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Cross-sectional Survey

Injury in yoga asana practice: Assessment of the risks

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ABSTRACT

Background: The risk of injury from modern yoga asana practice is poorly characterized in the scientific literature, but anecdotal reports in the lay literature and press have posed questions about the possibility of frequent, severe injuries.

Design: We performed a cross-sectional survey of yoga asana participants assessing their experience with yoga-related injury, using a voluntary convenience sample.

Results: A total of 2620 participants responded to our survey. Seventy-nine percent were between ages 31 and 60 and 84% were female. The majority of respondents lived in North America or Europe. Forty-five percent of participants reported experiencing no injuries during the time they had been practicing yoga. Of those who did experience an injury from asana practice, 28% were mild (e.g., sprains or nonspecific pains not requiring a medical procedure, with symptoms lasting less than 6 months) and 63% were moderate (e.g., sprains or nonspecific pains not requiring a medical procedure, with symptoms lasting from 6 months to 1 year). Only 9% of those reporting injuries (4% of the total sample) had a severe injury. The strongest predictors for increased probability of reporting an injury over a lifetime of yoga practice were greater number of years of practice ($p < .0001$) and teaching yoga ($p = .0177$). Other aspects of participant demographics or yoga practice habits were not related to likelihood of reporting a yoga-related injury.

Conclusions: We found the number of injuries reported by yoga participants per years of practice exposure to be low and the occurrence of serious injuries in yoga to be infrequent compared to other physical activities, suggesting that yoga is not a high-risk physical activity. More work is needed to clarify the causal relationships between the yoga participant characteristics, the asana practice style, and the risk of significant injury.

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1. Introduction

Concurrent with the growth of yoga participation worldwide is an increase in the opportunities for participants to experience both its potential benefits and risks. The most recent national survey of yoga participants in the United States completed by Yoga Alliance and Yoga Journal reported that 36.7 million people are doing yoga in the United States alone (Ipsos Public Affairs, 2016). This is an increase from 15.8 million participants in the U.S. in 2008 (Ipsos Public Affairs, 2016). The International Yoga Federation estimated that there were 300 million people practicing yoga worldwide in 2010 (IYF, 2010). Le Corroller et al., 2012 note that “The popularity

of yoga has created a need for empirical studies to evaluate the limitations and risks of yoga as a method of wellness.” With the rising popularity of yoga, critical voices have begun to surface in the news media and popular literature. Two New York Times articles by William Broad (i.e., “How yoga can wreck your body?” (Broad, 2012) and “Women’s flexibility is a liability (in yoga) (Broad, 2013)) have especially caught the public’s attention.

A difficulty in broadly claiming either benefits or injuries as a result of yoga is in first defining yoga. Yoga, a multi-faceted Sanskrit word, is defined in the classical yoga text, The Yoga Sūtras of Patanjali, by modern postural yoga master B.K.S. Iyengar as “restraint of fluctuations in the consciousness” (Iyengar, 2002, pp.50). Within the broader philosophy of Yoga are specific lineages that encompass practices intended to move the participant toward the experience of quieting the mental fluctuations or mental chatter; one of these lineages is Hatha Yoga (Muktibodhananda, 2008). It is

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within the lineage of Hatha Yoga that we find the practice of yoga postures or yoga asana.

It has been difficult for researchers to quantify either the benefits or risks of yoga, as even within the narrower category of postural yoga or yoga asana, there are numerous types of yoga asana practices. Little specific information has been reported in the literature on impacts of yoga regarding which yoga practices were performed in the studies and how they were performed. Modern postural yoga has been referred to in the literature as everything from “a gentle, non-traumatic exercise” (Dacci et al., 2016) to something that “when performed properly has little risk of adverse effects” (Le Corroller et al., 2012), to an activity where it is suggested that “participants and those wishing to become participants should confer with a physician prior to engaging in physical activity and practice only under the guidance of certified instructors” (Swain and McGwin, 2016). The previous statement is itself also problematic as there is no existing national, or international certifying board that issues licenses for yoga instructors. What does exist are several different voluntary registries of yoga teachers and schools that may issue a “registered yoga teacher” designation upon registration and often have low barriers to entry (Lucier, 2016; D'Angelo Friedman, 2015).

Despite the limitations of yoga research studies, the current body of research suggests participants experience a wide variety of wellness and health benefits. Participants report specific physical benefits such as increased strength and flexibility (Field, 2011), improved energy levels (Ross et al., 2013), improved sleep (Alexander et al., 2013; Ross et al., 2013) and weight maintenance (Ross et al., 2013) as well as improvements to general health and fitness (Birdee et al., 2017; Park et al., 2016; Alexander et al., 2013). Additionally, participants report psychological and other benefits, such as greater sense of happiness (Ross et al., 2013), improved social relationships (Ross et al., 2013), and reduced stress and increased relaxation (Park et al., 2016; Alexander et al., 2013; Field, 2011).

As yoga has spread, more reports have been made, primarily anecdotally and in the popular press, regarding potential serious risks of yoga (Broad, 2012, 2013; Krucoff, 2007; Paul, 2007). However, these assertions of adverse effects have not been corroborated in the scientific literature. Studies summarizing frequency of yoga-related injuries reported to medical facilities have reported relatively low numbers of injuries specific to yoga (Russell et al., 2016; Le Corroller et al., 2012). However, these reports published from hospital or medical clinic data may under-report total yoga-related injuries, especially non-serious, short-term injuries, as it has also been reported that many participants who incur an injury from yoga do not seek out medical assistance (Holton and Barry, 2014). It is also possible that with the growing popularity of yoga, the number of serious injuries is increasing. Swain and McGwin, 2016, reported greater numbers of yoga-related injuries (29,590 over a 13-year period) than other researchers when they summarized National Electronic Injury Surveillance System (NEISS) data to report yoga-related injuries for which the participant visited a hospital in the United States between 2001 and 2014.

Recent reviews of yoga treatments used in clinical trials to address a broad range of issues reported little to no adverse effects among yoga treatments compared to controls or comparison group treatments. Adverse effects in yoga treatment groups were reported infrequently and less often than in active control groups in randomized control trials/quasi-randomized control trials (Fishbein et al., 2014). When yoga interventions were compared to “usual care” comparison groups or exercise-type interventions, there was no difference in likelihood of experiencing an “adverse event” including serious or non-serious injury (Cramer et al., 2015), suggesting that the risk of injury in yoga is at least comparable to

and possibly less than other common types of physical activity or exercise used in wellness treatment studies.

Published information on specific injuries attributed to yoga have frequently been from small case studies, often reporting on a single individual who experienced an injury as a result of extreme activities that would be highly unusual for a typical yoga class or as a result of the participant's pre-existing medical condition (Dacci et al., 2016; Walker et al., 2005). A recent review of all case studies in the literature found only 37 case studies reporting a total of 76 unique cases of adverse effects related to yoga (Cramer et al., 2013). Of these, nine included participants with pre-existing medical conditions (e.g. glaucoma) who practiced postures that were contraindicated for their condition (e.g. headstand). Two others included cases describing persons practicing yoga postures and/or breathing techniques under the influence of psychoactive drugs. Two others included cases of a practice, voluntary vomiting, that would be considered extreme and very unusual for mainstream yoga participants (Cramer et al., 2013).

The limited research regarding risk of injury in yoga practice suggests that a large percentage of participants are not incurring injuries in yoga class (Park et al., 2016; Penman et al., 2012). Penman et al., 2012, reported 74% of 2353 Australian yoga participants surveyed had never experienced an injury from yoga. Similarly, Park et al., 2016 reported 70.5% of 380 American yoga students surveyed, reported no negative effects of yoga practice, including injuries. Likewise, less than 1% of 2230 yoga participants surveyed in a separate study had ever experienced an injury in yoga that led them to stop practice (Holton and Barry, 2014).

Of those yoga injuries that are occurring in mainstream yoga classes, little has been published that quantifies the specific injuries or identifies the context in which they are occurring. Yoga injuries have been generally categorized as primarily musculoskeletal injuries or sprains and strains (Swain and McGwin, 2016; Le Corroller et al., 2012). A few studies have more specifically pointed to knees (Le Corroller et al., 2012; Mikkonen et al., 2008), low back (Mikkonen et al., 2008), or shoulders (Le Corroller et al., 2012) as the body areas more commonly injured. A number of factors have been suggested as potentially contributing to yoga injuries, such as, inadequate teaching, inappropriate postures, or pressure from either the students themselves, or teachers, to achieve (Swain and McGwin, 2016; Fishman et al., 2009).

Very little research has been done to ascertain what specific contexts are associated with increased likelihood of injury in modern postural yoga and recent studies that have published reports on some aspect of the risk of injury in yoga have emphasized the need for a large survey of yoga participants to adequately report on incidences of injury (Cramer et al., 2013, 2015). Our project focused on addressing these questions in a survey of yoga participants across all levels and styles of yoga asana practice. Our study compiled data from a large sample of yoga participants regarding respondents' demographics, yoga practice habits, yoga experience levels, and related that information to injuries that they experienced.

2. Materials and methods

2.1. Study design

Our design was a cross-sectional descriptive survey, using a voluntary convenience sample. The data collected and presented here was part of a larger study structured with the intent to examine the physical, mental, and emotional experiences of yoga asana participants. In this manuscript we report solely on self-reported physical injuries experienced. In our study, “injury” means having experienced at least one injury during the

respondent's lifetime of yoga practice. In assessing the risk of experiencing any injury in yoga, injuries that required medical attention were not distinguished from mild or moderate injuries that healed with no medical intervention in a few weeks or less.

2.2. Survey distribution

The survey was distributed internationally to the yoga community through social media notices posted by Yoga International and Yoganatomy.com. Social media posts included information detailing the intent of the project and contained a link to the survey. An invitation to participate in the survey, information on the project, and a link to complete the survey was also distributed by direct email to members of the national United States yoga teacher registry, Yoga Alliance, and members of Yoganatomy.com. The self-administered questionnaire was available in English to be completed by participants at any time between August 23, 2016 and November 7, 2016.

2.3. Ethical considerations

When participants clicked on the link to begin the survey, they saw an introduction detailing the intent of the project, information regarding the anonymity of their responses, and a request for their informed consent to continue with the survey. All participants were informed about the nature and intent of the research and indicated their “informed consent” to provide the survey data entered. No individual survey questions were required; participants could choose to opt out of answering any question. All responses were anonymous and stored on a secure server. No personally identifying information was collected from participants, unless participants indicated their interest in participating in a follow-up questionnaire, in which case, they had the opportunity to enter their email address. That information was likewise stored on a secure server.

2.4. Survey questions

The survey, as a whole, was designed to summarize both the positive and negative experiences of modern postural yoga participants who were practicing yoga asana at the time of the survey. In this paper, we present the results only with respect to the relationship between yoga practice and risk of injury. Participants had the opportunity to complete survey questions specifically addressing the following: 1) demographics and leisure activity history, 2) yoga practice habits, and 3) self-reported experiences in yoga practice (positive and negative). About half (54.8%) of our total survey respondents ($n = 2620$) reported yes, when asked specifically if they had had at least one physical injury as a result of yoga asana practice during the lifetime of their practice. Those that responded “yes, they had experienced at least one yoga injury” ($n = 1436$) were asked a series of additional questions regarding the context of their yoga injury.

2.5. Data analysis

Data related to demographics, yoga practice habits of participants, and number of injuries over lifetime of practice, was summed and percent of survey participants that selected each response was calculated. Since each question was optional, a total sample size for each question as well as percent of total in each response category is presented. Survey respondents were asked to indicate which styles of yoga they practiced. The question allowed respondents to mark multiple styles if they practiced more than one style. Those participants who indicated that they practiced more than one style were summed into a single category “multiple

styles”. Since more than half of respondents (58%) indicated that they practiced multiple styles, we analyzed all yoga and injury data across all styles.

Additional survey questions allowed respondents to further describe their injuries. Responses from the open-ended question asking respondents to describe their injury (or their first injury if they had experienced more than one) were coded to summarize type of injury and severity of injury. Severity of injury was coded as: mild, moderate, or severe. Injuries were coded as mild if the participant took six weeks or less to recover, was not aware of pain from the injury outside of yoga practice, and did not see a doctor about the injury. Injuries were coded as moderate if the recovery time was greater than six weeks, but less than one year, the participant was aware of pain from the injury outside of yoga practice, and the participant did not need to see a doctor about the injury. Injuries were coded as severe if the respondent reported consulting a doctor to receive a medical procedure for the injury, had surgery as a result of a yoga injury, or reported the recovery time to be more than one year. Coding categories for types of injury were based on categories reported in previous research (Swain and McGwin, 2016; Mikkonen et al., 2008) for the purposes of comparing our data to existing published research. We added additional categories when there were multiple similar responses from survey participants that did not fit existing categories. Respondents were also asked to indicate in which body area or areas they experienced their yoga injury (or first yoga injury if they had experienced more than one). The question allowed respondents to mark multiple body areas. Those participants who indicated more than one body area were summed into a single category “multiple areas”.

A Chi-square goodness-of-fit test was calculated to evaluate whether individual contexts of injury in yoga practice were significantly more likely. Relevant results are reported in Table 6. A p -value of $\leq .01$ was used to delineate a statistically significant effect. Cramer's V was used to evaluate effect size of significant relationships. A Cramer's V value was used to indicate a weak association when it was between 0.1 and 0.2, a moderate association when it was between 0.3 and 0.4, and a strong association when it was equal to or greater than 0.5.

Responses from the open-ended question asking respondents to describe their injury (or their first injury if they had experienced more than one) were coded to summarize the reason they believed to be the cause of their injury. Coding categories for cause of injury were based on categories discussed in previous research (Swain and McGwin, 2016; Fishman et al., 2009) and additional categories were created when there were multiple similar responses from survey participants that did not fit existing categories.

A Chi-square test of independence was used to evaluate associations between yoga practice habits and likelihood of reporting an injury in yoga. All yoga practice contexts that individually had a significant association with experiencing an injury in yoga were examined together using multiple logistic regression to identify predictors of reporting an injury in yoga. A backwards elimination model selection procedure was used to select the final model. Odds ratios and predicted probabilities were used to report strength of predictors in the final logistic regression model. All statistical analyses were performed using R version x64 3.3.2 statistical software package.

3. Results

3.1. Participant demographics

Yoga participants represented in our survey were primarily female (84%), between the ages of 31 and 60 (79%), and residing in

either North America or Europe (86%) (Table 1). A little more than half of survey respondents (57%) reported participating in a non-yoga leisure activity for 0–15 h each month, while an additional 29% reported participating in a non-yoga leisure activity for 16–35 h each month, and 13% reported participating in a non-yoga leisure activity for more than 35 h each month (Table 1).

3.2. Yoga practice habits

The majority of yoga participants in our survey had been practicing for four years or more (81%), with 45% of respondents having practiced for ten years or more at the time of survey completion (Table 2). The largest percentage of respondents (58%) reported practicing multiple styles, rather than one particular style (Table 2). Among individual styles, Ashtanga (32%), Hatha (3%), Vinyasa flow (3%), and Iyengar (2%) were the most commonly practiced styles (Table 2). Participants typically practiced in the morning (65%) for 60–90 min (80%). Respondents reported practicing both with a teacher and on their own without a teacher (Table 2). Most participants reported that their primary yoga teacher had been practicing for seven or more years (79%) and was registered with either Yoga Alliance or another yoga teacher registry (85%; Table 2).

3.3. Yoga-related injuries

A total of 2260 participants responded to our question regarding number of injuries sustained from yoga practice. Of that total, 45% reported experiencing no injuries from yoga and 30% reported having only one injury during the time they had been practicing (Table 3). A small number of participants (8%) reported experiencing three or more injuries during the time they had been practicing (Table 3).

There was a weak association between number of injuries reported and years of practice. Number of yoga injuries reported went up as number of years of practice increased. Of those active

Table 1
Demographics of survey participants.

	Percent of sample	Sample size n = 2630
Age		
15–30	10%	
31–45	44%	
46–60	35%	
61+	11%	
Gender		n = 2625
Female	84%	
Male	15%	
Other/Prefer not to say	<1%	
Continent/Area of residence		n = 2494
North America	48%	
South America	2%	
Europe	38%	
Australia and New Zealand	5%	
Africa	1%	
Asia	6%	
Non-yoga leisure activity frequency of participation (hours per month)		n = 2099
0–7	29%	
8–15	28%	
16–25	17%	
26–35	12%	
36–45	5%	
46–60	4%	
60+	4%	

Table 2
Yoga practice habits of survey participants.

	Percent of sample	Sample size n = 2624
Years of yoga practice		
Less than 3 months	<1%	
3–6 months	1%	
7–12 months	3%	
1–3 years	15%	
4–10 years	36%	
More than 10 years	45%	
Have you practiced yoga consistently or off and on since you started?		n = 2617
Consistently	41%	
Off and on	59%	
Style of yoga practice		n = 2545
Multiple styles	58%	
Ashtanga	32%	
Hatha	3%	
Vinyasa/Flow	3%	
Iyengar	2%	
Other	2%	
Yin/Restorative	<1%	
Sivananda	<1%	
Bikram/Hot yoga	<1%	
Jivamukti	<1%	
Anusara	<1%	
Baptiste	<1%	
Kundalini	<1%	
How many days per week do you typically attend yoga class with a teacher?		n = 2487
1	24%	
2	16%	
3	17%	
4	14%	
5	15%	
6	12%	
7	2%	
What time of day do you typically practice yoga?		n = 2608
Morning	65%	
Afternoon	10%	
Evening	25%	
How many minutes is your typical yoga practice?		n = 2615
Less than 30 min	1%	
30	5%	
60	35%	
90	45%	
120	10%	
More than 120 min	3%	
How many different teachers have you attended yoga class with in the last 30 days?		n = 2609
0	9%	
1	24%	
2	24%	
3	15%	
4	8%	
5	4%	
More than 5	8%	
I don't practice with a teacher	8%	
How many years has your primary yoga teacher been practicing yoga?		n = 2620
Less than 1 year	<1%	
1–3	3%	
4–6	6%	
7–10	10%	
More than 10 years	69%	
I don't know	5%	

Table 2 (continued)

	Sample size
No primary teacher	7%
How many days per week do you typically practice yoga on your own without a teacher?	n = 2609
0	12%
1	14%
2	16%
3	14%
4	11%
5	14%
6	11%
7	7%
Do you teach yoga?	n = 2620
Yes	60%
No	40%
Have you ever taken a yoga teacher training?	n = 1573
Yes	95%
No	5%
Is your yoga teacher registered with Yoga Alliance or another registry?	n = 2598
Yes, registered with YA at the 200 h level	15%
Yes, registered with YA at the 500 h level	22%
Yes, registered with other registry	48%
No	4%
I don't know	11%

Table 3

Number of yoga-related injuries sustained (n = 2620).

Number of Yoga-Related Injuries Sustained	Percent of Total Respondents
None	45%
1 injury	30%
2 injuries	17%
3 or more injuries	8%

participants with more than ten years of yoga practice, 40% reported no injuries (Fig. 1).

When respondents provided enough information to categorize injuries by type, they were categorized as primarily sprain/strain (47.1%) or general pain of an unknown cause (35.1%; Table 4). Injuries were primarily rated as moderate (63%) or mild (28%). Severe injuries sustained from yoga accounted for only 9% of reported

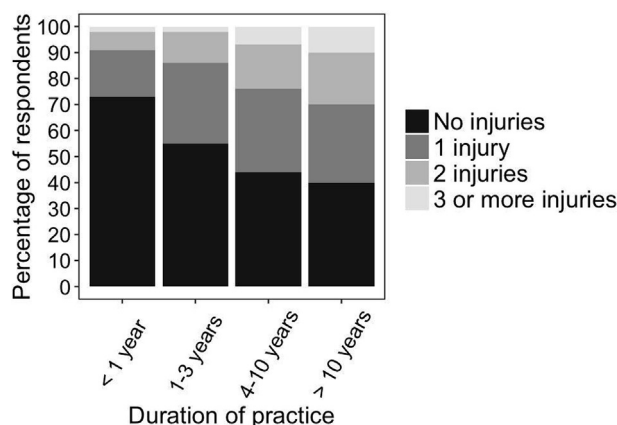


Fig. 1. Percent of injuries reported by respondents in each category of duration of practice experience.

Table 4

Type of yoga-related injuries sustained (n = 882).

Type of Injury	Percent of Injuries
Sprain/strain	47.1
General pain, cause unknown	35.1
Nerve impingement/pain	4.6
Torn meniscus	4.6
Bulge or herniation of spinal disc	2.4
Fracture	1.9
Dislocation	1.5
Torn labrum	0.8
Bursitis	0.6
Concussion	0.3
Abrasion/bruise	0.3
Frozen shoulder	0.3
Atrial fibrillation	0.1
Plantar fasciitis	0.1

Table 5

Percentage of injuries that occurred in body areas (n = 1299).

Body Area	Percent of Injuries
Knees	21.0
Lower Back	19.4
Shoulders	19.0
Hips (includes hamstrings)	15.9
Multiple Areas	8.2
Neck	5.4
Wrists	4.5
Upper Back	3.0
Ankles	2.1
Feet	1.5

injuries. The top four body areas where respondents reported any yoga injury were knees (21.0%), lower back (19.4%), shoulders (19.0%), and hips/hamstrings (15.9%; Table 5). Eighty percent of severe injuries reported also occurred in these four body areas.

3.4. Context of yoga-related injuries

Thirty-six percent of participants with an injury consulted a doctor about their injury. Average recovery time from a yoga injury was 6 months or less in 53% of subjects reporting any injury (Table 6). Among those who experienced a yoga injury, 36% also reported that they experienced a re-injury of the same area (Table 6). Almost half of participants (41.5%) said they continued to practice yoga when injured, but modified their practice.

Participants were just as likely to report that the injury happened all at once as they were to report that it seemed to build up over time (Table 6). Participants were more likely to report an injury in yoga when they were holding a posture (51%) or entering a posture (39%) than when they were exiting a posture ($\chi^2 = 180.01$, $df = 2$, $n = 1063$, $p < .0001$; Table 6). An injury was more likely to be reported when respondents were doing the full expression (86%) of a posture as compared to a modified version of the posture ($\chi^2 = 358.69$, $df = 1$, $n = 1199$, $p < .0001$). Respondents were equally likely to have become aware of the injury in the moment that it happened as they were to have become aware of their injury at some later time after the yoga practice in which it occurred (Table 6). Verbal pressure from a teacher was felt to have a contributing role in only 20% of injuries (Table 6). Participants more often experienced an injury in a guided style class (61%) than a self-practice style class (39%) ($\chi^2 = 27.53$, $df = 1$, $n = 1051$, Table 6).

3.5. Causes of yoga-related injury

A little more than a third of respondents did not say what they

Table 6
Contexts of injuries. (Pearson Chi-square comparing expected and actual context of injuries. Cramer's V is used for effect size to evaluate the strength of the relationship.) *indicates $p \leq .01$ and effect size ≥ 0.10 .

	Variables (n =)	Total (n =)	df	Pearson χ^2	p-value	Cramer's V (effect size)
*Injury diagnosed by doctor:						
Yes	508					
No	921	1429	1	60.37	<.0001	0.15
Recovery time from injury was:						
6 months or less	747					
More than 6 months	658	1405	1	2.82	.1006	0.03
*Experienced re-injury of area:						
Yes	512					
No	901	1413	1	54.58	<.0001	0.14
*Injury experienced as:						
Happened all at once	739					
Built up over time	619	1358	1	5.31	.0234	0.04
*Stage of posture when injury occurred:						
Entering pose	414					
Holding pose	544					
Exiting pose	105	1063	2	180.01	<.0001	0.30
*Version of posture when injury occurred:						
Full expression of pose	1032					
Modified version of pose	167	1199	1	358.69	<.0001	0.40
Participant was aware of injury:						
Right away	685					
Not until later	655	1340	1	0.34	.5886	0.01
*Pressure from a teacher contributed to the injury:						
Yes	289					
No	1126	1415	1	271.28	<.0001	0.30
*Class-type when injury occurred:						
Guided class	645					
Self-practice class	406	1051	1	27.53	<.0001	0.11

attributed the cause of their injury to. Those that did were most likely to attribute their yoga injury to pushing themselves too far (15.4%) or being pushed too far by a teacher's adjustment (12.5%; Table 7). The next most common reasons reported for an injury were perceived need for change in alignment within a posture or method of approach towards a specific posture (8.8%) and repetitive motion injury/too much of one movement (7%; Table 7).

In multivariable analysis, the strongest predictor for reporting at least one injury over a lifetime of yoga practice was years of practice. Those that had practiced for more than 10 years had a greater likelihood of reporting an injury relative to those with 0–3 years of practice (OR = 1.75; 95% CI 1.34, 2.27; $p < .0001$; Table 8). Those

that had practiced for 4–10 years also had greater likelihood of reporting an injury than those who had been practicing for 3 years or less (OR = 1.63; 95% CI 1.28, 2.07; $p < .0001$; Table 8). Similarly, though less strongly related than years of yoga practice, those who also teach yoga were more likely to report an injury (OR = 1.26; 95% CI 1.04, 1.52; $p = .0177$; Table 8). The predicted probability of reporting an injury based solely on years of practice was 41% for those with three years of practice or less, 56% for those who had been practicing for 4–10 years, and 59% for those who had been practicing for more than 10 years (Fig. 2). The predicted probability of injury increased when the participant was also teaching yoga (Fig. 2). Most factors related to yoga practice habits had no

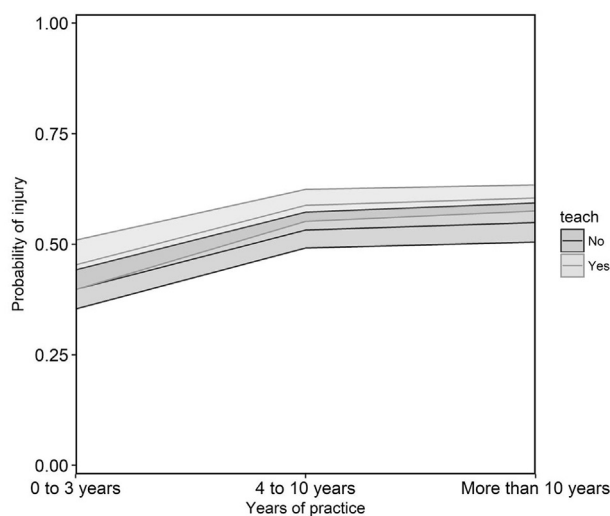
Table 7
Cause of injury as described by participant (n = 1371).

Reported Cause of Injury	Percent of Injuries
Respondent didn't say why they thought the injury had occurred	31.7
Participant pushed themselves too far/was overly enthusiastic	15.4
Involved a hand's-on adjustment by a teacher	12.5
Approach/alignment/method of doing the posture needed to change	8.8
It just happened/I don't know why	8.0
Repetitive motion	7.0
Yoga exacerbated an existing condition	3.6
Fell out of a pose/tripped/fell entering or exiting a pose	3.5
Verbal pressure from teacher to do something not right for participant	3.2
Not warmed up enough	1.3
Distracted	1.0
Overly tired/fatigued	0.9
Result of adjustment by fellow student in workshop or teacher training course	0.9
Participant didn't understand a teacher's instructions	0.8
Participant pushed through feeling of pain	0.7
Messing around with an isolated pose outside of practice	0.4

Table 8

Multivariable logistic regression analysis of factors associated with risk of yoga injury.

	OR	95% CI		p-value
Years of Yoga Practice:				
0–3 years	Ref	–	–	–
*4–10 years	1.63	1.28	2.07	<.0001
*More than 10 years	1.75	1.34	2.27	<.0001
Number of Days of Yoga Practice with a Teacher Each Week:	1.00	0.95	1.05	.9898
Duration of Typical Yoga Practice Session (in minutes):				
Less than 30	Ref	–	–	–
30	0.67	0.27	1.64	.3817
60	0.86	0.38	1.94	.7152
90	1.04	0.45	2.35	.9209
120	1.43	0.60	3.35	.4092
More than 120	1.95	0.74	5.13	.1734
Years of Practice Experience of Participant's Teacher				
Less than 1 year	Ref	–	–	–
1–3 years	1.76	0.56	5.94	.3428
4–6 years	2.13	0.72	6.80	.1802
7–10 years	1.46	0.50	4.57	.4959
More than 10 years	2.10	0.74	6.44	.1696
I don't know	1.10	0.37	3.53	.8730
No primary teacher	1.12	0.86	1.45	.2003
Is your teacher authorized/certified?				
No/I don't know	Ref	–	–	–
Authorized by Yoga Alliance (200 or 500 level)	0.96	0.74	1.24	.7424
Yes, other authorizing or certifying group	1.12	0.86	1.45	.3937
Do you teach yoga?				
No	Ref	–	–	–
*Yes	1.26	1.04	1.52	.0177
Age Group of Participant				
15–30	Ref	–	–	–
31–45	1.31	0.98	1.75	.0691
46–60	1.15	0.85	1.55	.3816
61 or older	0.66	0.46	0.96	.0293

OR = odds ratio, CI = confidence interval, Ref = reference category, *indicates significance at $p \leq .01$.**Fig. 2.** Predicted probabilities of reporting a yoga injury by number of years of yoga practice and whether or not participants also teach yoga.

relationship to likelihood of reporting an injury when number of years of practice was accounted for, including: typical duration of respondent's yoga practice, number of days each week that the participant regularly spent practicing either with a teacher, number of years that the participant's teacher has been practicing, age of the participant, or whether participant's teacher was registered with

the Yoga Alliance at the 200 or 500 h level or another yoga registry organization (Table 8).

4. Discussion

Given the estimated number of yoga participants worldwide, we found the number of serious injuries in yoga to be relatively small. In this large cross-sectional survey of yoga asana participants, primarily from North America and Europe, 45% had never experienced a yoga-related injury and an additional 28% had a mild injury not requiring medical attention or a long recovery time. Severe injury was quite infrequent (9% of those who reported an injury, 4% of the total sample). Our findings are consistent with previous reports that found that serious injury was a rare occurrence in yoga (Cramer et al., 2013; Penman et al., 2012). Research on other physical leisure activities suggests that severe injuries in yoga are less common than in many other activities. Hootman et al., 2002, reported that approximately 1/3 of their sample of physically active adults quit their physical activity (running, walking, jogging, or sports) as a result of an injury. Similarly, Parker et al., 2011 reported at least 27% of women training to run a marathon, experienced a severe injury during the training. Among those participating in cheerleading, Shields and Smith, 2009 reported that 19% of those surveyed had experienced a severe injury (e.g. concussion, dislocation, fracture) from their sport. Our findings may therefore help to put into context the anecdotal reports in the popular press, like those of Broad (2012) regarding extreme injuries in yoga.

While injuries that did occur in yoga were most commonly

reported as sprains and strains (47.1% of injuries) that did not require medical care (64% of injuries), yoga participation was not risk-free. This was consistent with existing research; the largest percentage of yoga injuries were reported as sprains or strains (Swain and McGwin, 2016; Russell et al., 2016; Mikkonen et al., 2008). Similarly, others found about $\frac{1}{3}$ (31%) of those reporting a yoga injury sought medical care (Holton and Barry, 2014).

Areas of the body that were most commonly reported as sites of injury among our survey respondents were similarly reported by others as areas vulnerable to injury. Other surveys of yoga injuries reported the most common sites of injury as the knees (Mikkonen et al., 2008; Le Corroller et al., 2012), lower back (Mikkonen et al., 2008), shoulder joints (Le Corroller et al., 2012) and hamstrings (Mikkonen et al., 2008). Swain and McGwin, 2016 reported more generally that trunk and lower limb were the most common sites of injury. Similarly, these are common areas for injury in other sports, such as dance and CrossFit (Montalvo et al., 2017; Prakash, 2017; Smith et al., 2016). Shoulders, knees, and lower back were the top three sites of injury reported among CrossFit participants (Montalvo et al., 2017). Knees (Prakash, 2017), hamstrings (Smith et al., 2016; Asklings et al., 2008), and low back (Smith et al., 2016) were frequently reported sites of injury for dance participants. It is likely that these areas of the body were the most commonly reported sites of injuries in multiple movement modalities because there are muscle attachments or joints at these areas that are especially vulnerable to overuse type injuries. This suggests a need for greater attention from both yoga students and teachers regarding the sensations that they experience in these areas during yoga practice.

We did not find that increased age predicted a greater risk of yoga injury. While others have suggested that older participants are at a greater risk for injury from yoga (Swain and McGwin, 2016), our results did not support that. We did not find any difference among age groups with regard to probability of reporting an injury or percent of reported injuries that were severe as compared to mild or moderate. As Swain and McGwin, 2016, reported only injuries reported to hospitals, it is possible that older participants are more likely to report their injury to a doctor, but not more likely to actually experience an injury from yoga overall.

The strongest predictor for reporting at least one injury over a lifetime of yoga practice was years of practice. Teaching yoga was also a predictor of reporting a yoga injury, although, less strongly related. There are potentially several reasons for this relationship. Merely spending more time at an activity increases the opportunities for some kind of injury to happen. Additionally, those that have been practicing yoga consistently for many years are likely doing more advanced asanas that require greater range of motion, as well as greater control over balance and proprioception, making those asanas inherently riskier. It is possible that teaching yoga was related to increased likelihood of reporting an injury simply because teaching, for those who demonstrate postures in their classes, is another example of spending more time moving through yoga postures. It is also possibly a reflection of the physical nature of teaching a movement-based activity. Additionally, teachers may feel pressured to achieve in their own practice because they are taking on the role of the teacher. Finally, it is also likely that teachers, just like more experienced yoga participants who do not teach, are doing more advanced asanas that are potentially riskier.

Rather than one primary factor, many different factors were cited by survey respondents as the cause of their yoga injuries. Doing too much (doing too many postures, repetitive motion injury from repeating a specific movement too many times, or simply over-stretching) was mentioned most often as the cause of injury. Inadequate teaching was also reported, in the form of either poor instruction or injurious hands-on assists, but it was not the primary

cause of injury suggested by most respondents. The third most common reason that participants reported as contributing to pain or an injury was simply that some aspect of how they were practicing needed to change for them. For example, one student said, "I am now aware that by not paying attention to the position of the back foot in the virabhadrasana [warrior pose] sequence that I was compromising my knees".

It seems, rather than there being something necessarily inherently risky about yoga itself, participants are getting hurt when they are doing postures inappropriate for them as individuals or they are getting hurt because they are practicing with an approach that is not a good fit for them. A cultural bias toward an attitude of "more is better" and "no pain, no gain" could also be contributing to an increased chance of injury in yoga practice, as has been reported in other physical activities and sports (Tynan and McEvilly, 2017; Salwin and Zajac, 2016; Tibbert et al., 2015). Others have also suggested that excessive effort and practice inappropriate for the individual (e.g. beginning yoga participants attempting more advanced postures) could be contributing to injuries in yoga (Cramer et al., 2013; Le Corroller et al., 2012; Fishman et al., 2009; Mikkonen et al., 2008).

Yoga teacher training programs do not seem to be preparing teachers with the specific knowledge needed to help students avoid injuries. We found that the likelihood of participants to report an injury was not reduced when their teacher was registered with either the largest yoga teacher registry, United States-based Yoga Alliance (Yoga Alliance, 2017a), or another yoga teacher registry. Registration with Yoga Alliance or another yoga teacher registry ostensibly suggests sufficient mastery of necessary skill sets to teach yoga, because, in order to register, one must have completed a yoga teacher training program that meets the minimum standards set by Yoga Alliance and is registered with the organization (Yoga Alliance, 2017b). However, in practice, these standards do not seem to effectively cover the skills needed to reduce injury in yoga, as we did not find that less injuries were reported by those participants with registered teachers.

What may be missing from the knowledge base of many yoga instructors then, is an understanding of how to tailor yoga postures and sequences for each individual student, how to coach students to work within an appropriate level of effort, as well as, how to recognize signs that a student may be pushing things beyond what is healthy for them. We found that the most common format of teaching yoga was a guided, follow-the-leader style class of a defined time (usually an hour) and that participants were more likely to report an injury when in a guided style class than in a self-practice style class (Table 6). The guided class format increases the conditions under which the individualization of yoga is lost. Students attending guided yoga classes may be tempted or encouraged to "keep up" by doing postures not necessarily appropriate for them, may do too many postures when their body is not yet conditioned for that, or could feel pressured to move too quickly into postures without time needed to assess how they feel. Smaller group classes, where students work on a specific sequence individualized for their needs and at their own pace have the potential to alleviate these pressures.

4.1. Limitations of the study

Several limitations exist regarding the interpretation of the findings from this study. Selection bias as a result of the sampling methods may have affected how closely the resultant sample represented the pool of those who currently or previously have participated in yoga. Invitations to take part in the survey were distributed through social media and direct email, which required that the participants have access to a computer and be engaged

with social media channels and/or email. Additionally, while the survey was distributed through both social media and direct email internationally, completion was limited to those with English language proficiency, which could have limited the breadth of experiences reported. Likewise, the survey distribution methods may not have resulted in a representative sample of all yoga practice styles. As there is an abundance of yoga-related media from which to choose, it is possible that some yoga styles were more or less represented among the media we selected for survey invitation distribution. We were surprised that the greatest percentage of respondents indicated that they practice multiple styles rather than primarily one style. Likewise, we were surprised by the high percentage of participants that identified Ashtanga as the yoga style they practice compared with the much smaller percentages of respondents that identified other individual styles of practice. This was possibly an artifact of our survey distribution channels and could have limited the responses we received. Self-selection bias, may also have excluded groups such as those who no longer participate in yoga, as they may not have known about the survey, or may have thought it was not relevant to them. It may also have limited the responses of those who did not have strong positive or negative feelings about yoga and were therefore not motivated to complete a survey.

4.2. Future directions

Our survey raises many questions about the causes of asana related injury that it was not designed to answer. There is considerable variability among yoga practices. Yoga asana styles differ in the postures that they do, the way in which the postures are taught (with or without props or hands-on assists, for example), the temperature of the room, and in other aspects of practice context. The students attracted to one or another style may differ in their physical aptitudes for yoga as well as their attitudes toward practice related pains or other warning symptoms. More specific circumstances of injury could likely be identified for particular styles of practice. Examining the context and types of injuries that are occurring among yoga participants of specific styles would allow those that teach and study these practices to evaluate how the practices can be modified to further reduce risk and would allow prospective participants to better judge whether yoga activities are a good fit for them. To be better able to apply knowledge of risk for injury towards modifying the practice appropriately for each individual participant in order to reduce injury, future studies should be conducted with population samples of specific practice styles.

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Conflicts of interest

None.

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