

RESEARCH

Yoga at the Intersection of Research and Service

Part 1: Experimental Foundations

Stephanie M. Shorter, PhD

Mind-Body Collective | stephanie@mind-bodycollective.com

The yoga service research literature strives to represent the convergence of community service, empirical rigor, and therapeutic best practices. This article offers a primer for understanding reliability and validity as the foundations of good measurement techniques in yoga research and the basis of drawing correct inferences from any dataset. Different areas of yoga research tend to be characterized by different types of validity. As a result, the strengths of yoga service research are different from but complementary to the strengths of well-controlled laboratory yoga research. Some alternative experimental designs are suggested for yoga service research that expand beyond the commonly used pre-post design. Finally, a neuroanatomical pathway uniting brain and body is discussed and is shown to be the pathway through which yoga service providers can heal and transform. Interestingly, this pathway also unites yoga research in the laboratory and yoga service in action.

Yoga research has increased 10-fold in peer-reviewed publications across the past few decades. As of March 2013, 74 yoga research studies had already been published and indexed in PubMed this year (figure 1; Dr. Troy Cellmer via Active Life DC, 2013), which continues a trend of exponential growth in the last decade. These studies document the physical and psychological benefits of practicing yoga using research protocols that typically focus on *asana* (see Büssing et al., 2012 for a review).

Therapeutic yoga has also recently proliferated in the United States with the efforts of service-based yoga organizations, especially those that function as hubs to share resources and field-tested methods, such as the Give Back Yoga Foundation (www.givebackyoga.org) and the Yoga Service Council (www.yogaservicecouncil.org). Yoga service involves sharing yogic practices to underserved populations that might not otherwise be exposed to the healing benefits of practicing yoga. We may not have the clearest operational definition of yoga service, yet we know it when we see it. The success of the inaugural Yoga Service Conference in 2012 and the demand for this journal are excellent metrics for how quickly yoga service—yoga therapy in the field—is advancing.

Building the evidence base for yoga as a natural healing modality that takes the whole person into account—mentally, physically, and spiritually—will take a village. It will take

efforts in the lab and efforts in the field and clinic; just as importantly, it will involve connecting these efforts or at least meeting in the middle. The emergence of yoga service research literature represents how community outreach, experimental expertise, and clinical best practices are coming together in a novel and powerful way. Other authors have articulated some of the issues around bringing yoga therapy and yoga research together (e.g., Bullock, 2013; Hagins & Khalsa, 2012; Bhavanani, 2011) and have prepared yoga therapists to confidently introduce the growing evidence base to allopathic medicine professionals (e.g., Birch, 2012).

This article describes a conceptual framework for varied yoga research methodologies and discerns how the strengths of laboratory research differ from the studies being done by yoga service organizations—differences that are complementary in their approaches and outcomes. By reviewing some classic concepts in drawing inferences from scientific data, this article may point the reader to new possibilities in experimental design beyond the widely used pre-post design.

The yoga community at large has proven itself to be very interested in research, given the popularity of workshops on how to conduct yoga research that frequently kick off the annual International Association of Yoga Therapists (www.iayt.org) conferences. In the same spirit, what is presented below is offered with the goal of elevating the yoga community to greater degrees of research sophistication. We will begin with some bedrock foundations of experimental design to pave the way.

The Continuum of Validity

In experimental design, *validity* is of primary concern. Validity refers to accuracy in measurement, but it is important to realize that there are several types of accuracy in how we measure complex phenomena. These fall into two main categories of validity: internal validity and external validity. Different experimental designs tend to be strong in one but less so in the other. *Internal validity* taps into the certainty with which we know we are measuring what we intend to measure. The most pristine and simplified laboratory conditions where all variables are

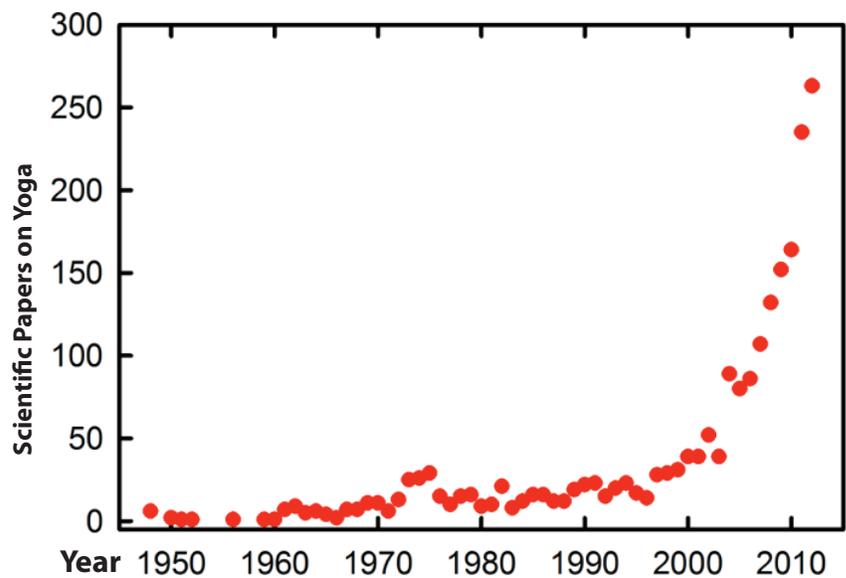


Figure 1. Exponential growth of the yoga research literature in the past decade. Published with permission from Active Life DC.

diligently controlled (what we refer to as experimental reductionism) will lead to the strongest internal validity. We can be confident that we are accurately measuring the phenomenon of interest and making valid conclusions from the data—in this case, the cognitive, psychological, or physical benefit of practicing yoga.

Yoga research often employs self-report questionnaires. In designing valid questionnaires, several types of internal validity become relevant. For example, there is validity as defined by whether the measurement taps into all facets of the concept being studied (content validity) and the degree to which the measurement predicts another measurement that is already established (predictive validity). Only when a whole list of validity criteria gets satisfied do we say that we have a psychometrically sound instrument that has scientific utility (Nunnally & Bernstein, 1994). See Baer et al. (2006) for an exemplary demonstration of the necessary rounds of psychometric testing with various mindfulness measuring instruments. A questionnaire's strong internal validity is only established after multiple tests and refinements, so this is why one cannot casually write a new questionnaire and publish data with it right away; the psychometric groundwork has to be done first to literally validate that the questions are accurately tapping into what was intended.

While the psychometric approach is necessarily very dependent on statistical analyses (often complex, iterative statistical techniques like factor analysis), it serves the reader well to keep statistics and validity in two separate mental categories. To explore this relationship between

statistics and validity, we need to introduce the concept of *reliability*, a precursor of validity. Reliability refers to repeatability in collecting data. If something is measured multiple times and the same result occurs each time, then the measurement technique is reliable. Let's take the example of a bathroom scale. The scale might be off in such a way that it registers that you weigh three more pounds than you actually do. But every time you weigh yourself, the number is consistently three pounds off the actual (true or valid) weight. So your scale is functioning *reliably* but is not functioning *validly*. Although a simple example, it shows us that a measure can be reliable when it is not valid. However, the opposite is not true. If the scale produces a different number each time, then there is no way to know the true weight of the person. A measurement instrument can never function validly (accurately) if it can't function reliably (consistently).

Statistical analysis is fundamentally about establishing reliability, while good experimental design is the concrete foundation of validity and correct logical conclusions. Using more complex data analysis strategies will not make for better quality data and more clever conclusions. All manner of complex statistical gymnastics can be done on a shoddily designed experiment, but those analyses can't save the day to draw clear and strong inferences. From shoddy design comes shoddy data. There is an old adage that says calling in the statistician to perform a miracle after flawed data collection is like calling in the physician to work wonders at the autopsy!

In addition to high reliability as a prerequisite, we can associate strong internal validity with standardization, reductionism, control, and causation. Well-designed, reductionistic experiments tend to be high in internal validity and focused on mechanisms.¹ These studies are more likely to include biomedical markers that correlate with behavior change. Using biomedical markers in mind-body research is a growing trend and gives a competitive advantage in securing grant funding to support the research efforts because biomedical

¹ Because *mechanism* may be novel in this context to some readers and will subsequently be used throughout the rest of the article, a thorough working definition is offered. Most simply, a mechanism is what determines a certain behavior. More thoroughly, it refers to both the cause-and-effect principles and the components that operate according to these principles. How we define a mechanism in practice depends on what we are interested in. A mechanism could be simultaneously found in culture or in molecules. Modern science ultimately drives for the most fine-grained answer possible. When talking about yoga research, mechanisms usually refer to a change in anatomy and physiology that causes behavior change.

markers get at mechanisms (high internal validity, explaining cause and effect).

Similarly, all other things being equal, it is also easier to get grant funding when the data collection strategy is based on a randomized control trial (RCT) design. An RCT involves having participants in a study randomly assigned to either an experimental group or a control group; each participant has an equal chance of being assigned to either group. Such random assignment is relied upon to create equivalent groups and rule out pre-existing biases where individuals would be more drawn to volunteer for one group over the other. RCTs are commonly thought of as the gold standard in biomedical research and, to their credit, they do create strong internal validity, but they also often require a sacrifice. That is, RCTs can often have diminished generalizability, meaning that we know how the results worked in one laboratory scenario but we don't yet know how the phenomenon works in the real world in general.

External validity is, in a sense, at the other end of the spectrum opposite to internal validity, which is why they tend to tradeoff with each other: When internal validity is the highest, external validity will be the lowest, and vice versa. External validity refers to generalization, the degree to which we can make broad conclusions that accurately reflect the entire population of yoga practitioners in the real world. Unfortunately, when experimental design is more naturalistic, like when studying a yoga service program in action, we can make general conclusions from the data, but we can only talk of correlation, not causation. Field studies (applied science) tend to be naturalistic and stronger in external validity, meaning that their results can often be generalized to other similar scenarios and populations. This is great news for yoga service organizations because it means that data can be shared, paving the way to establishing sound practices within the field. When we make measurements in a natural state, we can draw more accurate conclusions about the entire population of individuals who practice yoga from our specific sample.

Yoga service research tends to have higher external validity and lower internal validity. However, that doesn't mean yoga service research is less scientific. Science refers to the process, not the result (much like practicing yoga). An overwhelming majority of published studies about the benefits of yoga rely on the pre-post design in which measurements are made at baseline (pre), then a yoga program is implemented (intervention), and then the same measurements are repeated again (post). The

logic is simple: Is there an improvement from the pre to the post measurement? Although the most popular design in use, it turns out that this experimental design is one that is easily susceptible to several challenges to internal validity. However, there are other appropriate alternatives that are well suited to yoga service research.

Alternative Designs for Yoga Service Research

Campbell and Stanley (1963) and Cook and Campbell (1979) are classic references on experimental and quasi-experimental designs that can readily be applied to measuring behavior—in this case, measuring transformation through yoga. Depending on the experimental design, a study is more or less susceptible to threats to internal or external validity. For example, inaccurate (invalid) results can come from history, maturation, repeated testing effects, or participants differentially dropping out of one study group more than another; the data become biased, which leads to invalid measurements and invalid conclusions. In the conclusion section of many research reports, authors often cite small sample size as a limitation of their study, but rarely do the more biting threats to validity get admitted, even though they are certainly there. Take a moment to recall our quirky bathroom scale and how limited sample size is a criticism of reliability. When reliability is not established, then our confidence in validity is naturally lessened too.

Table 1 presents the pretest-posttest control group design (line A) and two alternative designs that are rarely used in social science or biomedical research. Following the conventions of Campbell and Stanley (1963), O's represent an observation or measurement, and X's represent an experimental intervention. The logic of the pretest-posttest control group design is, given that group 1's and group 2's O's are equal when first measured, if they differ when measured again, we can ascribe that difference to X (e.g., yoga intervention). That is, the yoga intervention probably caused the change. This is the best-case scenario but the design itself has not made that logic airtight. Let's consider two alternatives that are sometimes superior, depending on the research question at hand.

The Solomon four-group design (table 1, line B) can be seen as an elaboration on the basic pre-post building block. The multiple observations of four groups can serve to rule out the threats to internal validity not covered when just two groups are tested in pre-post fashion. Further, a huge advantage is built-in replication. Scientists have more confidence in the accuracy of a result when it has been demonstrated several times over. With

A. Pretest-Posttest Control Group Design (Experimental)				
Group 1:	O	X	O	
Group 2:	O		O	
B. Solomon Four-Group Design (Experimental)				
Group 1:	O ₁	X	O ₂	
Group 2:	O ₃		O ₄	
Group 3:		X	O ₅	
Group 4:			O ₆	
C. Counterbalanced Design (Quasi-Experimental)				
Group 1:	X ₁ O	X ₂ O	X ₃ O	X ₄ O
Group 2:	X ₂ O	X ₄ O	X ₁ O	X ₃ O
Group 3:	X ₃ O	X ₁ O	X ₄ O	X ₂ O
Group 4:	X ₄ O	X ₃ O	X ₂ O	X ₁ O

Table 1. Diagrams of three different research designs.

O = an observation (measurement).

X = experimental intervention (e.g., yoga program).

Random assignment to all groups is required.

a classic pre-post design, this means conducting several studies, which can get costly in both time and money. With the Solomon four-group design, the effect of the intervention (e.g., yoga program) is assessed in four different ways and, ideally, this pattern falls out of the observations: $O_2 > O_1$, $O_2 > O_4$, $O_5 > O_6$, and $O_5 > O_3$. Moreover, these comparisons provide a sophisticated frame of reference for interpreting the results of other pre-post studies that use the same yoga intervention. This design could be cleverly used in a yoga program for children or adolescents because it has a built-in way of factoring out the changes in latter observations that are due simply to maturation, not the yoga intervention per se. For efficiency, O_6 can serve as the baseline observation for a subsequent study.

Another alternative to the pre-post design that is particularly well suited to compare the therapeutic efficacy of practicing yoga against other mind-body or physical exercise interventions is the counterbalanced design (table 1, line C). Counterbalancing refers to when there are multiple interventions being tested and each participant or group experiences every intervention in a different order. Unlike the other two designs we've considered, the counterbalanced design effectively uses the participant as his/her own control. Statistical analyses that are geared for "within-subjects" comparisons are more sensitive than those that do "between-subjects" comparisons, like the previously mentioned designs. In effect, the "noise" in each participant's data gets subtracted out; this mathematical step of cleaning the data

cannot happen when comparisons are drawn across different individuals. The counterbalanced design is a wise approach if the goal is to establish the relative effectiveness of a particular yoga program protocol—for example, if you wanted to show that a new yoga protocol (X_1) has a stronger effect on participants than your original protocol (X_2), as well as acupuncture treatments (X_3) and a particular type of manual bodywork (X_4).

Much more can be said about the use of these and other experimental designs that could expand the repertoire of yoga researchers. We have just been able to scratch the surface here. The take-home messages are that there is a broader experimental design menu than simply the commonly used pre-post design and that these other designs have strong suits for particular situations. Thus, the nature of the question being asked should, after careful consideration, determine the experimental design; the pre-post design should be the result of a conscious decision and not the default option.

Two Different Types of How

Therapeutic yoga research and yoga service research are both on the quest of asking how, yet they are often in search of two different answers. Not a koan, this distinction of two kinds of “How?” is useful to keep in mind as the two fields of research develop. In effect, these niches of yoga research will develop in different ways—and rightly so because each area has its own advantages and utility.

The first how question gets at *how yoga works*. We can identify mechanisms when internal validity is strong. We can explain the cognitive, psychological, or physical benefits of practicing yoga. We can make statements about cause and effect at the very root of what instigates behavioral change. It is more mechanism-focused and moves into theory building.

The second how question is more descriptive and programmatic: *How do we use yoga to change people's lives?* The mechanism of interest is at the level of the group or the whole person, not brain structures or chemistry. It is less involved with theory and more focused on describing how to apply the results of the yoga program (i.e., external validity).

Yoga service research often validates and shares best practices, which are often applicable to a broad population. So when yoga service research asks how, it refers to the story of yoga changing lives, in a broader, more realistic, sometimes more qualitative—and yes, often more messy—way than mechanism-focused yoga research. Yoga service is about sharing self-transformational tools

to empower individuals to change their lives. Hopefully, it is obvious that both answers are important; sometimes we need to *explain* in a *specific* way, and sometimes we need to *describe* in a more *general* way. Human behavior is complex and can only be fully understood by examining it from multiple viewpoints and gross-to-fine levels of analysis. This means taking different approaches to answering the question “How?” on various levels.

Although standardization is a logical necessity in research, the more that we standardize a yoga protocol, the more we lose that human touch and the compassionate tailoring of a yoga practice to the individual student. In the author's experience, this has been an ongoing debate at SYTAR (the annual Symposium for Yoga Therapy and Research conference), going back to at least 2008. It gets at the very motivation of why do yoga research in the first place—that is, if we know it works (and we do), then is yoga research a waste of time? This critique brings us to an examination of different motivations for doing both types of research on the effects of practicing yoga.

Research Motivations and Relation to Funding

Therapeutic yoga research is largely done to explain (hence, internal validity is emphasized). The goal is to narrow down the anatomical and physiological mechanisms of how moving and breathing mindfully can affect a person so profoundly. The motivation is in understanding cause and effect in a pure, logical, deterministic way, which can be a challenge when talking about the elusive mind-body bridge.

Running a research program can be very expensive. Publishing a study with a 12-week protocol that has both questionnaires and biomedical markers can easily cost \$200,000 or more; each question answered has a high price tag. An all-important criterion in grant funding is that the researchers must be posing questions that unveil mechanisms. This slant in how we ask questions translates into a bias and oversimplification in the kinds of answers we receive, and it changes the culture within which modern scientists operate (Palmer & Zajonc, 2010). Funding must precede this type of research, and the demands to be competitive to snare that funding shape the very questions that are asked.

Yoga service research, on the other hand, is more applied and programmatic in the real world (i.e., related to high external validity). An organization usually has developed a yoga service program over time and has received feedback from participants that the program is

enjoyable and effective. The organization may have qualitative and anecdotal evidence that the program works well; they hear the stories that yoga is changing the program participants' lives. However, to convince grantors to fund the work, it is often necessary to have quantified evidence and show statistically significant effects. The motivation for publishing research about their program is based on program evaluation and its necessity in securing funding to continue to expand the services. The research is needed first to secure more funding.

It may be useful to think of mechanism-focused therapeutic yoga as having a top-down approach, while yoga service research has a bottom-up approach. The top-down approach is about providing the hard evidence required to induce a systemic change in our culture's health care approach. Only when the health benefits of practicing yoga are rigorously documented (multiple studies across many samples where the RCT design carries a special weight for convincing an audience of health care decision makers) will the allopathic medical community begin to open the doors more widely to yoga therapy. Yoga service, on the other hand, is a bottom-up, grassroots approach, putting the knowledge into action right here and now.

It is exceedingly difficult to fund and operate both a basic mechanism-focused research program and provide yoga outreach to members of the community. Because of funding limitations, few groups are actively involved in both reductionistic yoga research and community-oriented yoga service simultaneously. A notable exception is the Austin-based nonprofit organization PURE Action (www.pureaction.org), which has a research program based in the cardiovascular and metabolic benefits of Bikram Yoga, a style of asana practice that readily lends itself to experimental study because of its set sequence of 26 postures (i.e., a standardized protocol; Hunter et al., 2013). At the same time, PURE Action also provides classes at no cost to underserved Austin residents.

Sample Diversity

There tends to be greater gender and ethnic diversity in yoga service studies. Therapeutic yoga studies originate in university or medical settings and often recruit individuals who already practice yoga. As shown by Quilty et al. (2009), yoga practitioners in America generally tend to be wealthy, educated, Caucasian females. By extension, therapeutic yoga research also leans more heavily to affluent, educated, and ethnically homogeneous participants. Yoga service research, on the other hand,

is motivated to reach the broadest swath of the public, especially minority and underserved populations—ideally, meeting them where they are and not making the participants fit the protocol but rather having the protocol accommodate the yoga participants.

Bringing It All Together: Mechanism Supports Service

Finally, let's turn our attention to finding the entry point in the nervous system through which yoga service providers can heal and transform. Even before we bring asana into the conversation, one of the most critically foundational pieces to a yoga service program is providing a psychologically safe place for the participant to explore his or her thoughts without fear, criticism, or punishment and to return once again to experience the sensations of the body. Interestingly, some research is now beginning to show mechanistically how yoga works in the nervous system. What it reveals is the very reason that yoga is so well received by many of the populations that yoga service organizations reach. Having a psychologically safe place is at the heart of both.

Streeter et al (2012) is an advance in yoga theory with its emphasis on how yoga asana and breathing can increase the activity of the parasympathetic nervous system. This paper is a developmental landmark because it represents that enough knowledge has accumulated so that theory may begin to be constructed. *The field is beginning to move from description to explanation.* At the same time that the theory offers an explanatory framework for how yoga asana works, the paper also gives credence to the social component of yoga service programs.

To understand Streeter et al's theory, we must introduce the vagus nerves. These nerves are one of twelve pairs of cranial nerves that originate in the brain and then exit the brain and innervate the face, neck, and periphery of the body to carry out various sensorimotor functions (such as moving the eyes and controlling the voice). The vagus nerves provide a bidirectional information highway between the brain, the autonomic (peripheral) nervous system, and the organs. The term *vagus* comes from the Latin word for *wandering*; those vagus nerves are wanderers. They meander and bifurcate throughout the torso, synapsing with the heart (to pace the heart beat), lungs, and organs of digestion and elimination. Through mechanical stimulation by yoga asana (literally stretching the vagus nerves in the torso; chest-opening postures are particularly effective in this regard) and mindful breath-

work (a breathing rate of six cycles per minute is optimal; see Bernardi et al., 2001, for fascinating demonstrations using pranayama and chanting), the tone of the vagus nerves is improved and the autonomic nervous system moves toward a healthier, moment-to-moment dynamic balance of sympathetic and parasympathetic activity. Consequently, all organs and systems move toward greater health. Vagal tone (and its correlate heart rate variability) will be discussed more within the yoga community in the coming years.

Porges (2011) discusses the evolution of the bifurcating vagus nerve, some branches of which are coated in myelin sheaths and some not. Myelin is a layer of proteins and fatty lipids that insulate nerve cells. Myelin makes information transmission faster for the coated nerves and, just like rubber insulation on electrical wires, decreases the chance of cross-talk interference of electrical signals from neighboring nerve cells. The myelinated vagus nerve is the more recent evolutionary development in mammals and forms the basis for feeling safe in social situations. When we are in unsafe conditions, we revert back to cortisol-driven sympathetic activity (the fight-or-flight response). When we are in safe conditions, our bodies can initiate the relaxation response and begin to repair themselves and uninstall those unhealthy conditioned patterns of fear, anger, and trauma. Complementary to Porges's polyvagal theory, Devi (2012) shares her observations of a new paradigm of relaxation in medicine. By physiologically escaping the conditioning and restoring autonomic nervous system balance, yoga helps to bring people out of unsafe places of vulnerability.

Yoga service programs naturally come with a built-in social component that empowers people. The influence of the warm relationship with the yoga instructor or with other participants in the program is something that, with the most rigorous experimental mindset about how yoga works, we may opt to eliminate, control for, or negate through the use of co-variance statistical techniques. The social support that participants get in addition to the yoga asana/breathing/meditation is, strictly speaking, a confounding variable, which is troublesome in mechanism-focused yoga research. In yoga service research, even if using a standardized protocol, the yoga intervention is a yoga-plus-social-support intervention. However, this is a positive in that the social support adds to the therapeutic benefits. While social variables may muddy the internal validity of a study, they do capture an accurate snapshot of how yoga service programs function in the real world. Very importantly, these social

variables are critical ingredients in the recipe for success in recruiting for and expanding such yoga programs.

Most of the underserved populations that yoga service organizations reach out to (e.g., incarcerated individuals, veterans, homeless individuals, survivors of domestic abuse and sexual assault) are working with some level of trauma. Psychological trauma manifests in the physical body—it is said that the body keeps score. Providing a methodology to safely access this somatic trauma is, in part, why an asana-based intervention can be so transformative in releasing long-held traumatic emotional-behavioral patterns and their associated chronic hypervigilant physiological states (Karl, 2012; Emerson & Hopper, 2011; Emerson et al., 2009). Manafort and Libby (2013) of the Veterans Yoga Project (www.veteransyogaproject.org) do a fine job of clearly explaining the three core symptoms of post-traumatic stress disorder—hyperarousal, re-experiencing, and avoidance—and how mindful yoga can empower people in releasing and moving beyond trauma.

In quite a literal way, the vagus nerves are a mechanism for unlocking trauma and tension in the body and, in effect, soothe the anxious brain by way of a back door through the parasympathetic pathway. Yoga service programs that produce the greatest results are the ones that start by creating a safe space where unconditional positive regard can be brought to the individuals they serve.

Molly Lannon Kenny (2011), founder of the Samarya Center (www.samaryacenter.org), which brings yoga to individuals in mental health and hospice settings in Seattle, has articulated this sentiment very beautifully: "Sometimes I feel, even with all my clinical background and my empirically inclined mind, that what I am really offering is the experience of total love and acceptance—and that, in fact, is the very thing that heals them."

Ultimately, the validity of our work is much more than creative asana sequencing and clever data analysis strategies. Awareness on the breath happening within a safe place transforms lives, and that is what we are bringing into focus with the growing yoga service research literature. 🌱

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