The Daily Influences of Yoga on Relational Outcomes Off of the Mat

Abstract

Background: Despite the wide array of health benefits that have been evidenced with yoga, a clear gap exists examining how yoga impacts connections with oneself and to others. Aims: The objectives of the present study were twofold: (1) to describe the day-to-day variability in daily yoga practice and relational outcomes and (2) to examine the direct and indirect effects of yoga practice on relational outcomes. Methods: Community-dwelling yoga practitioners ($n = 104$, age range: 18–76 years) with a yoga practice of at least once a week were recruited for a 21-day diary study. Practitioners were asked to complete daily Internet surveys at the end of the day which included questions with respect to one’s yoga practice and relational domains (i.e., mindfulness, [self-]compassion, and social connectedness). Results: Multilevel analyses revealed yoga and relational outcomes to be dynamic phenomena, indicated by substantial variation (intraclass correlations $= 0.34$–$0.48$) at the within-person level. On days when an individual practiced more yoga than their usual, greater mindfulness ($b = 2.93$, standard error $SE = 0.39$, $P < 0.05$) and self-compassion ($b = 1.45$, $SE = 0.46$, $P < 0.05$) were also reported. 1-1-1 multilevel mediation models demonstrated that yoga has an indirect effect on both compassion and social connectedness through increases in mindfulness at the within- and between-person levels. In models testing self-compassion as the mediator, the indirect effect of daily yoga practice on compassion was significant, although limited to the within-person level. Conclusions: These findings suggest that a routine yoga practice could positively impact how a practitioner relates to themselves and to others, both on a day-to-day basis, and with accumulated practice.

Keywords: Compassion, daily variability, intensive longitudinal methods, mindfulness, social connectedness

Introduction

At present, there are approximately 20 million adults in the US practicing yoga, with statistics from national surveys demonstrating continuous growth. Similarly, in the scientific community, the National Institutes of Health is investing to better understand the effects and mechanisms of mind–body approaches such as yoga, as evidenced by the recent increase in grant calls. While the literature has certainly proliferated over the past decades demonstrating a wide array of salutary health benefits, a clear gap in the literature is present examining the “relational” (intra- and interpersonal) influences of yoga practice. Understanding the extent to which yoga can influence the relational aspects of one’s life is a worthwhile endeavor, considering that human beings have an inherent need to feel connected, trusted, and loved. Moreover, positive interpersonal relationships such as feeling connected and practicing concern for others have been linked to psychological and physical well-being. Although according to yogic philosophy, the effects of yoga practice are purported to extend off of the mat, not just to oneself (intrapersonal), but also to others (interpersonal), the evidence is lacking and relational outcomes remain understudied. Preliminary support exists that yoga influences interpersonal domains such as compassion and a sense of connectedness, but the potential mechanisms of these effects are not understood. One proposed pathway through which yoga can help individuals relate to others is by instigating intrapersonal changes (e.g., facilitating self-awareness and positive attitude toward oneself), which may subsequently lead to a more compassionate and/or nonreactive nature for handling interpersonal relationships, thereby also enhancing social connectedness. Two key intrapersonal resources cultivated

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through yoga are mindfulness and self-compassion. Many researchers have demonstrated the integral role of mindfulness in deriving health benefits from contemplative practices, including yoga practice.[12,13] Defined as a skill of paying attention in the present moment with a nonjudgmental attitude,[14] mindfulness has been studied primarily as an intrapersonal skill, although it encompasses both internal and external experiences, potentially impacting the way in which one relates not just to self but also to others.[15]

In addition to the meditative (mindfulness) element which lies at the core of yoga practice, it also embraces a compassionate and nonharmful attitude founded on the yamas and niyamas, the ethics, or guiding life principles of yoga. Self-compassion, defined as a kind way of relating to oneself in the face of one’s own shortcomings and inadequacies,[16] may therefore complement mindfulness as another essential ingredient of yoga practice which underlies its effects on interpersonal outcomes. Studies indicate that self-compassion serves as a potent predictor of health and well-being,[17] and emerging evidence demonstrates that yoga can generate self-compassion.[12,18]

In a pilot study by Gard et al., self-compassion mediated the effects of a 4-month residential yoga intervention on increased quality of life and reductions in stress.[19] Whether self-compassion derived from yoga practice, as complementary to mindfulness, can facilitate how one relates to others remains to be determined.

The present study utilized intensive longitudinal methods to evaluate whether daily yoga practice is associated with relational outcomes. An intensive longitudinal design[20] was utilized to characterize the natural variability in psychosocial outcomes of daily yoga practice off of the mat among community-dwelling yoga practitioners with varying levels of experience. Capturing how relational outcomes fluctuate from day to day as a function of daily yoga practice can also prove useful for developing and refining subsequent randomized controlled trials incorporating intensive assessments.

The initial objective of this study was to characterize the potential fluctuations that may be present in the relational variables of interest (i.e., mindfulness, self-compassion, and social connectedness) at the within- and between-person level as a function of daily yoga practice across a period of 21 days. Second, we examined the daily influences of yoga practice on relational domains and explored whether daily mindfulness and self-compassion mediated these effects. We hypothesized that, on days when practitioners practiced more yoga than their usual (or on yoga practice days), they would report enhanced daily mindfulness and self-compassion, which would be associated with enhancements in the interpersonal outcomes of compassion and social connectedness.

### Methods

#### Participants and procedures

Community-dwelling yoga practitioners with varying yoga experience were recruited for a prospective 21-day diary study. Interested participants were screened through an online screening survey, or over the phone. Eligibility criteria included (a) being at least 18 years of age, (b) practicing yoga at least once a week, and (c) having daily access to Internet. Of the 120 consented participants initiating the daily assessment portion of the study, nine participants discontinued after enrollment due to inability to comply with the study procedures, two participants did not complete the final questionnaire, and five provided insufficient daily data (<50%) to be included in the analyses. Figure 1 depicts the participant flow.

Participants were recruited through handouts and flyers placed in community locations, including yoga studios (with approval from owners) where flyers were distributed in class, and study announcements were also made in the studios’ newsletter(s). An online ad was also posted on the research studies’ website for volunteers at the local institution.
At baseline, participants provided informed consent and completed demographic and psychosocial questionnaires. During this initial session, participants were instructed on accessing the daily Internet surveys through a secure website at the end of each day (between 7:00 p.m. and 2:00 a.m.) over the course of the 3-week period. After the 21 days, participants completed a second session with one final psychosocial questionnaire (Note: regional participants were asked to complete all of the surveys at home, but were provided extensive instruction over the phone). All procedures were approved by the Institutional Review Board at the local institution.

Baseline assessment

Demographics

At the initial laboratory visit, participants provided background information with respect to their age, education, income, gender, marital status, as well as yoga practice and experience. Body mass index was assessed from height and weight obtained in the laboratory using standard procedures. Regional participants (n = 28) provided self-reported height and weight.

Daily assessments

Yoga practice

Self-reported yoga practice was assessed from the question, “Did you practice yoga today?” (yes/no response). If participants indicated yes, follow-up questions asked about the duration (in minutes) and location (i.e., community studio, home practice, and other) of the day’s yoga practice.

Mindfulness

Four items were modified for the daily timescale to capture mindfulness of mind and body. Two items captured mindfulness of the mind: “I noticed thoughts and emotions as they came and went” and “I was caught up in thinking about the past or the future instead of being in the present.” For mindfulness specific to the body, two items were utilized from the State Mindfulness for Physical Activity Scale:[21] “Today, I felt present in my body” and “Today, I listened to what my body was telling me.” Within-person reliability (R) was 0.61. Mindfulness of mind with body had within- and between-person correlations of rs = 0.40–0.51.

Self-compasion

Two items from Neff’s Self-Compassion Scale-Short Form (SCS-SF) were modified to be used in the daily context to assess self-compasion: “Today, I gave myself the caring and tenderness I needed.” and “Today, I was disapproving and judgmental about my own flaws and inadequacies.”[22] The first item represented a self-kindness item, whereas the second represented a self-judgment item. R was 0.37, and responses to the two items to assess self-compasion had within- and between-person correlations of rs = 0.30–0.45.

Compassion

Two items from the modified Differential Emotions Scale (mDES) were used to capture compassion.[23] Participants were asked to indicate how often they have felt a combination of emotions throughout the day (three sets of emotions are listed for each overarching emotion in the mDES). For the present work, emotions such as (1) sympathy, concern, compassion and (2) love, closeness, or trust were combined to obtain a daily compassion score. These two items were combined to create a compassion score due to the fact that compassion and love are both primarily emotions that facilitate the development and maintenance of intimate social bonds with others,[24] and previous instruments of compassion include love (i.e., altruistic love) as a component of compassion.[25] Rc was 0.36, and responses to the two items to assess compassion had within- and between-person correlations of rs = 0.37–0.40.

Social connectedness

Two items from the Social Connectedness Scale (i.e., “I was able to relate to the person(s) around me.” and “I felt isolated from others.”)[26] were used to assess social connectedness. The within-person reliability (R) for social connectedness was 0.55. Responses to the two items to assess social connectedness had within- and between-person correlations of rs = 0.48–0.49.

Ratings for mindfulness, (self-)compassion, and social connectedness were all made on a Visual Analog scale (0–100). Anchors were marked as ranging from 0 (strongly disagree) to 100 (strongly agree), with an exception to compassion with anchors 0 (not at all) to 100 (very much).

Covariates

Psychological and physical health status

The literature has demonstrated positive influences of relational variables on both psychological and physical well-being,[27,28] thus, in the analyses, psychological and physical health were included as covariates. Two items from the Health-Related Quality of Life Questionnaire were adapted to assess global mental and physical health status.[29] Psychological and physical health were assessed through two items each, “Today, my emotional/physical health was...” (rated on a 0–100 scale from very poor to excellent) and “Today, my emotional/physical health interfered with my daily activities” (rated on a 0–100 scale from not at all to extremely). The two items were combined to create an overall psychological and physical health score. Responses to the two items for both psychological and physical health statuses were moderately correlated at the within-and between-person level (rs = 0.48–0.58 and 0.56–0.67, respectively).

Time/reactivity

The day in study sequence controlled for any changes related to reactivity in daily self-reports of the relational
outcomes. Since relational outcomes are likely to be influenced by the social calendar, time of week was defined to contrast weekdays (0 = Monday through Friday) with weekends (1 = Saturday and Sunday).

**Additional covariates**

Overall yoga experience was also included due to the possibility that experienced practitioners may differ in their overall levels or variability on the relational outcomes of interest. Since the present sample consisted of a wide age range (18–76 years) of practitioners, and evidence suggests that self-compassion may increase with age, especially later in life,[27] age also served as a covariate in the final models.

**Statistical analysis**

Considering the nested nature of the data (days nested within persons), two-level multilevel models were tested to examine within- and between-person associations. All models were estimated using SAS 9.3 PROC MIXED (SAS Institute Inc, Cary, NC, 1996)[30] with restricted maximum likelihood estimation (treating any incomplete data as missing at random). Prior to analyses, all between-person predictors were grand mean centered and all within-person predictors were person-day centered following standard procedures.[31] Supplementary File 1 shows sample equation and specifics in modeling. To investigate the daily influences of yoga practice to enhance relational outcomes (mindfulness, self-compassion, and social connectedness), these outcomes were regressed on daily yoga practice, controlling for covariates (psychological and physical health, age, yoga experience, day in study, and weekend). Yoga practice was operationalized as the duration of one’s practice (in minutes). The duration of yoga practice was natural log transformed and was the only transformed variable due to skewness (2.58). Transformed values were used to calculate correlations and to estimate parameters in the multilevel models examining the continuous yoga practice (minutes) variable.

**Multilevel mediation analysis**

To empirically test the intra- to interpersonal pathways proposed in a conceptual framework developed through qualitative data obtained from this study,[32] a second series of multilevel models were tested to examine the possible mediating roles of mindfulness and self-compassion in the between- and within-person relations linking yoga to compassion and social connectedness. As all variables of interest were assessed at the daily level (i.e., Level-1), 1-1-1 multilevel mediation models were estimated at the within-subjects level (Supplementary File 2 shows equations and detail with respect to mediation analyses). Current recommendations were followed that place emphasis on the higher power direct test of the indirect effect for demonstrating mediation.[33] Because traditional approaches in testing multilevel mediation using hierarchical linear modeling are prone to confounding within-group effects with between-group effects, the suggested principles outlined by Zhang et al.[34] were used to appropriately test multilevel mediation at both the between- and within-person levels [Figures 2 and 3]. In order to make inferential conclusions about the ab path, the Monte Carlo bootstrapping procedure was utilized to test the significance of the indirect effect with 20,000 replications to make inferential conclusions about the ab path. Monte Carlo simulation is a simple yet powerful technique, and the appropriate between- and within-coefficients were used to generate separate confidence intervals appropriate for each level of analysis.[35]

**Results**

Characteristics of the study participants are depicted in Table 1. Many styles and types of yoga practice were represented (e.g., Hatha, Iyengar, Bikram, and Ashtanga). Participants completed surveys for a total of 2059 of the 2184 possible person-days (94.3% completion rate) to be included in the analysis. Out of the 1035 times that
yoga was practiced across participants and throughout the 21-day period (% of yoga days), studio practice occurred 42.7% of the time, home practice 49.3% of the time, and 8% in a different context (e.g., outdoors and yoga room at the airport). On average, participants practiced yoga for 9.41 days (standard deviation $[SD] = 4.53$; range 2–21) out of the 21-day period (approximately 2.23 times a week).

Descriptives, intraclass correlations (ICCs), and correlations are presented in Table 2. On yoga practice days, participants practiced yoga for approximately 50.08 min ($SD = 39.47$). Overall, participants demonstrated moderate to high levels of mindfulness ($mean = 64.53$, $SD = 19.24$), self-compassion ($mean = 65.06$, $SD = 23.25$), and compassion ($mean = 67.07$, $SD = 21.77$), with the highest between-person $means$ observed in social connectedness ($mean = 81.59$, $SD = 16.09$), all assessed on a 0–100 scale. ICC estimates indicated more than half of the variability in the duration of yoga practice (i.e., on yoga practice days) to be attributed to within-person differences (66.2%, ICC = 0.34), with all of the intra- and inter-personal outcomes of interest demonstrating substantial within-person variability.

**Daily yoga practice predicting intra- and inter-personal outcomes**

**Mindfulness**

Unstandardized parameter estimates from the multilevel models predicting mindfulness are presented in Table 3 (column M1). Model 1 regressed daily mindfulness on self-reported yoga practice and the remaining covariates. Both a within- ($\gamma_{10} = 2.93$, standard error $[SE] = 0.39$, $P < 0.05$) and between-person association ($\gamma_{01} = 7.39$, $SE = 2.44$, $P < 0.05$) between yoga practice and mindfulness emerged such that on days when an individual practiced more yoga than their usual, greater mindfulness was reported (i.e., based on parameter estimates, for every 5 additional minutes of yoga practice, practitioners reported a 0.27 increase in mindfulness). Daily and overall yoga practice explained 3.7% and 12.9%, respectively, of the variance in mindfulness, as calculated by the pseudo-$R^2$ statistic.

Positive relations were also found linking mindfulness and psychological health at both the daily ($\gamma_{10} = 0.29$, $SE = 0.02$, $P < 0.05$) and overall ($\gamma_{00} = 0.50$, $SE = 0.09$, $P < 0.05$) levels. That is, on days when practitioners reported greater psychological health than their usual, practitioners reported enhanced mindfulness, and practitioners with higher psychological health overall reported greater mindfulness in comparison to practitioners with lower psychological health overall. A significant association was demonstrated between daily physical health and mindfulness ($\gamma_{10} = 0.05$, $SE = 0.02$, $P < 0.05$); however, the between-person effect of overall physical health on mindfulness was nonsignificant such that no differences in overall physical health was observed in relation to one's overall mindfulness. The total between- and within-person variation explained by the final predictive model was 47.9% and 22.3%, respectively.

**Self-compassion**

Unstandardized parameter estimates from the multilevel models predicting self-compassion are presented in Table 3 (column M2). The within-person association between yoga practice and self-compassion was significant such that on days when an individual practiced more yoga than their usual, greater self-compassion was reported ($\gamma_{10} = 1.45$, $SE = 0.46$, $P < 0.05$). Parameter estimates indicated that, for every 5 additional min of yoga practice, practitioners

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**Table 1: Participant characteristics for the daily OM study**

| Variable                           | Mean  | SD       | Range  |
|------------------------------------|-------|----------|--------|
| Age                                | 41.7  | 16.1     | 18-76  |
| BMI                                | 25.00 | 4.93     | 17.8-44.0 |
| Yoga experience (years)            | 8.23  | 7.15     | 0.33-40 |
| Home practice                      |       |          |        |
| Times per week                     | 2.46  | 2.00     | 0-7    |
| Average duration                   | 29.25 | 32.23    | 0-105  |
| In-class (e.g., studio) practice   |       |          |        |
| Times per week                     | 2.03  | 1.54     | 0-7    |
| Average duration                   | 69.39 | 32.23    | 0-180  |

Frequency of studying yoga philosophy (%)  
Three times a week or more | 7.7   
1-8 times per month | 37.5  
Less than once per month | 32.7  
Never | 22.1  

Type/style of yoga practice* (%)  
Hatha yoga | 39.43  
Iyengar | 8.41  
Bikram | 6.59  
Triyoga | 5.02  
Power | 4.16  
Ashtanga | 3.82  
Kripalu | 3.36  
Kundalini | 3.36  
Vinyasa | 3.31  
Other | 22.54  

Education (college graduate) (%) | 78.9  
Income (earning above >$75,000) (%) | 37.5  
Employment (%)  
Full time | 43.3  
Part time | 30.8  
Marital status (%)  
Married/domestic partnership | 47.1  
Gender (female) (%) | 92.3  
Sexual orientation (heterosexual) (%) | 93.3  
Race/ethnicity (Caucasian) (%) | 88.5  

*Participants were asked to indicate the type or style of yoga practice they most often engaged in. Participants who did not know specifically the type or style of yoga generally indicated Hatha yoga. SD=Standard deviation, BMI=Body mass index.
Table 2: Descriptives, intraclass correlations, and correlations of yoga practice (minutes) and relational outcomes

| Variable                      | Mean   | SD     | Range | ICC  | 1    | 2    | 3    | 4    | 5    |
|-------------------------------|--------|--------|-------|------|------|------|------|------|------|
| Yoga practice (min)           | 50.08  | 39.47  | 0-150 | 0.34 | -0.08| -0.13| 0.18 | -0.08| 0.16 |
| Mindfulness                   | 64.53  | 19.24  | 21.5-100 | 0.38 | 0.20 | 0.25 | 0.63 | 0.21 | 0.34 |
| Self-compassion               | 65.06  | 23.25  | 8-100 | 0.38 | 0.14 | 0.62 | 0.29 | 0.36 |
| Compass                      | 67.07  | 21.77  | 4.5-100 | 0.48 | 0.04 | 0.39 | 0.31 | -    | 0.34 |
| Social connectedness         | 81.59  | 16.09  | 31.5-100 | 0.39 | 0.05 | 0.46 | 0.40 | 0.47 |

Means and SDs represent person-level descriptives. ICC represents the proportion of between-person variability. Coefficients above the diagonal represent between-person correlations, and coefficients below the diagonal reflect within-person and across-day correlations. In the above table, yoga practice represents yoga practice days (i.e., on days when yoga was practiced). SDs=Standard deviations, ICC=Intraclass correlation coefficient.

Table 3: Multilevel models predicting mindfulness, (self-) compassion, and social connectedness with the continuous yoga practice (minutes) variable

| Variable                      | M1               | M2               | M3               | M4               |
|-------------------------------|------------------|------------------|------------------|------------------|
|                               | Coefficient (SE) | Coefficient (SE) | Coefficient (SE) | Coefficient (SE) |
| Fixed effects                 |                  |                  |                  |                  |
| Intercept, γ_{00}             | 65.72* (0.98)    | 68.47* (0.90)    | 64.93* (1.36)    | 80.59* (0.96)    |
| Overall yoga practice (min), γ_{01} | 7.39* (2.44)   | 1.87 (2.17)      | 8.01* (3.63)     | 3.70 (2.36)      |
| Daily yoga practice (min), γ_{10} | 2.93* (0.39)    | 1.45* (0.46)     | 0.20 (0.44)      | -0.01 (0.39)     |
| Overall mindfulness, γ_{02}   | -                | 0.58* (0.09)     | 0.51* (0.14)     | 0.38* (0.09)     |
| Daily mindfulness, γ_{20}     | -                | 0.45* (0.03)     | 0.18* (0.02)     | 0.25* (0.03)     |
| Overall psychological health, γ_{03} | 0.50* (0.09)   | 0.32* (0.09)     | 0.31* (0.14)     | 0.55* (0.09)     |
| Daily psychological health, γ_{30} | 0.29* (0.02)    | 0.28* (0.02)     | 0.18* (0.02)     | 0.22* (0.02)     |
| Overall physical health, γ_{04} | 0.09 (0.09)    | -0.09 (0.07)     | -0.22 (0.22)     | -0.28 (0.08)     |
| Age, γ_{05}                   | 0.08 (0.06)     | 0.02 (0.05)      | 0.07 (0.08)      | 0.05 (0.05)      |
| Yoga experience, γ_{06}       | 0.01 (0.13)     | -0.18 (0.11)     | 0.11 (0.19)      | -0.03 (0.12)     |
| Weekend, γ_{07}               | 1.54* (0.56)    | 1.15 (0.62)      | -0.62 (0.73)     | 0.44 (0.64)      |
| Day in study, γ_{08}          | 0.04 (0.04)     | 0.06 (0.05)      | -0.20* (0.05)    | -0.14* (0.05)    |

Random effects

|                         | M1               | M2               | M3               | M4               |
|-------------------------|------------------|------------------|------------------|------------------|
| Intercept, σ_{20}        | 68.94* (10.80)   | 46.71* (7.88)    | 141.67* (21.86)  | 55.71* (9.22)    |
| Daily yoga practice, σ_{21} | 3.83* (2.02)    | 6.28* (2.89)     | -                | -                |
| Residual variance, σ_{e} | 128.17* (4.21)  | 154.64* (5.10)   | 209.91* (6.74)   | 167.21* (5.37)   |
| -2LL                    | 16,040.6         | 16,387.9         | 17,041.8         | 16,509.6         |
| AIC                     | 16,046.6         | 16,393.9         | 17,045.8         | 16,513.6         |

Note: Unstandardized estimates and SEs. Coefficients for daily yoga practice (min) represent parameter estimates from transformed scores. -2LL = -2 Log Likelihood, AIC=Akaike Information Criterion. *P<0.05

reported a 0.11 increase in self-compassion. As calculated by the pseudo-R² statistic, daily yoga practice explained 2.2% of the variance in self-compassion.

Significant associations also emerged linking self-compassion and mindfulness such that on days when participants reported being more mindful than their usual, they reported higher self-compassion ($\gamma_{01} = 0.45, SE = 0.03, P < 0.05$). Overall trait mindfulness was also associated with greater overall self-compassion ($\gamma_{02} = 0.58, SE = 0.09, P < 0.05$). Both daily ($\gamma_{30} = 0.28, SE = 0.02, P < 0.05$) and overall ($\gamma_{03} = 0.32, SE = 0.09, P < 0.05$) psychological health was also positively associated with self-compassion.

That is, on days when practitioners reported greater psychological health than their usual, practitioners reported enhanced self-compassion, and practitioners with higher psychological health overall reported greater self-compassion in comparison to practitioners with lower psychological health overall. Conversely, no significant associations emerged between physical health (daily and overall) and self-compassion. The total between- and within-person variation explained by the final predictive model was 67.1% and 33.2%, respectively.

**Compassion**

Unstandardized parameter estimates from the multilevel models predicting compassion are presented in Table 3 (column M3). Model 3 examined whether self-reported yoga practice and the remaining covariates predicted greater compassion. The within-person association between yoga practice and compassion was nonsignificant at the between-person level. However, at the between-person level, a positive and significant association emerged between yoga practice and overall compassion ($\gamma_{01} = 8.01, SE = 3.63$, $P < 0.05$).
Positive and significant associations arose between mindfulness and compassion both at the within- and between-person levels. To elaborate, on days when participants reported being more mindful than their usual, they reported enhanced compassion (within: $\gamma_{b2} = 0.18$, $SE = 0.02$, $P < 0.05$), and when practitioners reported greater mindfulness overall, they also reported greater compassion overall (between: $\gamma_{b3} = 0.51$, $SE = 0.14$, $P < 0.05$). Both daily ($\gamma_{b2} = 0.18$, $SE = 0.02$, $P < 0.05$) and overall ($\gamma_{b3} = 0.31$, $SE = 0.14$, $P < 0.05$) psychological health were positively associated with compassion. No significant associations emerged between physical health (daily and overall) and compassion. The total between- and within-person variation explained by the final predictive model was 36.6% and 13.1%, respectively.

**Social connectedness**

Unstandardized parameter estimates from the multilevel models predicting social connectedness are presented in Table 3 (column M4). Model 4 regressed daily social connectedness on self-reported yoga practice and the remaining covariates. No significant associations emerged between yoga practice and social connectedness at either the within- and between-person level.

Positive and significant associations also emerged linking mindfulness and social connectedness ($\gamma_{a2} = 0.25$, $SE = 0.03$, $P < 0.05$), such that on days when practitioners reported being more mindful than their usual, they also felt a greater sense of connectedness. The between-person influence of overall mindfulness on social connectedness was also significant ($\gamma_{a2} = 0.38$, $SE = 0.09$, $P < 0.05$) demonstrating that practitioners with higher mindfulness overall reported greater social connectedness in comparison to individuals with lower overall levels of mindfulness. Both daily ($\gamma_{a2} = 0.22$, $SE = 0.02$, $P < 0.05$) and overall ($\gamma_{a3} = 0.55$, $SE = 0.09$, $P < 0.05$) psychological health were positively associated with social connectedness. No significant relations were found between physical health (daily and overall) and social connectedness. The total between- and within-person variation explained by the final predictive model was 58.3% and 19.3%, respectively.

**Multilevel mediation analysis of yoga practice and interpersonal outcomes**

The first set of multilevel mediation analyses examined whether yoga had an indirect effect on compassion through enhancements in mindfulness. Table 4 shows results from analyses. A positive and significant association between yoga practice and mindfulness emerged both at the within- ($\gamma_{b1} = 2.88$, $SE = 0.34$, $P < 0.05$) and between-person levels ($\gamma_{a1} = 7.38$, $SE = 2.44$, $P < 0.05$). Mindfulness demonstrated both a within- ($\gamma_{b1} = 0.18$, $SE = 0.03$, $P < 0.05$) and between-person effect ($\gamma_{a3} = 0.51$, $SE = 0.14$, $P < 0.05$) on compassion. The indirect effect of daily yoga practice on compassion at the within-person level was 0.53 ($P < 0.05$; 95% confidence interval [CI] [0.34, 0.75]). That is, on days when a practitioner practiced more yoga than their average, they reported greater mindfulness, which, in turn, was associated with improvements in their levels of compassion. The between-person effect was 3.77 ($P < 0.05$; 95% CI [0.98, 7.48]), demonstrating that mindfulness also mediated the yoga and compassion pathway, at the between-person level [Figure 2].

The second set of multilevel mediation analyses examined whether yoga practice demonstrated an indirect effect on social connectedness through improvements in mindfulness. Table 4 shows results from analyses. Daily yoga practice demonstrated a positive and significant association with mindfulness both at the within- ($\gamma_{b1} = 2.88$, $SE = 0.34$, $P < 0.05$) and between-person levels ($\gamma_{a1} = 7.38$, $SE = 2.44$, $P < 0.05$). Mindfulness was also positively and significantly linked to social connectedness both at the within- ($\gamma_{a3} = 0.25$, $SE = 0.03$, $P < 0.05$).  

| Table 4: 1-1-1 multilevel mediation models with mindfulness as a mediator |
|-------------------------------------------------------------|
| **Coefficient (SE)** |
| **Path a** | **Path b and c’ (Model 1)** | **Path b and c’ (Model 2)** |
| Mindfulness | Compassion | Social connectedness |
| Intercept ($\gamma_{oa} \gamma_{a0c}$) | 65.73* (0.98) | 64.93* (1.36) | 80.59* (0.96) |
| Daily yoga practice (min) ($\gamma_{b1} \gamma_{a1c}$) | 2.88* (0.34) | 0.20 (0.44) | -0.009 (0.39) |
| Daily mindfulness ($\gamma_{a2}$) | - | 0.18* (0.03) | 0.25* (0.03) |
| Overall yoga practice (min) ($\gamma_{a3} \gamma_{b3} \gamma_{a3c}$) | 7.38* (2.44) | 8.01* (3.63) | 3.70 (2.36) |
| Overall mindfulness ($\gamma_{a3c}$) | - | 0.51* (0.14) | 0.38* (0.09) |
| Random effects | | | |
| Intercept ($\sigma_{a0c} \sigma_{c0c}$) | 68.80* (10.80) | 141.67* (21.86) | 55.71* (9.22) |
| Residual variance ($\sigma_{c} \sigma_{c}$) | 130.47* (4.19) | 209.91* (6.74) | 167.21* (5.37) |

Note: Unstandardized estimates and SEs. Coefficients for daily yoga practice represent parameter estimates from transformed scores. Model 1=The $b$ and $c'$ path to compassion, Model 2=The $b$ and $c'$ paths to social connectedness. *$P<0.05$. SEs=Standard errors
\( P < 0.05 \) and between-person levels (\( \gamma_{01} = 0.38, SE = 0.09, P < 0.05 \)). The indirect effect of daily yoga practice on social connectedness at the within-person level was \( 0.72 (P < 0.05; 95\% CI [0.51, 0.96]) \), indicating that, on days when a practitioner practiced more yoga than their usual, they reported greater mindfulness, which was associated with enhancements in social connectedness. The between-person effect was \( 2.80 (P < 0.05; 95\% CI [0.83, 5.44]) \), indicating that mindfulness also mediated the yoga and social connectedness pathway at the between-person level [Figure 2].

**Role of self-compassion as a mediator**

The last set of multilevel mediation analyses examined whether yoga had an indirect effect on compassion through increased self-compassion. Table 5 shows results from analyses. A positive and significant association between yoga practice and self-compassion emerged both at the within- \( \gamma_{01} = 2.73, SE = 0.40, P < 0.05 \) and between-person levels \( \gamma_{01} = 6.17, SE = 2.51, P < 0.05 \). Self-compassion indicated a within-person effect on compassion \( \gamma_{11} = 0.17, SE = 0.02, P < 0.05 \), and the between-person effect was nonsignificant \( \gamma_{00} = 0.15, SE = 0.15, P = 0.31 \). The indirect effect of daily yoga practice on compassion at the within-person level was \( 0.47 (P < 0.05; 95\% CI [0.30, 0.67]) \), demonstrating that, when a practitioner practiced more yoga than their usual, greater self-compassion was reported, which, in turn, was linked to improvements in compassion. The between-person effect (0.94) was not significant, with the CIs overlapping with 0 (95\% [-0.86, 3.38]) [Figure 3].

**Discussion**

The present study was the first intensive longitudinal study to examine the influences of yoga practice on the understudied relational outcomes of mindfulness, (self-) compassion, and social connectedness in yoga practitioners with a diverse range of yoga experience. Given that, in general, yoga research has been dominated by controlled experimental studies in laboratory-based settings, a particular strength of the current work was the use of a community-dwelling sample, which suggests that results reflect “shared experiences” of yoga practitioners of varying backgrounds (i.e., experience, style, and age), suggesting the unfolding of one’s yoga practice in an ecological, real-world setting. Collectively, findings demonstrated substantial within-person variability in the intra- and interpersonal outcomes of yoga and supported the notion that practitioners can reap relational benefits from yoga practice (both daily and overall), which may be facilitated by yoga’s effects on intrapersonal resources, namely, mindfulness and self-compassion.

First, a positive within-person association emerged between yoga practice and self-compassion such that, on days when practitioners engaged in more yoga than their usual, enhancements in self-compassion were also found. Qualitative studies have highlighted the ways in which yoga practice serves as a self-care strategy for practitioners.[9,11,32] The present findings support this notion of yoga as a practice that may generate greater kindness toward oneself, adding to the current evidence base.[18,19] It should be noted, however, that the measure of self-compassion used here reflects only selected self-kindness items, but not mindfulness and common humanity items, as is the case in the SCS-SF instrument by Raes et al.[22] and conceptualization of this construct according to Neff.[36] Perhaps, that is why the strength of the yoga and self-compassion association in this study was modest, at least at the daily level (although pseudo-\( R^2 \) values warrant careful interpretation[23]).Still, over time, these daily-level influences from yoga practice may help practitioners garner a steady diet of self-compassion, helping them obtain a self-compassionate nature, which may translate not only to enhanced health and well-being, but also extend positively to healthy interpersonal relationships.

Results from the self-compassion literature have consistently shown a negative association of self-compassion with depression, anxiety, rumination, and self-criticism.[39] Yoga may therefore be a promising and

| Coefficient (SE) | Path a To self-compassion | Path b and c' To compassion |
|------------------|--------------------------|---------------------------|
| Fixed effects    |                          |                           |
| Intercept (\( \gamma_{00}, \gamma_{01} \)) | 67.75* (1.05) | 64.84* (1.42) |
| Daily yoga practice (min) (\( \gamma_{01}, \gamma_{11} \)) | 2.73* (0.40) | 0.26 (0.43) |
| Daily self-compassion (\( \gamma_{11} \)) | - | 0.17* (0.02) |
| Overall yoga practice (min) (\( \gamma_{00}, \gamma_{01} \)) | 6.17* (2.51) | 10.87* (3.78) |
| Overall self-compassion (\( \gamma_{03} \)) | - | 0.15 (0.15) |
| Random effects   |                          |                           |
| Intercept (\( \sigma^2_{u0}, \sigma^2_{u1} \)) | 70.27* (11.39) | 159.76* (24.45) |
| Residual variance (\( \sigma^2_{e0}, \sigma^2_{e1} \)) | 184.33* (5.92) | 208.81* (6.71) |

*Note: Unstandardized estimates and SEs. Coefficients for daily yoga practice represent parameter estimates from transformed scores. SEs=Standard errors. *P<0.05
accessible tool that can specifically tap onto an individual’s kindness toward themselves, with potentially far-reaching consequences on their health and well-being. Interventions have been developed to specifically foster compassion (e.g., Neff’s Mindful self-compassion program, and Gilbert’s compassionate-focus therapy). Yet, in general, these programs are less accessible to the general population and offer less flexibility to participants (i.e., different styles and types, as in yoga practice). Given yoga’s rising popularity, as well as the numerous health benefits that have been documented with practice, it is encouraging to note that self-kindness is yet another resource that can be cultivated. Moreover, yoga may serve as an alternative modality for clinical populations, or for individuals who may be unresponsive to other structured programs. For instance, the movement-based nature of yoga (which allows the body to serve as a vehicle to access one’s mind) and implicit attention to cultivate a compassionate attitude may prove more effective and suitable to specific individuals or subgroups (e.g., in depressed and anxious persons, self-compassion has been perceived to be inaccessible, or difficult to embrace). It is also interesting to consider these findings in light of other research that typically demonstrate greater impact of yoga (as a movement-based practice cultivating mindfulness) on the reduction of psychological symptoms as compared to other contemplative practices (e.g., body scan and sitting meditation). It may be that the physical movement, contemplative, and relational aspects of yoga practice reinforce each other to generate more potent psychological effects.

With respect to the interpersonal outcomes of compassion and social connectedness, no direct within-person influences emerged from yoga practice. A between-person effect of yoga practice on compassion was demonstrated such that practitioners with a greater overall yoga practice reported greater overall compassion. Interestingly, this between-person association was unique to compassion and did not emerge for social connectedness. A few studies have indicated compassion to be a means for generating feelings of closeness and connectedness. Hence, it could be that a longer time span is warranted to detect the overall influence of yoga on social connectedness. An experimental study with novice practitioners may help clarify these relations. In addition, as the current sample scored high on social connectedness in general, there may have been a ceiling effect. It should also be noted that the conceptualization of compassion was limited in that it was captured through the mDES, which is a validated instrument assessing emotions. While compassion is viewed as an emotion which facilitates intimate bonds with others, it has been defined theoretically and has been perceived qualitatively to go beyond emotions, translating into actual acts of compassion. Accordingly, from the present study, whether yoga practice actually translates to compassionate behaviors remains to be determined. Because terms such as compassion, empathy, and altruism have been used rather interchangeably, future research studies seeking to assess these qualities should invest sufficient time and effort in determining appropriate ways to assess these relational outcomes.

Consistently through the study, mindfulness was strongly linked to yoga practice both at the within- and between-person levels. This was perhaps not surprising, given meditative components are the integral aspects of the practice. In addition, the examination of the indirect pathways provided preliminary evidence to support the notion that one of the mechanisms through which yoga may work to influence one’s interpersonal domains (here compassion and social connectedness) is through greater mindfulness. The findings corroborate previous results, which noted intrapersonal changes taking place prior to interpersonal effects. It would be worthwhile for future research to examine individual difference variables (e.g., personality trait) or other potential moderators (e.g., gender, context, and style of practice) to better understand for whom and when yoga practice may have the maximum impact on relational outcomes, thus aiding in the optimization and tailoring of interventional programs.

Limitations and future directions

The results should be interpreted with respect to the following shortcomings. In particular, as this was the first intensive longitudinal study investigating relational outcomes of yoga, limited empirical evidence was available to help guide study design (e.g., duration of study and timescale of assessments). The present study thus provides preliminary empirical basis for designing future intensive longitudinal studies examining the effects of yoga on comparable outcomes, especially given the substantial variability was observed across the 21-day period. Another limitation of this work lies in the observational, concurrent nature of the work, which precludes any conclusions about the causality of these associations. Future studies should carefully consider their outcomes of interest and adjust the frequency of assessment (i.e., appropriate timescale) to best meet their objectives. In a similar vein, as this study was observational in nature, a subsequent step would be to test whether the direct and indirect pathways hold true in a controlled experimental context.

While it is clear that intensive longitudinal studies can enrich the repertoire of research inquiries that can be addressed and provide ecological validity, a warranted step is to establish reliable instruments that can accurately assess these relational variables in shorter timescales and with repeated assessments (i.e., daily, momentary). In fact, the within-person reliabilities observed in the present...
study were in the low-to-moderate range (although what is considered to be a valid within-person reliability value in intensive longitudinal data is still debatable, and this is an issue which requires systematic work in the field in general). Although this may have partially been due to the low number of items that were employed to reduce participant burden and maximize compliance, it could be that a few additional items are needed to more accurately capture these relational constructs.

Finally, the generalizability of findings is clearly restricted due to the homogeneity of the present sample who were predominantly Caucasian, female, and of high socioeconomic status. While this reflects the demographics of yoga practitioners in the US (and users of complementary and alternative medicine in general[47]), it will be imperative for future yoga research to expand the sample pool to include a diversity of healthy and clinical populations, especially as the acceptability of yoga continues to grow and expand; encouragingly, even among those with diverse cultural backgrounds.[48]

Implications and Conclusions

Although the daily influences of yoga still need to be examined among novice yoga practitioners (i.e., participants in the present study were regular yoga practitioners; defined as practicing yoga at least once a week) and in other subgroups; it appears that with sustained practice, positive relational benefits can be garnered, both at the intra- and interpersonal levels. While experimental evidence is warranted as a subsequent step, current findings re-emphasize the promise of yoga practitioners in the US and users of complementary and alternative medicine in general[47], it will be imperative for future yoga research to expand the sample pool to include a diversity of healthy and clinical populations, especially as the acceptability of yoga continues to grow and expand; encouragingly, even among those with diverse cultural backgrounds.[48]

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Conflicts of interest

There are no conflicts of interest.

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