, reportable protocol rationale. A fourteen-item framework is proposed to make technique selection, ordering, progression, accommodation and participation accounting visible in future adolescent pranayama research.

Keywords: pranayama; protocol design; adolescents; sequencing; safety

INTRODUCTION

Pranayama occupies an unusual position among mind-body practices. It operates through a process that runs without instruction yet yields to deliberate control at any moment, giving it a direct, teachable link between

voluntary action and the autonomic systems governing arousal, attention, and emotional regulation. That accessibility explains much of its appeal for adolescent programs. The practice requires no equipment, no floor space beyond a seat and no vocabulary of postures that must first be learned.

Accessibility has produced volume. Pranayama now appears across school programs, clinical adjuncts and public health initiatives, and the evidence base has expanded accordingly. What has expanded more slowly is the reasoning that connects a research question to the particular set of techniques used to answer it.

Consider what a reader learns from a typical published protocol. The techniques are named. The number of weeks is given, usually the number of sessions per week and often the minutes per session. What follows from there is generally the outcome data. The reader learns which practices were used without learning why those practices and not others; in what order they were introduced and on what grounds that order was chosen; what a participant did on a day when the assigned practice was unsuitable; and whether such a day counted toward the reported attendance figure.

These are answerable questions. The physiological literature distinguishes clearly between technique families, the module development literature has produced explicit methodology for constructing and validating a practice set, and the safety literature identifies which practices warrant which precautions. The material for a defensible rationale exists. What the field has yet to settle is whether such rationale belongs in the report.

This review draws that material together for the adolescent case. It examines the four techniques that recur most often in adolescent and school programs, sets out what is known about ordering and dosage, addresses safety and participation including the specific matter of menstruation and closes with a framework intended to make protocol reasoning reportable.

Approach to The Literature

This is a narrative review. It follows the reasoning of the field rather than a pre-specified systematic search, and it makes no claim to exhaustive coverage of any area it draws on.

Literature was assembled across five areas: physiological studies of individual pranayama techniques, principally those reporting autonomic or heart rate variability outcomes; systematic reviews and meta-analyses of pranayama and yoga interventions; methodological literature on yoga module development and validation; adverse event and safety literature covering yoga and breath practices; and research on adolescent participation in physical activity, including work on menstruation as a determinant of participation. Sources were identified through indexed databases and through the reference lists of retrieved articles.

Where evidence is contested, the review reports the disagreement rather than resolving it. Where guidance rests on traditional rather than clinical authority, that provenance is stated.

The Case for Explicit Protocol Rationale

Two recent syntheses show what the current reporting convention costs.

Katla and colleagues [1] conducted the first systematic review of yoga module development and validation, examining thirty-seven articles that described how a practice set was constructed. Their assessment used a purpose-built twenty-three-item checklist covering development, validation and feasibility. Among the development items were the sequence of practices, the dose and frequency of the intervention, the involvement of experts at the design stage and the reporting of adverse effects. Applying this instrument, the authors rated 21.6 percent of the studies as high quality and 8.11 percent as low, with the majority falling in between. Literature review was the usual method of constructing a module and expert Likert scoring the usual method of validating it. Around half of the studies tested feasibility.

The pattern matters because these thirty-seven articles were selected precisely because they described their development process. Studies that named practices without explaining how those practices were chosen were excluded at screening. The quality distribution therefore describes the better-documented end of the field.

Katla and colleagues also recorded what the modules looked like in practice. Session length ranged from twelve to ninety minutes and averaged about fifty. Sessions ran between one and five times weekly. Complete interventions lasted from five days to three months, averaging seven weeks. Three articles omitted dosage information altogether. Among the authors' recommendations was that modules be graded so that participants move from simpler practices toward more demanding ones, an argument for progression as a design principle rather than as an incidental feature.

The second synthesis shows the analytic consequence. Mütze and colleagues [2] conducted a systematic review and meta-analysis of pranayama for mental disorders, drawing on seven randomized controlled trials. Slow practices including Nadi Shodhana, Ujjayi and Shitali appeared alongside fast practices including Bhastrika and Kapalabhati, combined within single interventions across the included studies. The authors reported that they were unable to differentiate the effects of slow from fast techniques, attributing this both to the small number of studies and to the combination of technique types within every one of them. Against passive controls, the pooled reduction in symptom severity was small, with a standardized mean difference of -0.27 on intention-to-treat analysis and -0.35 per protocol. Quality of life showed an effect in per-protocol analysis only. Depression outcomes showed no significant difference.

The finding about differentiation deserves emphasis. A field that combines practices with opposite autonomic signatures inside a single protocol, and then reports the protocol as a unit, forecloses the question of which practice did the work. Every additional trial constructed on that pattern adds to the aggregate evidence for pranayama while leaving the mechanism question exactly where it was.

Explicit sequencing rationale addresses both problems at once. It gives readers the grounds for the design and it creates the record from which future syntheses could eventually separate technique effects.

Physiological and Evidential Profiles of Four Widely Used Techniques

Four techniques recur across adolescent and school-based programs. They differ in mechanical demand, in autonomic effect and in how readily a supervisor can confirm that a young practitioner is doing them correctly. Those differences carry the design implications set out in Section 5.

Anulom Vilom (Nadi Shodhana)

Alternate nostril breathing is a slow, self-paced practice in which the practitioner closes one nostril, inhales through the other, then reverses. It has no forced component. Its rhythm is set by the practitioner rather than by a count imposed from outside, which makes it tolerant of individual differences in lung capacity and in confidence.

The physiological case for slow regulated breathing is the strongest in this literature. Laborde and colleagues [3] pooled 223 studies of voluntary slow breathing and tested its effect on vagal tone at three separate points: while the breathing was under way, in the period straight after one session, and at the end of a course of repeated sessions. Vagally mediated heart rate variability rose at all three. Their verdict was that the practice is inexpensive, asks nothing of equipment and carries little expected risk.

Saoji and colleagues [4], reviewing roughly 1,400 references on yogic breath regulation, found the weight of evidence pointing toward beneficial effects across neurocognitive, psychophysiological, respiratory, biochemical and metabolic function, and judged pranayama safe when practiced under qualified instruction. Work specific to alternate nostril breathing and cognition has also accumulated, with Ghiya [5] concluding from a review of clinical trials that the practice is associated with improvements in cognitive performance, while noting methodological variability across the studies reviewed.

Evidence in the target population reinforces this. Kuppusamy and colleagues [6] conducted a randomized controlled trial of yoga breathing in healthy adolescents and reported changes in heart rate variability consistent with a shift toward parasympathetic regulation, establishing that the autonomic response documented in adults appears in adolescents as well. The broader mechanistic account advanced by Streeter and colleagues [7] links yogic breathing to increased vagal tone, elevated gamma-aminobutyric acid activity and improved emotional regulation, and supplies the theoretical frame within which these autonomic findings are usually read.

For adolescent programs, the practical features matter as much as the physiology. The technique is visible: a supervisor can see whether the hand position is correct and whether the breath is slow. It is self-limiting, since a practitioner who breathes too forcefully will notice. It carries the lowest precaution burden of the four.

Bhastrika

Bhastrika, the bellows breath, uses forceful inhalation and forceful exhalation at speed. Both phases are active, which distinguishes it mechanically from Kapalabhati.

The most directly relevant evidence for adolescent affect comes from Novaes and colleagues [8], who conducted a randomized controlled trial of four weeks of Bhastrika and reported reductions in anxiety and negative affect accompanied by altered activity in the amygdala, anterior cingulate cortex, anterior insula and prefrontal cortex under functional magnetic resonance imaging. This remains one of the few studies to pair an affective outcome with neuroimaging for a single named technique, and it is the reason Bhastrika appears in protocols aimed at emotional outcomes.

The forceful character of the practice places it in a different safety category from alternate nostril breathing, discussed in Section 7.

Kapalabhati

Kapalabhati uses forceful, rapid exhalation driven by abdominal contraction, with inhalation passive. It is classified with Bhastrika among the fast practices, and its autonomic signature runs opposite to that of slow breathing.

Malhotra and colleagues [9] compared Kapalabhati with slow deep breathing in a quasi-experimental study of sixty participants, measuring heart rate variability. Kapalabhati produced sympathetic dominance while slow deep breathing promoted parasympathetic activity. The contrast is the clearest single demonstration that these practices are not interchangeable and that a protocol combining them is combining opposites.

Evidence in young people comes chiefly from acute designs. Telles and colleagues [10] found that a single session of high-frequency yoga breathing improved performance on an attention task in pre-teen children, which is the principal reason fast breathing appears in protocols with cognitive outcomes. Its precaution profile is the most demanding of the four and is addressed in Section 7.

Bhramari

Bhramari, the humming bee breath, produces a sustained hum on exhalation. It is slow, requires no forced effort, and is unusually easy to verify, since a supervisor can hear whether a room is practicing.

The evidence here carries an instructive complication. Trivedi and colleagues [11], using Holter recording with twenty-three participants, compared humming against physical activity, emotional stress and sleep, and found that humming generated the lowest stress index of the four conditions, concluding that regular practice can support parasympathetic function. Nivethitha and colleagues [12], however, recorded heart rate variability in sixteen healthy volunteers before, during, and immediately after five minutes of Bhramari, and found increased heart rate and increased low-frequency spectrum alongside reduced high-frequency

spectrum during the practice, with values returning toward baseline afterward. They interpreted this as parasympathetic withdrawal during the practice itself.

These findings are reconcilable, since one describes the state during practice and the other the aggregate effect of a routine and both sample sizes are small. The point for protocol design is that even a technique universally described as calming has a contested acute autonomic profile. Labels such as calming and energizing are useful shorthand and poor substitutes for the underlying measurements.

Principles for Ordering Techniques Within A Multi-Week Program

Ordering is the least documented element of protocol design and the one most amenable to reasoned justification. Four principles are supportable from the material above.

Skill before load. Katla and colleagues [1] recommend that modules be graded so participants move from simpler practices toward more demanding ones, and that a trained instructor be present in the early phase. Applied to the four techniques, this favors opening with the practice that is self-paced, unforced and easiest to verify. Alternate nostril breathing satisfies all three conditions. A participant who has spent several weeks establishing a slow, controlled breath brings that control to a forceful technique introduced later. A participant who meets a forceful technique first has no such base.

One variable at a time. Introducing techniques singly and at intervals, rather than presenting a full set at the outset, has two justifications. It respects the graded-progression argument, and it produces a record in which any change in a weekly outcome measure can at least be described against a known point of introduction. A protocol that begins with all four techniques forgoes that structure permanently.

Cumulative rather than substitutive practice. A program may add each technique to those already established or may replace one with the next. The cumulative pattern preserves the earlier practice as a base and lengthens sessions predictably; the substitutive pattern holds session length constant and tests each technique in relative isolation. Both are defensible. What matters is stating the choice, because the two designs answer different questions and a reader cannot infer which was used from a list of technique names.

Arousal profile should inform position. Given that slow breathing raises vagally mediated heart rate variability [3] while Kapalabhati produces sympathetic dominance [9], the position of a forceful technique within both the session and the program is a design decision with physiological content. Whether a session that ends on a forceful practice leaves adolescents in a state suited to returning to a classroom is a reasonable question for any program delivered within a school day and closing on a slower practice is a defensible response.

A worked implication follows for the four techniques under discussion. Opening with alternate nostril breathing establishes controlled, unforced breath under supervision. Introducing forceful techniques subsequently, singly and separated by several weeks, places the higher-demand practices on an established base and keeps their introduction points distinguishable. Closing the sequence with Bhramari places a slow, easily verified practice at the end, where it can serve as a settling practice within each session once the full set is in use. This is one defensible ordering rather than the only one. This review focuses on the reasoning, which should appear in the report, rather than the particular arrangement, which will vary with the population and the aims of the study.

Dosage: Session Length, Frequency and Program Duration

Dosage in this literature is set more often by setting than by principle.

Mütze and colleagues [2] found session length ranging from five to sixty minutes, frequency from twice weekly to daily, and program duration from one to six weeks, with an average of 17.5 sessions across the included trials. Katla and colleagues [1] found session length ranging from twelve to ninety minutes,

averaging about fifty, frequency from one to five sessions weekly and duration from five days to three months, averaging seven weeks.

Two observations follow.

The first concerns duration. An average of roughly seventeen sessions over one to six weeks is a short exposure against which to test a practice whose benefits are argued to accumulate through repetition. The graded-progression logic in Section 5 requires enough weeks for each technique to be established before introducing the next. A program of four techniques introduced at intervals needs a duration that most trials in the current literature would not accommodate. Longer programs are correspondingly informative, and their duration is worth treating as a design feature to be reported and justified rather than as a practical residue. Twelve weeks recurs as a workable period in school-delivered adolescent work; Kapoor and Jairus [13], for example, ran a twelve-week yogic intervention with adolescent girls in Punjab using a quasi-experimental non-equivalent control group design, with assessment at baseline, eight weeks and twelve weeks.

The second concerns session length. The fifty-minute average in the module literature reflects the inclusion of asana and relaxation components in most yoga modules. A pranayama-only protocol has no equivalent floor. Short sessions are compatible with the physiological evidence, since the slow breathing meta-analysis [3] reports effects during and immediately after single sessions, and the Bhramari studies [11, 12] used practice periods of a few minutes. For adolescent programs delivered within a timetable, a short session repeated at high frequency is a defensible and reportable design choice, and its rationale should appear alongside it.

Safety, Contraindication and Participation

The Overall Picture

Cramer and colleagues [14] conducted a systematic review and meta-analysis of the safety of yoga drawing on ninety-four randomized controlled trials involving 8,430 participants across 1975 to 2014. Measured against usual care and against exercise, yoga showed no elevation on any of the four counts examined: events attributed to the intervention, minor events, serious events, and withdrawals prompted by an adverse event. Compared with psychological and educational interventions, yoga participants experienced more intervention-related adverse events, with an odds ratio of 4.21, and more non-serious adverse events, with an odds ratio of 7.30. The authors concluded that yoga appears as safe as usual care and exercise, and called for improved safety reporting in future trials.

That conclusion is reassuring at the level of the practice as a whole. It also aggregates across practices with materially different demands, which is where the more useful detail lies.

Forceful Techniques Warrant Specific Precaution

Mütze and colleagues [2] recorded minor adverse events in fifteen pranayama participants; the symptoms reported ran from anxiety and breathlessness through coughing, dizziness and a sense of constriction to headache and neck pain. They reported that fast breathing techniques, and Kapalabhati in particular, showed a greater association with adverse events than slow methods did.

The case literature supplies a rare but instructive endpoint. Johnson and colleagues [15] reported a spontaneous pneumothorax in a healthy twenty-nine-year-old woman attributed to Kapalabhati practice, and framed the case as an illustration that adverse effects can follow when the body is pushed to physiological extremes. A single case report establishes possibility rather than incidence, and the practice is performed safely by very large numbers of people. Its value for protocol design lies in confirming that the mechanical demand of forceful exhalation is real and that supervision, graded introduction and a stated stopping rule are proportionate responses to it.

The practical implication is that a protocol combining slow and forceful techniques carries an internally varying risk profile, and that safety provisions should be specified at the level of the technique rather than at the level of the program.

Menstruation and the Accommodation That Goes Unreported

Traditional and practitioner guidance widely holds that forceful abdominal practices, Kapalabhati and Bhastrika among them, are unsuitable during menstruation. A search of the indexed literature locates this guidance principally in traditional texts and practitioner sources rather than in trial protocols or clinical studies, and the present review identified no controlled evidence establishing harm from these practices during menstruation. The guidance should therefore be described accurately: it is a long-standing convention of practice with limited clinical evidence either supporting or refuting it.

Its practical force does not depend on that evidence. Harvey and colleagues [16] conducted a global scoping review of menstruation and physical activity in adolescents, drawing on eighty-six studies across thirty-three countries. They describe a bidirectional relationship in which menstruation acts as a barrier to participation through symptoms, societal stigma and access to menstrual products, while physical activity may relieve symptoms for some. The barrier is documented, substantial and culturally variable.

Any pranayama program delivered to adolescent girls over several weeks and containing forceful techniques will therefore encounter participants who are unwilling or unable to perform the assigned practice on particular days, whether because of symptoms, because of the traditional guidance, because of what a family or teacher has advised, or because of the practical circumstances of managing menstruation at school. This is a predictable feature of the population rather than an incidental disruption.

Three consequences follow for protocol design, and each is reportable.

First, an accommodation should be pre-specified. A participant who should not perform Kapalabhati on a given day needs a defined alternative, which the evidence above suggests should be a slow, unforced practice such as alternate nostril breathing or Bhramari. Specifying this in advance converts an improvisation into a documented protocol feature.

Second, the accommodation should be recorded. Which practice was substituted, and on how many occasions, is information a reader needs in order to know what the intervention consisted of.

The third concerns attendance accounting, and it is the most easily overlooked. A study reporting high attendance in a mixed-sex adolescent cohort has necessarily made a decision about how to count a session in which a participant was present and practicing an accommodated alternative. Counting such a session as attendance is entirely defensible, since the participant was present and practicing. Reporting the figure without stating the rule leaves the reader unable to interpret it. The definition of attendance is a methodological choice and belongs in the methods.

Handled this way, menstruation moves from an unstated complication to a documented design feature, and the resulting attendance and adherence figures become interpretable.

Considerations Specific to Adolescents

Beyond the above, adolescent delivery raises considerations that a protocol can address explicitly. Screening for respiratory conditions, particularly asthma, is relevant given the mechanical demands of forceful practice. Supervision ratio determines whether technique errors are caught, and Katla and colleagues [1] recommend a trained instructor in the early phase in particular. A stated stopping rule, instructing participants to cease and rest on dizziness or breathlessness, gives young practitioners explicit permission to stop and reduces the pressure to continue in a group setting. Only a portion of the modules Katla and colleagues reviewed reported instructor qualification, and it is straightforward to state.

A Reporting Framework for Pranayama Protocol Design

Katla and colleagues [1] provide a general twenty-three-item instrument for yoga module quality. The framework below extends the sequencing and safety items of that instrument for the specific case of a multi-technique pranayama protocol. It is offered as a reporting aid rather than as a quality score, and every item is answerable at the design stage.

Selection

1. Each technique named, with its classical source and a plain description of its mechanics.
2. The autonomic or physiological classification of each technique, with supporting citation.
3. The rationale for including each technique, referred to the study's outcome domains.

Sequencing

4. The order of introduction, with the week or session at which each technique enters.
5. Whether practice is cumulative or substitutive.
6. The rationale for the order, referred to progression, arousal profile or skill demand.
7. The position of each technique within a session, where the session contains more than one.

Dosage

8. Dose per technique, expressed in rounds, ratio or minutes as appropriate.
9. Session length, weekly frequency and total program duration, with the reasoning behind the duration.
10. Any criteria used to advance a participant from one stage to the next.

Safety and Participation

11. Instructor qualification and the supervision ratio.
12. Screening applied before enrollment, with the conditions screened for.
13. Pre-specified accommodations, covering menstruation and transient illness, naming the substituted practice, together with a record of how often each was used.
14. The definition of attendance, stating explicitly whether an accommodated session counts, alongside the adverse event definition and the monitoring method.

Items 13 and 14 are the additions this review argues are most consequential and most often absent. They are also among the least burdensome to supply, since they require a decision the research team has already made in practice, written down.

Limitations of this Review

This review is narrative. It follows the reasoning of the field rather than a pre-specified protocol; it was not registered, and it applied no formal quality appraisal to the studies it draws on. A systematic review of sequencing rationale in published pranayama protocols would establish the prevalence of the reporting gap described here, which the present review characterizes rather than quantifies.

Coverage is confined to English-language indexed literature. Traditional sources are referred to as the origin of practice conventions rather than analyzed as texts, and a review conducted from the textual tradition would treat the sequencing question differently and would add to what is offered here.

Several of the physiological studies cited carry small samples, a limitation the review notes at the points where it bears on interpretation, particularly in the case of the contested acute profile of Bhramari. The framework in Section 8 is derived from the reasoning assembled here and awaits empirical evaluation of whether its use improves the interpretability of published protocols.

CONCLUSION

The material required to justify a pranayama protocol is already available. The physiological literature distinguishes slow from forceful practices and characterizes their autonomic effects. The module development literature supplies an explicit methodology for constructing and validating a practice set and argues for graded progression. The safety literature identifies which practices carry which precautions and establishes that yoga overall compares favorably with conventional exercise. Research on adolescent participation documents menstruation as a substantial and predictable influence on whether young people take part.

What remains is the convention that this reasoning belongs in the published report. Its absence has an identifiable cost: the most recent meta-analysis of pranayama for mental disorders could not separate the effects of slow from fast techniques, because every trial available to it combined the two and reported the combination as a unit.

For adolescent programs specifically, two items deserve particular attention. The first is the order in which techniques are introduced, a decision with physiological content that should be reported with its reasoning. The second is the accommodation made for participants who cannot perform an assigned practice on a given day, menstruation being the most predictable such circumstance in any program running for several weeks in a mixed-sex cohort. Pre-specifying that accommodation, recording its use and stating how attendance was counted would make participation figures interpretable and would cost the research team very little.

Protocol design in this field is presently a matter of judgment exercised privately and reported as a list. It can become a matter of judgment exercised explicitly and reported as reasoning, and the evidence to support that shift is in hand.

Declarations

Ethics approval. Not applicable. This review analyzes published literature and involved no human participants.

Consent for publication. Not applicable.

Availability of data and materials. Not applicable. All sources analyzed are published and cited.

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