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Research Article

DISEASE MANIFESTATIONS

Effects of Acute Change in Health Status on Human Female Sexuality

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Abstract *Background.* Life history theory suggests that organisms face allocation challenges between maintenance and reproduction. In the face of acute illness, organisms may prioritize investments in immune function to improve condition, but do so at some expense to sexuality. *Objective.* Here, we investigate the effects of acute illness on human female sexuality using a quasi-experimental design. *Methods.* Both when sick and two weeks later when recovered, thirty women (mean age = 23 y, SD = 1.4 y) completed a questionnaire assessing sociodemographic attributes, symptom severity, and several measures of sexuality. *Results.* While sick, women reported markedly lower sociosexuality scores in all but one of the four domains: receptivity (female reactions that denote a willingness to engage in copulation). During illness, symptom severity was unrelated to measures of sexuality. Partnering status did not interact with health status in predicting measures of sexuality. *Conclusions.* These findings show that acute changes in female health status impacted sexuality, consistent with expectations from life history theory. These findings contribute to larger theoretical and empirical discussions regarding context-specific variation in female sexuality.

Keywords sexuality; attractivity; life history; health and disease; emergency life history

1. Introduction

Organisms face species-, sex- and context-specific life history allocation challenges when optimizing investment in growth, maintenance, and reproduction [1,2]. For organisms during their reproductive years, one potential allocation challenge occurs between maintenance and reproduction. An organism's lifetime reproductive success may be optimized by investing in maintenance functions such as immune responses to pathogens even if that results in compromised reproductive function and output [3,4]. Conversely, conditions may favor reproductive investment, even in the face of compromised maintenance, if that yields a higher lifetime reproductive success [2]. Understanding the evolutionary principles guiding such allocation strategies is relevant to theorizing sex differences in adult immune function and behavioral risk-taking, including in the case of higher rates of adult human male age-specific mortality [5,6,7].

Our focus here is human female life history allocation challenges during sickness. In the context of responding to an acute illness, it is hypothesized that reproductive effort and more specifically women's sexuality is downregulated to accommodate increased allocation of resources to maintenance. Life history theory would suggest that in the face of an acute illness, a female may activate immune function to facilitate a successful response and enhanced survival. However, that same activation may come at expense to investment in reproductive effort. This view is consistent with what Wingfield and colleagues termed "the emergency life history response" [8]. The response is made up of physiological and behavioral processes selected to attenuate the risks labile perturbation factors (unpredictable, and short-lived events, e.g., immune-challenge) posed to an organism's fitness [8].

Hormones have been implicated in the development of sickness behaviors (e.g., lethargy, decreased libido, and anorexia) which, though seemingly maladaptive, may help organisms mitigate the risk of metabolic debilitation [9,10]. Elevated glucocorticoids in bird models, for example, are hypothesized to induce a range of adaptive behaviors: they affect the regulation of food intake, directly suppress reproductive behavior, and more [10]. Research on hormone-mediated immunity has implicated testosterone [3,11] and oxytocin [12] in human males and in mice models, which suggests that male and female immunity is linearly related to estrogen levels [13]. Moreover, cytokines engage in extensive bidirectional communication between endocrine and nervous system processes and in so doing they successfully coordinate immune response and expression of sickness symptoms [14]. The degree of sensitivity cytokines have to contextual features (e.g., acute infection/labile perturbation factors) allows them to disclose information on energetic reserves, nutrient levels, breeding state, severity of infection and more [9], thus optimizing the manner by which disease burden trades off with key life functions.

Advancements in the field of ecological immunity also suggest that immune response is an energetically costly process that, like investment in key life history traits, also competes with fitness components (for a review see [15]). Indeed, when sickness becomes so severe it threatens survival; mating efforts may be muted long enough to allow immune investments to increase compensatory prophylaxis [16].

The convergence of expectations from life history theory and ecological immunity regarding allocation shifts between illness and reproduction has stimulated empirical research in nonhuman animals and even human males [3]. Research on generations of *Drosophila nigrospiracula* shows that artificial selection for increased resistance to a pathogen results in decreased fecundity [17]. Researchers using different methodologies (lipopolysaccharides) and researchers using different species (rats, snails, house crickets) [18, 19, 20] have obtained similar results. It has also been shown that features conducive to mating success, outputs such as sexual dimorphisms (in Chickens: [4]), sexual displays (in Insects: [1]), and sexual competition (in Sparrows: [10]), are often negatively implicated by naturally occurring and experimentally induced immune challenges [3, 10] (see [21] for a discussion of increased sexual attractiveness in immune-challenged male mealworm beetles).

Furthermore, nonhuman research suggests that females may be more likely than males to decrease mating efforts when ill [22]. This is especially true of species in which females, by means of internal offspring gestation, long-term post partum investment in offspring care, and so forth, incur more energetically expensive reproductive costs than males. In such cases, female individuals modulate investment in maintenance and reproduction such that maintenance goals are prioritized and sickness behaviors capable of suppressing mating behaviors (e.g., decreased libido) are more likely to develop [9]. Mammalian support for this hypothesis includes laboratory experiments in which the effects of immune challenge are simulated on equally treated male and female rats, where it has been observed that mating effort is more strongly muted in females than in males [18]. As such, the emergency life history strategy of sick females, because of their high offspring investments, often prioritizes personal health (maintenance) over copulation opportunities (reproduction) because doing so enables reaping long-term reproductive fitness benefits [8].

To our knowledge, however, theoretically-based expectations concerning effects of illness on sexual behavior have not been tested in human females. Lending further support for testing potential impacts of health status on female sexuality several lines of evidence largely amassed by evolutionary psychologists suggests investment in some of the components that make up human female sexuality exhibit facultative adjustments depending upon context and individual attributes. It has been shown that features of human female sexuality vary by age [23, 24], relationship status [25], reproductive status [26, 27], personal physical condition (as measured by self-perceived attractiveness) [28], and psychological condition (as measured by mood, extroversion and/or vitality) [29, 30]. Moreover, a large and still growing body of research suggests that changes in these investments occur in response to variation in hormonal profiles across the ovulatory cycle [31, 32, 33, 34, 35] (readers interested in comparing biosocial and adaptationist perspectives on ovulation-dependent changes in human female sexuality are advised to references [36, 37]). For example, in accordance with fertility-dependent changes on the reproductive playing field, a study on behavior across the ovulatory cycle found that women's graphed illustrations of outfits they would wear to "a social gathering where single attractive peers were likely to be present and opposite sex socializing would take place" were more revealing if drawn by a woman in the follicular phase than by her luteal phase counterpart [32].

In a classic 1976 paper, Frank Beach identified three heuristic behavioral domains of mammalian female sexuality [38]. It is worth mentioning that though these three domains can each be further divided into behavioral and nonbehavioral categories, such distinctions are arbitrary given both forms of expression are not mutually exclusive and rather operate jointly. The first domain, attractivity (here fore after referred to as attractiveness), measures a female's stimulus value in her ability to evoke a sexually appetitive response in males. The second domain, proceptivity, refers to male-directed female actions conducive to sexual interaction (e.g., solicitation behaviors). Lastly, receptivity refers to female reactions to male conspecifics that denote a willingness to engage in sexual activities.

To investigate the potential impacts of health status on human female sexuality, we employed a quasi-experimental research design based on within-subject changes in acute health status. We recruited a sample of women experiencing an acute illness (a respiratory tract infection—or RTI), having them complete a questionnaire containing measures of sexuality (attractivity, receptivity, proceptivity, and sexual desire) and other relevant variables, and subsequently having them complete the same measures when recovered (refer to Table 1 for dependent measures of sexuality). To comprehensively measure female sexuality, we used emotional and behavioral domains. For the emotional domain, we focused on sexual desire because of its role as a central motivational aspect of sexuality and because sexual desire has been implicated in the emergency life history literature as a feature sensitive to downregulation [8]. Moreover and consistent with other research (e.g., [38]), we distinguished attractiveness, proceptivity, and receptivity as behavioral aspects of female sexuality. In light of theoretical and empirical studies of female sexuality, we hypothesized that

Table 1: Dependent measures of sexuality (range 1–5).

	Ill		Recovered	
Dependent measures of sexuality	Mean	STDV	Mean	STDV
Sexual desire	2.20	0.87	3.56	1.10
Present attire	2.46	0.86	3.83	0.91
Facial attractiveness	3.83	0.75	4.16	0.70
Body attractiveness	3.50	1.13	4.03	1.03
Sexiness	3.86	0.94	4.23	0.73
Proceptivity	2.16	2.37	3.76	2.12
Receptivity	3.06	1.36	3.30	1.44

(1) female sexual desire will be lower when sick as opposed to when recovered and (2) sexual desire will be inversely related to the severity of the symptoms experienced during sickness. Furthermore, because the expression of female sexuality is also characterized by behavioral processes, we hypothesized that (3) attractiveness, proceptivity, and receptivity would be lower when women were sick compared to when they were healthy. Lastly, because some findings suggest that partnership status is a central aspect of female sexuality, we hypothesized that (4) partnership status would moderate the effects of health status on sexual desire, attractiveness, proceptivity, and receptivity.

2. Methods

All participants, after receiving both verbal and written information of the methods and procedures for this study, completed an informed consent form approved by the University of Nevada, Las Vegas (UNLV) Office of Research Integrity Institutional Review Board.

Thirty participants were included in this study. Inclusion criteria required subjects be heterosexual women experiencing the symptoms of an acute respiratory tract infection (ARTI) (e.g., cold, influenza, bronchitis, sinusitis, whooping cough, pneumonia, etc.), having cycles free from menstrual irregularities (i.e., with a single menstruation period lasting longer than 21 days but less than 36 days), not be pregnant, and not have a sexually transmitted disease, urinary tract infection, or acute pelvic inflammation. Additionally, women with either a chronic illness or other pre-existing conditions were excluded from the study.

The reason for excluding participants with sexually transmitted diseases, urinary tract infections, acute pelvic inflammation and/or other pre-existing conditions was two-fold: (1) to control for the effect co-occurring diseases could have on the sexuality and symptom severity measures collected and (2) to exclude women with higher than average sociosexualities. Furthermore, participants hormonally distinct from regularly cycling/nonpregnant women were excluded to control for irregular endocrine-immune interactions. Lastly, we purposefully narrowed our sample demographic to heterosexually identifying women because mate preference data for male faces (though not reported here) were collected.

In an attempt to ensure that participants were experiencing ARTIs, recruitment efforts were concentrated on Medical Centers/Clinics. At both the Wellness Center on the UNLV campus and at the University Medical Center in North Las Vegas, female patients with ARTIs were given a flyer with a research team member's contact information if they were interested in participating in the study. Participants not recruited at the Medical Center/Clinic were recruited from the University campus and invited to participate in the study if observed experiencing ARTIs symptomology. Participants completed a six-page questionnaire designed to assess socio-demographic attributes, relationship status, sexuality, symptom severity, and current (if any) hormonally based contraceptive and/or medication. For the follow-up condition, participants had the option of completing the same measures—at least two-weeks later—via an online portal or at the UNLV Evolution and Human Behavior Lab. Partnered participants answered additional questions about their relationship length and relationship quality. Relationship quality was calculated based on answers to three 5-point Likert scale questions about sexual, emotional, and overall satisfaction, with scales anchored by 1 (almost never satisfied) and 5 (always or almost always satisfied).

The sexuality measures obtained from participants applied to four domains: sexual desire, attractiveness, proceptivity, and receptivity. The question assessing sexual desire was drawn from Rosen et al.'s (2000) instrument for the assessment of sexual function (the FSFI) [39]: "in the last 48 hours, how would you rate your level (degree) of sexual desire or interest?" Answers were given on a Likert scale from 1 (none at all) to 5 (very high). Participants were asked to answer—in terms of "how you feel right now"—three, 5-point Likert scale questions about their self-assessed attractiveness: "compared with most women, how attractive is your body to men?", "compared with most women, how attractive is your face to men?", and "compared with most women, how sexy would men say you are?" A composite of these three items was generated as a measure of attractiveness (Cronbach's $\alpha = .845$). Inspired by the methods of Durante et al. [32], women were asked what their likely reaction would be to two hypothetical scenarios to serve as measures of proceptivity ("if in the next 48 h you had the opportunity to attend a party single and attractive men would also attend, how would you likely dress?") and receptivity ("if in the next 48 h you were asked on a dinner date by a single attractive man, how would you likely respond?"). Though for both scenarios participants had the option of selecting a response of "would not attend at all" or "would not agree to the date," the scales we used differed; the first offered six options ranked 0–5, and

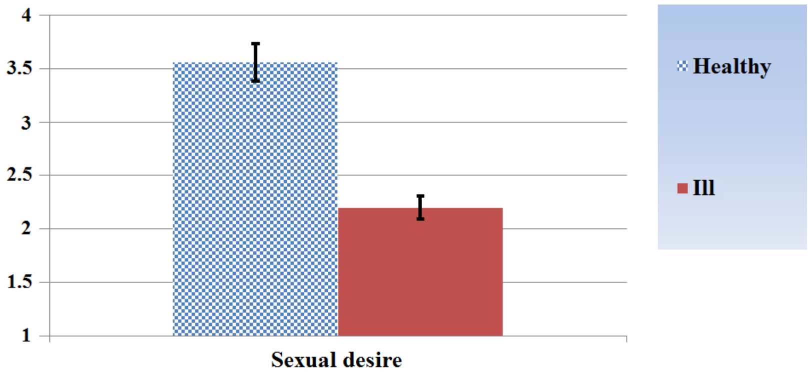

Figure 1: Sexual desire scores ($\mu \pm 95\%$ CI) depending upon women's health status.

the second offered five options, ranked 1–5. Also inspired by Durante et al. [32], women were asked to evaluate the attractiveness of their present attire on a 1–5 scale; this measure could be variously viewed as a measure of attractiveness, receptivity, or proceptivity, but we included it as an additional measure of sexuality.

Lastly, to evaluate symptom severity, we asked participants to (1) identify the overall severity of their symptoms by selecting a score from Wong's 0–10 point picture pain scale [40] and (2) from a list, check-off which of the seven behavioral symptoms (lethargy, loss of appetite, skin sensitivity, decreased libido, abnormal weakness, adipsia [abnormal avoidance of drinking water], and somnolence [abnormal sleepiness]) and nine physical symptoms (nausea, runny nose, sinus congestion, cough, swollen glands, sore throat, vomiting, headache, and diarrhea) they experienced in the last 48 h [9]. A composite number of these sixteen total potential symptoms was generated to serve as the second measure of symptom severity.

Though seemingly not homogenous, the items used to score attractiveness share commonalities. In the present study, we used Cronbach's alpha to assess the degree of interrelatedness among the three questions measuring attractiveness (perceived: facial attractiveness, body attractiveness, and overall sexiness). After confirming a high degree of internal consistency from the values of the items appraising attractiveness during the sick condition (Cronbach's $\alpha = .845$) and recovered condition (Cronbach's $\alpha = .762$) a summed attractiveness composite was used in our analyses. The main focus of the present study was on female context-specific sexuality, with "sick/healthy" being the dichotomized independent predictor of dependent measures of sexuality. As such, most of our analyses used a two-factor repeated-measures ANOVA to compare differences between conditions. We considered female age as a possible covariate but because women were of similar ages we did not adjust for age in the analyses presented. Correlations relied upon Pearson's coefficient. Two-tailed tests were employed, and alpha was set at .05.

3. Results

The sociodemographic profile of this sample represents a young adult and predominantly university undergraduate sample of women. The average age of the 30 women in the sample was 23 (SD = 1.4) y. The ethnic background of the sample consisted of 15 Caucasian, 4 Asian American, 5 Hispanic, 5 African American, and a woman of one "other" ethnicity. Nineteen of the 30 participants in the study were in a relationship. The average relationship length reported by partnered participants was 37.4 (SD = 30.6) m. Average sexual (mean = 4.5, SD = 0.6), emotional (mean = 4.5, SD = 0.6), and overall (mean = 4.6, SD = 0.7) relationship satisfaction scores at baseline among partnered women were all high, and scores did not differ (all $P > .172$) between sick and healthy conditions. Two of the women had children. Fifty-two percent of partnered women reported a contraceptive use as opposed to 33% of single participants.

3.1. Hypothesis 1

To compare human female sexual desire between conditions, repeated-measures ANOVA (independent variable: health status; dependent variable: sexual desire experienced during the last 48 y) was employed. As hypothesized, women's sexual desire differed depending upon whether they were sick or healthy ($F_{1,29} = 77.50$, $P < .0005$). These differences are displayed in Figure 1 (error bars were set at the 95% confidence interval). Women had markedly lower sexual desire when sick compared to when healthy. As a measure of effect size, the partial $\acute{\eta}^2$ was .728.

3.2. Hypothesis 2

Symptom severity was expected to be inversely related to sexual desire during the time when women were sick. We used a two-tailed Pearson bivariate correlation analysis to test this relationship. We found that during the sick condition, pain rating score was unrelated to sexual desire ($r = -.144$, $P = .447$).

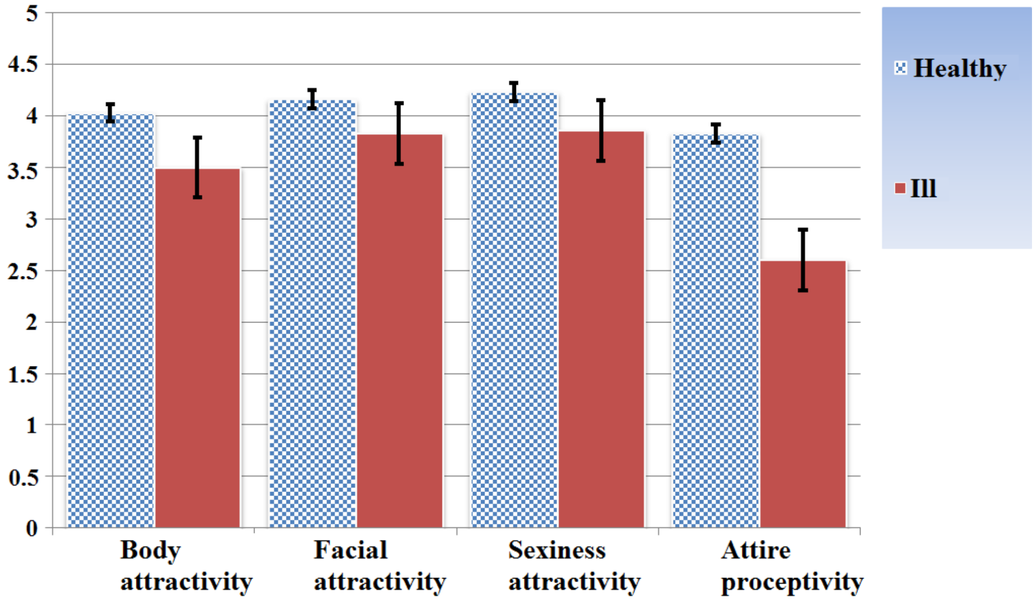

Figure 2: Differences in Attractivity and Proceptivity ($\mu \pm 95\%$ CI) depending upon women's health status.

3.3. Hypothesis 3

We received partial support for the hypothesis that women's attractivity, proceptivity, and receptivity would be lower during illness compared to when recovered. Effects were analyzed each by means of repeated-measures ANOVA (independent variable: health status, dependent variable: attractiveness, proceptivity, and receptivity). The attractiveness domain reached statistical significance. Analysis revealed that the composite measure of attractiveness differed by women's condition (sick/recovered) ($F_{1,29} = 52.17$, $P < .0005$). Each of the domains of attractiveness (face, body, and overall sexiness) also differed by women's sick/recovered condition. These differences in domain-specific and overall attractiveness are displayed in Figure 2 (error bars set at the 95% confidence interval), showing that women reported lower attractiveness when sick compared to when healthy. As a measure of effect size, the partial $\acute{\eta}^2$ was .643 for condition-dependent differences in women's composite measure of attractiveness.

As a measure of proceptivity, we asked how a woman would dress if given the opportunity to attend a party that attractive men would also attend. Women reported differences on this measure depending upon health status ($F_{1,29} = 11.41$, $P = .002$). Women indicated they would dress more attractively when healthy, with partial $\acute{\eta}^2 = .282$ as a measure of the effect size in this contrast.

As a measure of receptivity, we asked how a woman would respond if asked on a dinner date by a single attractive man. Women's responses to this measure of receptivity did not differ by health status ($F_{1,29} = 1.61$, $P = .214$). As an additional measure of sexuality, women's evaluation of their present attire differed depending upon health status ($F_{1,29} = 43.96$, $P > .0005$), with $\acute{\eta}^2 = .603$.

3.4. Hypothesis 4

To test for potential interactions between relationship status and dependent measures of sexuality (i.e., sexual desire, attractiveness, proceptivity, and receptivity), we used relationship status as a between-subjects factor in repeated-measures ANOVA. However, no significant interactions were found, with receptivity the only measure emerging as a trend (all $P > .085$).

4. Discussion

This study was designed to test for effects of acute change in health status on human female sexuality. The study employed a powerful within-subject design, with women answering the same items concerning sexuality approximately two weeks apart between sick and recovered states. Women reported lower sexual desire, attractiveness, and proceptivity when ill compared to the healthy condition, with no differences reported for the measure of receptivity. There was no relationship between symptom severity and sexual desire during illness, nor were there any interaction effects between relationship status and health status upon dependent measures. Additionally, it is worthwhile noting that although variation existed both within and between subjects, with respect to menstrual cycle phase and contraceptive use, this study marks the first time researchers have explicitly articulated and measured the condition-dependent importance of health status as a meaningful determinant of women's sexual desire and other classically defined aspects of sexuality (attractivity, proceptivity, and receptivity). The effect sizes for differences in sexual desire, attractiveness, and proceptivity were large. The large effect sizes mean that much of the variation in these measures of sexuality reflects differences in health status. This study adds to a growing body of research theorizing and measuring female sexuality in a wider life history perspective.

One central question is how to interpret differences in female sexuality depending on health status. A conservative approach would see these differences as indicative of behavioral plasticity, while leaving open the question of whether these differences are adaptive. It could be argued that downregulation of female sexuality during an illness state is an adaptive means of conserving energy to enhance maintenance functions and regain health. It could also be argued that women's downregulated sexuality during illness is a byproduct of fighting off the potentially deleterious effects of infectious disease. It will take more experimental research, with both humans and nonhuman animals, to better distinguish such alternative interpretations of this measurable plasticity. In a related vein, whether such differences represent fundamental life history allocation tradeoffs remains an open question. It is not clear whether acutely downregulating some measures of female sexuality during illness could have meaningful impacts on long-term reproductive fitness, as a potential maintenance versus reproductive effort tradeoff would entail. The findings can be viewed as consistent with modeling of "emergency life history phases" in which survival and maintenance is prioritized in the face of acute challenges [8].

4.1. Areas of future research

Several features of the sample warrant commentary when placing the findings in wider contexts. Women in the study consisted of a young adult, largely childless, and ethnically diverse university sample. A slight majority of women were in relationships. Viewed across a life course, these are women who are likely facing heightened importance of finding and testing potential romantic partners in an arena in which partners are readily available. This could mean that potential differences in women's sexuality depending on health status are more magnified compared with other ages and reproductive states (e.g., older women, in relationships of longer duration, and with children, might experience less pronounced shifts in proceptivity depending on health status). This would be worthy of future study. Furthermore, findings from this study are obviously restricted to women. Whether men experience the same kinds of shifts in sexuality would also be worthy of study, since life history theory could point to sex-specific allocation challenges depending upon health condition. Additionally, this sample falls within the pool of what Henrich et al. [41] called WEIRD populations (i.e., Western, educated, industrialized, rich, and democratic). It would be worthwhile to test similar shifts in samples of variable sociocultural milieus.

The focus on acute respiratory tract infections (ARTIs) also merits attention. Such a focus has several advantages in the present study: this category of ailments is relatively common and thus ecologically relevant, and it is associated with acute impacts on health status. ARTIs are also common global ailments, as data from the World Health Organization [42] indicate. From an evolutionary perspective, however, it could be noted that many of the pathogens contributing to ARTIs in this and other global samples have emerged relatively recently (e.g., strains of the flu), in association with humans living in larger communities and acquiring pathogens from domesticated animals [43].

Moreover, research on ecologies conducive to disease transmission would nicely contribute to the literature. Much regarding pathogen-host coevolution remains unknown. However, studies on vertebrates suggest that pathogens manipulate a host behavior in a variety of ways [44]. Furthermore, we know very little about the role sickness symptoms play in mediating disease, despite such interactions carrying serious implications for the study of public health. Future research should investigate which symptoms benefit the fitness of the pathogen (e.g., via increased opportunities for communicability [45]), or benefit the host.

4.2. Limitations

The study is subject to limitations. One is the sample size of 30 women. The sample size results in lower power, which could be relevant to null findings with respect to putative interaction effects between female relationship status and health status on sexual measures. As an example, a larger sample might reveal a significant interaction of these variables on women's receptivity. Another limitation is the self-report measures of symptom severity and sexuality; with both respectively benefiting from a more sensitive method capable of objective classification and/or more rigorous assessment of proceptivity and receptivity. For example, methods based upon partner reports, biometric measurements, eye tracking [46], or experimental social interaction [47] could serve as additional methodological enhancements. More objective measures of attractiveness can facilitate discussion whether down-regulated perceptions of attractiveness during illness are due to physiological byproducts of the disease (e.g., increased pallor) or are more psychological in nature.

Moreover, although less than half of our sample (36%) followed up via online portal, it is possible that this disparity could give rise to systemic bias in responses, such as those following up online reporting artificially inflated/deflated sexuality scores. This could most apply to questions concerning participants' evaluation of present attire attractiveness. Evaluations of such conditions, which arguably are context sensitive (e.g., women “staying in” might dress differently than women “going out”), can be problematic under these circumstances and can warrant further analysis. That said, in the present study, the large effect size obtained for this type of variable suggests that methodological sampling differences did not decidedly affect the measures for which significance was achieved. Given the contextually sensitive nature of human female sexuality, future studies would benefit from considering the potentially adverse effects of both disparate follow-up methodologies and online sampling.

Lastly, although there is precedence in the human immunity literature [11] and clear benefits to using a within-subjects quasi-experimental design, an inherent feature of this methodology is the problem of order effects by means of participant-acclimation to the repeated-measures sampling regime. It is possible that the opportunistic nature of recruitment, with women always sampled first while sick and second when recovered, adversely influenced the nature of the second sampling, causing women to report lower sociosexuality at time of first/second sampling. However, women did not report significantly lower scores for all domains of sexuality (e.g., receptivity), suggesting that participant responses cannot be accounted fully by order effects. Regardless, future studies would benefit from employing either a counterbalance design, with varying orders of health conditions sampled, or by including a control group composed of healthy participants sampled at the same time interval/with the same frequency.

5. Conclusion

In summary, we tested the effects of acute changes in health status on human female sexuality, employing a within-subject quasi-experimental design. Women reported markedly lower sexual desire and measures of attractiveness and proceptivity, but no differences in receptivity, when sick with an acute respiratory tract infection compared with a recovered condition. These differences in health status-related sexuality can be situated within a wider interdisciplinary life history and ecological immunity frameworks as well as within existing literature on human female sexuality. Human female life history allocations appear to downregulate central features of sexuality when facing an acute illness, a further evidence of the contingent nature of female sexuality.

Conflict of interest The authors declare that they have no conflict of interest.

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