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Impact of COVID-19 Related Stress on Sexual Desire and Behavior in a Canadian Sample

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ABSTRACT

Objectives: We evaluated various facets of sexual health in Canadians across phases of the COVID-19 pandemic. *Methods:* Online questionnaires every four weeks from April–August 2020. *Results:* Higher COVID-19 stress predicted higher baseline dyadic sexual desire, lower relationship satisfaction, higher desire for solitary sexual behavior, and higher likelihood of experiencing sexual coercion among people with a live-in romantic partner. Dyadic sexual desire and pandemic-related stress both decreased with time, whereas solitary sexual behavior decreased and dyadic sexual behavior increased among participants without a live-in romantic partner. *Conclusions:* Our findings reveal differential impacts of COVID-19 related stress on sexual outcomes.

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When the World Health Organization declared COVID-19 a global pandemic on March 11, 2020, people's lives changed abruptly, and, in ways that would not be known to them for months to come (Boyraz & Legros, 2020). The lasting impact of COVID-19 is yet to be determined (World Health Organization, 2020) but is being actively monitored. When public health measures immediately tightened in March 2020 to limit travel and face-to-face social interaction, there was speculation that increased time spent together among couples would translate into increased sexual activity. There was even considerable media speculation of a baby boom in late 2020. This then launched several research groups to empirically evaluate this question and served as the basis for our current study goal to gather longitudinal data from a cohort of Canadians throughout the phases of the pandemic where social distancing measures were progressively relaxed.

In Canada, federal and provincial health orders initially restricted all forms of travel and contact, with only essential services remaining open as of mid-March 2020. Changes in those provincial health orders were under the jurisdiction of each individual province, and there were some differences in the speed and process of relaxing public health guidelines across Canada. Overall, however, all provinces moved from the highest levels of lockdown to a progressive loosening of restrictions until approximately September 2020. Like other countries around the world, there has been much interest from the Canadian government in how its citizens were coping throughout (Statistics Canada, 2020).

Soon after the COVID-19 lockdown, there were several studies launched to examine the impact of the pandemic on sexual health. One Chinese study that collected data from over 550 individuals in March 2020 revealed reductions in sexual frequency (37%), desire (25%), and satisfaction (39% of men and 32% of women) (Li et al., 2020). Notably, 32% of men and 18% of women planned to increase their number of sexual partners or engagement in risky sexual behaviors once lockdown measures were lifted (Li et al., 2020). These findings highlight deteriorations in sexual health for a sizable minority of individuals, and a possible increase in risky sexual

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activity once social distancing policies were lifted. Conversely, another study carried out early in the pandemic with a focus on 120 married men and women from Southeast Asia revealed minimal changes in sexual frequency, with 50% of the sample reporting positive changes in their emotional bonding with partners in response to social distancing (Arafat et al., 2020). Of note, however, the study was restricted to those married and living with their partner, which was a limitation, and neither study examined the impact of psychological variables on these outcomes.

A more recent study of 1,559 American adults recruited via social media and led by the Kinsey Institute was focused on changes in sexual activity, and also the types of new sexual activities reported. They found that over half of their sample reported reductions in partnered sexual activities, including mutual masturbation, giving oral sex, receiving oral sex, vaginal intercourse, and anal intercourse (Lehmiller et al., 2021). A total of 43.5% also reported a decline in the quality of their sex lives, and this was moderately related to increasing rates of loneliness. In contrast to hypotheses, these changes were not related to gender or age. Of interest, 20.3% of respondents reported making a new addition to their sex life, the most common example being trying new sexual positions and sharing sexual fantasies with a partner. Perhaps surprisingly, stress and loneliness were associated with trying new sexual activities, pointing to the possibility that these activities were means of coping with stress.

It is likely that any impact of public health measures on sexual behavior and function may be related to underlying levels of personal stress. Past pandemics (e.g., SARS) have illustrated the effects of quarantine on psychological stress, including impacts on trauma symptoms and depression (Hawryluck et al., 2004). Data on mental health of 3,000 Canadians (mean age 49.1 years) in the first wave of the COVID-19 pandemic revealed significant effects on mental health that differed by gender, sexual orientation, household income, ethnicity, and disability status (Jenkins et al., 2021). Nearly 40% reported a deterioration in their mental health since the onset of the pandemic, with women being more likely to self-report impacts than men (44% vs

32%, respectively). Results showed significant rates of anxiety and worry (46% of those sampled), boredom (39.4%), loneliness and isolation (30.5%), and sadness (26.8%) (Jenkins et al., 2021). Participants also indicated that being concerned over contracting the virus was a major source of their stress. Other sources of stress included finances, job loss, experiencing physical or emotional domestic violence, and all of these were most prominent among those with preexisting mental health issues (Jenkins et al., 2021). Another nationally representative study of 1,800 Canadians reported an increase in participants' self-reported anxiety as being very high, from 5% before COVID-19 to 20% during the pandemic (Dozois, 2020). Alarmingly, depression rates more than doubled from pre-pandemic (4%) to during the pandemic (10%) with participants predicting further escalations in their depressive symptoms if isolation continued.

Given that daily stress is found to be highly associated with, and negatively predicts, sexual activity and satisfaction (Bodenmann et al., 2010), it is important that stress be evaluated in the context of COVID-19 related changes to sexual behavior and desire. It is also possible that stress has the opposite effect on facets of sexuality given evidence that sexually active individuals during the pandemic reported lower rates of depression and anxiety, leading the authors to speculate that sexual activity might have been used to manage these psychological symptoms (Mollaioli et al., 2021).

The extent to which sexual activity between couples during the pandemic is wanted versus unwanted deserves further exploration. It is also possible that some individuals may be engaging in consensual but unwanted sexual activity as a means of reducing the known relationship conflict that was exacerbated by the pandemic (Luetke et al., 2020). Consensual but unwanted sexual activity is known as sexual compliance and may serve to benefit a relationship by maintaining harmony (Vannier & O'Sullivan, 2010). Half of committed young adults aged 21-30 report engaging in sexual compliance (O'Sullivan & Allgeier, 1998) and that rate may be higher among older adults, and those with low sexual desire (Vannier & O'Sullivan, 2010). Since rates

of intimate partner violence have been repeatedly documented to have increased with COVID-19 (Jetelina et al., 2021; Muldoon et al., 2021) consistent with the data from past pandemics, and since gender-based violence increases during times of stress (Gormley & Lopez, 2010), it is important that low sexual desire and sexual compliance be carefully distinguished from unwanted and non-consensual activity that would be occurring in the context of intimate-partner violence. Furthermore, the extent to which having a live-in romantic partner, versus a partner who does not live with an individual, has not been adequately taken into consideration. Few studies have sought to disentangle these factors in general, and none (that we are aware of) in the current climate of the COVID-19 pandemic.

Current study

Though there have been several studies on COVID-19 and sexual health from around the world-Turkey (Karagöz et al., 2020), Spain (Ballester-Arnal et al., 2020), Italy (De Rose et al., 2021), and Australia (Coombe et al., 2020) as examples, data are needed on the impacts of the pandemic on couples' sexual desire, sexual behavior, sexual compliance, and experiences of sexual coercion separately. We examined the relationship between COVID-19 related stress and these parameters of sexuality during the early stages of the pandemic, when lockdown measures were at their strictest, and we predicted a negative effect of stress on these sexual outcomes, including higher rates of sexual coercion associated with stress. Additionally, we evaluated a potential moderating impact of the presence versus absence of a live-in romantic partner on these associations, and because relationship satisfaction might be impacted in different ways than these sexual outcomes, we examined relationship satisfaction over the various phases of the pandemic. We examined the patterns of these sexual outcomes over the course of four time points as Canadian public health restrictions on social interactions progressively loosened. We predicted that dyadic sexual desire and sexual behaviors, as well as relationship satisfaction would increase over the assessment points as pandemic controls began to lift. We treated the effects of the pandemic phases on solitary sexual desire, solitary sexual behaviors, sexual compliance, and sexual coercion as exploratory analyses. Finally, because whether a partner is living with an individual or not might impact these facets of sexual health, we used live-in partner status as a moderating variable.

Materials and methods

Participants

Participants were recruited online through social media advertisements that read, "How has COVID-19 affected your sexuality?" and invited individuals to "participate in an online survey examining the short- and long-term impacts of COVID-19 on social, psychological, and behavioral aspects of sexual health." These (unpaid) advertisements were posted on the research team's Twitter and Instagram accounts, and one of the co-author's accounts was used to post on a wide array of Facebook pages and groups (400+) specific to geographical communities across Canada (e.g., local marketplace/trading, local universities, sexual news, health clinics. LGBTQ2SA + organizations). Of note, prior to posting on Facebook groups the group administrator was contacted, the purpose of the study was explained, and they approved the advertisement.

To be eligible participants must have been 19 years old or older; able to read and write in English fluently, and reside in Canada during the time of the study. Of 1,452 individuals who expressed an interest by clicking on the survey link, a total of n = 1,342 provided consent to participate and n = 1,075 initiated the questionnaire. To ensure only valid data were analyzed, participants were excluded from analyses if they met one of the following criteria, which was informed by previous findings on conducting online research (Teitcher et al., 2015): (1) a Recaptcha score of less than 0.5, which indicated that responses were likely not human but rather robot or "bot" responses; (2) provided inconsistent responses to items that were asked more than once throughout the questionnaire (i.e., itemspertaining to age and relationship status); or (3) duplicate responses were identified by duplicate email addresses. This process led to n = 56responses being removed for the following reasons: having a Recaptcha score below 0.5 (n = 45), inconsistent responses to items pertaining to age and relationship status (n = 7), duplicate responses (n=3), and to disclosing they did not reside in Canada (n=1). Our final sample size after removing invalid responses was n = 1,019, and of this, n = 761 (74.7%) completed the entire questionnaire. This number satisfied our power requirements according to which we aimed to recruit 600 people to assure 95% power to find small size effects in multivariate regression at alpha = .01

Procedure

Interested candidates were taken to the study consent form via an anonymous Qualtrics Survey URL link provided on the online study advertisements. After indicating that they had read and understood the study procedures, met eligibility criteria, and agreed to participate, participants were directed to the online questionnaire package, which included demographic questions, COVID-19 health status and related stress, frequency of sexual behaviors, sexual desire, sexual compliance, and sexual coercion in relationships. At the end of the baseline questionnaire package, participants were asked to provide their email address to be entered into a draw for the monthly prize as well as to be contacted for follow-up questionnaires. Every four weeks participants received an individualized Qualtrics Survey URL link, assessing the same measures. The four time points of data collection corresponded to: time 1 (T1; April-May 2020), time 2 (T2; May-June 2020), time 3 (T3; June-July 2020), and time 4 (T4; July-August 2020). Of note, pandemic measures loosened in many Canadian provinces in June 2020, with further allowance for social contact in July and August 2020, before pandemic control measures tightened again during the second wave of the pandemic which hit Canada in the Fall of 2020.

All study procedures were approved by the Behavioral Research Ethics Board at the

University of British Columbia and all participants provided e-consent to participate.

Measures

Demographics

The following demographic variables were assessed: ethnicity, age, education, employment, income, gender identity, sexual and romantic orientation, religious affiliation, relationship status, current living situation, province/territory of residence, current health status, medication use, sexual history including history of unwanted sexual contact and relationship status.

Sexual desire

The Sexual Desire Inventory (SDI-2; Spector et al., 1996) was administered at all timepoints. The SDI-2 is a 14-item measure that assesses frequency and strength of solitary and dyadic sexual desire. The SDI-2 has strong internal consistency for both the Dyadic scale ($\alpha = .86$) and the Solitary scale ($\alpha = .96$) and a test-retest reliability of r = .76 over a one-month period (Spector et al., 1996). In our sample, we found Cronbach's α to be very good for the solitary ($\alpha = 0.86$) and the dyadic ($\alpha = 0.86$) subscales. The dyadic subscale was computed as a sum total of items 1-8 and the solitary subscale was computed as a total of items 10-12. As recommended by the authors of the scale, items 9, 13, and 14 were not included because they do not quantify desire (Spector et al., 1996).

Frequency of sexual behaviors

We used an investigator-developed measure of sexual behavior frequency at each time point. Two items assessed the frequency of solitary (i.e., how many times did you engage in sexual activity alone—solitary sexual activity, solo masturbation)) and partnered (i.e., how many times did you engage in in-person sexual activity with a partner—partnered or dyadic sexual activity) sexual behavior within the last month. Participants answered using a 7-point scale with the following response options: (0) not at all; (1) once; (2) a few times a week—less than 4; (3) about once a week; (4) 2–3 times a week; (5) almost every day; (6) more than once a day.

Sexual compliance

We adapted Vannier and O'Sullivan's (2010) measure of sexual compliance, which was originally developed for their daily diaries study, for use in this study. The measure asked the following aspects of the most recent sexual encounter: type of sexual activity, who initiated activity, degree of wanting to engage, perception of partner wanting to engage, pressure to engage, and who controlled pace of encounter. For this study, we only used the question about wanting to engage (How much did you want to engage in sexual activity at that time?) scored on a 7-point scale from 1 (*not at all*) to 7 (*very much*). Higher scores indicated lower compliance.

Sexual coercion

The prevalence and severity of sexual coercion in intimate relationships was assessed at all timepoints with the 34-item Sexual Coercion in Intimate Relationship Scale (SCIRS; Goetz & Shackelford, 2010). The SCIRS assesses a partner's psychological and behavioral tactics within the past month on a scale from 0 (act did not occur in the past month) to 5 (act occurred 11 or more times in the past month). Items ask about coercive psychological and behavioral tactics ranging from subtle manipulation to overt threats or use of violence. We only used the SCIRS full scale sum score where higher scores indicated higher levels of coercion. The SCIRS was originally specific to assessing heterosexual contexts of female respondents reporting male partner behaviors (i.e., used "he/him" pronouns in items). Items were adapted to excluded gendered language (e.g., "My partner hinted that they would withhold benefits that I depend on if I did not have sex with them."). Cronbach's alpha for our sample was .95.

Relationship satisfaction

Participants' relationship satisfaction was measured by *The Relationship Assessment Scale* (RAS; Hendrick et al. 1998). It is a brief measure of global relationship satisfaction consisting of seven items, each rated on a Likert scale ranging from 1 to 5. It is suitable for use with individuals who are in an intimate relationship, such as married couples, cohabiting couples, engaged couples, or dating couples. The brevity of the scale increases its utility in clinical settings and for online administration. Research has shown the scale to be correlated with other measures of love, sexual attitudes, self-disclosure, commitment, and investment in a relationship (Hendrick et al. 1998). The mean of the seven items is computed as a summary measure and ranges from 1 to 5. Cronbach's alpha for our sample was 0.89.

COVID-19-related stress

At the time of this study, there was no validated measure of COVID-19 related stress so we created one to use in this study. We adapted items from the COVID Stress Scales that were at the time in development by Taylor et al. (2020). Items asked about the degree to which the respondent worried about the impact of the pandemic on a number of factors such as own physical health, health of loved one, and financial impacts, rated on a 7-point scale from 1 (*not at all worried*) to 7 (*very much worried*), with total scores denoting higher rates of COVID-related stress. Cronbach's alpha for our sample was 0.71.

Live-in partner status

Participants were asked to indicate with a yes/no answer whether they lived with their romantic partner(s).

Data analysis

Differences in baseline COVID-19-related stress were compared by sex, gender, age, ethnicity, sexual orientation, and socioeconomic status. Next. the relationship between COVID-19 stress and all sexuality outcomes and relationship satisfaction at time 1 were examined. Hierarchical regressions were used to determine to what extent COVID-19-related stress predicted baseline sexual desire, frequency of sexbehaviors. sexual compliance, sexual ual coercion, and relationship satisfaction while controlling for relevant baseline demographic variables. A Linear Mixed Model with random intercept approach was used to examine changes in sexuality outcomes and in COVID related stress across four time points.

	Frequencies	
Demographic variables	n (%)	Mean COVID-19 related stress scores
Education ^a		
Attended some high school	12 (1.2)	4.42
Graduated high school	69 (6.8)	4.28
Attended some college	222 (21.8)	4.04
Graduated 2-year college	114 (11.2)	4.08
Graduated 4-year college	323 (31.7)	4.04
Post-graduate degree	265 (26.0)	3.73
Income ^a		
Less than \$20,000	171 (16.8)	4.19
\$20,000-\$39,999	173 (17.0)	4.19
\$40,000-\$59,999	148 (14.5)	4.11
\$60,000-\$79,999	130 (12.8)	3.76
\$80,000–\$99,999	98 (9.6)	3.79
\$100,000-\$119,999	72 (7.1)	3.94
\$120,000-\$139,999	40 (3.9)	3.89
\$140,000-\$159,999	36 (3.5)	3.71
\$160,000-\$179,000	19 (1.9)	3.74
\$180,000-\$199,000	18 (1.8)	3.60
\$200,000-\$219,999	15 (1.5)	3.80
\$220,000-\$239,999	8 (.8)	3.57
\$240,000-\$259,999	6 (.6)	4.40
\$260,000-\$279,000	6 (.6)	3.72
\$280,000-\$299,000	2 (.2)	3.60
More than \$300,000	24 (2.4)	3.21
Prefer not to answer	53 (5.2)	-
Natal sex		
Male	288 (28.3)	3.87
Female	721 (70.8)	4.03
Prefer not to answer	10 (1.0)	
Gender identity		
Man	289 (28.4)	3.91
Woman	647 (63.5)	4.00
Non-binary	74 (7.3)	4.08
Prefer not to answer	9 (.9)	-
Sexual orientation		
Heterosexual	533 (52.3)	3.92
Gay/Lesbian	129 (12.7)	3.87
Other	340 (33.4)	4.11
Prefer not to answer	17 (1.7)	-
Ethnicity ^a		
White	710 (69.7)	3.90
Person of Color	299 (29.3)	4.17
Relationship		
Single	320 (31.4)	4.01
In relationship	699 (68.6)	3.93
Living situation		
Live-in romantic partner	374 (36.7)	4.01
No live-in romantic partner	645 (63.3)	3.97

Table 1. Participant characteristics at baseline (column 2) and mean COVID-19 related stress scores for participant subgroups (column 3).

Note. "Prefer not to answer" responses were treated as missing values and thus category totals may be less than n = 1,019 participants who consented to participate.

^aStatistically significant association with COVID-19 related stress. Detailed statistics are presented in the Results section of the paper.

Regarding missing data, listwise deletion was used because T1 data had a very small proportion of missing values. For longitudinal analyses, using multilevel modeling analyses with full-information maximum likelihood estimation allowed for all time points of data to be used in the analyses and this method is considered one of the best approaches to missing data (Schafer & Graham, 2002).

Results

Sample description

The mean age of the participants was 30.23 years (SD = 9.90) and ranged from 19 to 81. Most of the participants (92%) reported attending at least some college with 57% having a graduate or post-graduate degree (see Table 1, column 2, for detailed descriptives). The majority of

participants worked either full time (43%) or part time (20%). Most people in the remaining group reported being a student or being unemployed, with small numbers in other employment categories, e.g., on disability or stay-at-home parent. Half of the participants reported an income below \$60,000 CAD (Table 1, column 2). Regarding ethnicity, 70% identified as White, 7% as Chinese, 3.6% as South Asian, and 3.4% as Indigenous. All other ethnic groups were each represented by less than 3% of the participants. The majority of participants reported no religious affiliation (67%) followed by Christian Protestant and Catholic (10% in each) and Jewish (3%). The rest of the religious affiliations (e.g., Buddhist, Pagan, etc.) were reported by fewer than 2 percent of the sample. In terms of geographic location. all provinces and territories were represented with most participants coming from British Columbia (35.5%), Ontario (19.4%), Quebec (13.2%) and Alberta (9%). The percentages of participants from other parts of Canada ranged from 0.7% (Prince Edward Island) to 6.5% (Yukon).

In terms of gender and sexual orientation, most of our participants identified as women, and as heterosexual. Detailed proportions of natal sex, gender identity, and sexual orientation categories are presented in Table 1. In terms of romantic orientation, 60% of those identifying as men reported being exclusively or predominantly attracted to women whereas 30% reported exclusive or predominant romantic attraction to men. Among those identifying as women, 70% were exclusively or predominantly attracted to men and 7% were exclusively or predominantly attracted to women. Among gender non-binary participants (n = 74), 40% reported being exclusively or predominantly attracted to women, 23% equally attracted to women and men, and 20% exclusively or predominantly attracted to men. Thirty one percent of the respondents said they were single. Among those in some form of relationship, 15% reported dating and 38% married or in common law relationship. Overall, 37% reported living with a partner.

In terms of health, 24% of participants reported having a current medical condition and 51% reported taking prescription or non-prescription medication (including hormone supplements). Current sexual difficulties were reported by 15% of the sample, with 4% being treated for sexual dysfunction. Over half of the participants (54%) reported experiencing non-consensual sexual contact, with 24% of those participants experiencing non-consensual sexual contact in childhood, and 53% of those participants indicating non-consensual experiences in adulthood, while 23% indicated experiences in both childhood and adulthood. Sixty-nine percent of participants reported to be in some kind of romantic relationship while 37% reported living with a romantic partner (Table 1).

COVID-19 related stress and demographic variables at baseline

Mean values of COVID-19 related stress were compared for a selection of demographic variables (based on existing literature and the goals of this study) and are presented in Table 1 (column 3). Pandemic-related stress was not related to either age of participants (Pearson r = -.034. p = .299) or to participant gender (F = 0.641, p =.527) or to participant natal sex (t = -1.702, p =.089). Sexual orientation was also not related to stress (F = 2.882, p = .057) and neither was participants' relationship status (t = -1.452, p =.147). Regarding socioeconomic variables, higher education and higher income were associated with lower COVID-19 related stress (Spearman r= -.117, p <.001 and r = -.151, p <.001, respectively). In terms of ethnicity, we grouped participants into White and people of color (POC) and found that participants who identified as POC reported higher stress levels than White participants (t = -3.109, p = .002).

Sexuality and relationship variables at baseline

Mean levels of solitary and dyadic desire, solitary and dyadic sexual activity, sexual compliance, and sexual coercion are presented in Table 2. At baseline, scores on solitary desire, dyadic desire, and solitary sexual activity were all in the moderate range of their scales, respectively. Dyadic sexual activity at baseline was on the lower end of the scale range, sexual compliance was on the **Table 2.** Baseline levels of solitary and dyadic sexual desire, solitary and dyadic sexual behavior, sexual compliance, sexual coercion, relationship satisfaction and COVID-19 related stress for the entire sample (n = 1,019) and scale ranges.

Sexuality variables	Mean SD	Reference scale range
Solitary sexual desire	12.66 (5.97)	0–23
Dyadic sexual desire	38.19 (11.72)	0–62
Solitary sexual activity	3.29 (1.65)	0–6
Dyadic sexual activity	1.79 (1.75)	0–6
Sexual compliance ^a	5.78 (1.48)	1–7
Sexual coercion	1.58 (5.77)	0-170
Relationship satisfaction	4.15 (0.75)	1–5
COVID-19 related stress	3.98 (1.24)	1–7

^aHigher scores indicate lower levels of sexual compliance.

higher end of the scale range (higher scores indicate less compliance), and reports of sexual coercion were very low. Participants' scores on the measure of relationship satisfaction were in the high range.

COVID-19 related stress predicting sexual outcomes at baseline

COVID-19 related stress and its interaction with live-in partner status were examined as a predictor of relationship satisfaction and sexual outcomes (i.e., solitary sexual desire, dyadic sexual desire, solitary sexual behavior frequency, dyadic sexual behavior frequency, sexual compliance, and sexual coercion) at baseline (T1) in a series of hierarchical regression models with control variables entered at step 1, COVID-related stress and live-in partner status added at step 2, and interaction term added at the step 3. Demographic variables that were either marginally or significantly related to the level of COVID-19 stress were included in each regression model as controls (ethnicity, sex, education, income, and sexual orientation). Detailed statistics are reported in Table 3.

In terms of control variables, education and ethnicity did not predict any of the sexual outcomes. Income was associated only with the frequency of solitary sexual behavior (higher income predicted lower solitary sexual frequency). Males scored higher than females on solitary and dyadic sexual desire, on frequency of solitary sexual behavior, and they scored lower than females on sexual compliance (indicating that, as expected, females are more likely to experience consensual but unwanted sex than males). There was no difference between males and females on frequency of dyadic sexual behavior. In terms of sexual orientation, lesbian/gay participants and those categorized as other reported higher solitary desire and higher frequency of solitary sexual behavior than heterosexual participants. Lesbian/ gay participants, however, reported less frequent dyadic sexual behavior than heterosexuals.

In terms of the main effects, higher COVID-19 related stress predicted, above and beyond the control variables (ethnicity, sex, education, income, and sexual orientation) higher dyadic desire, higher level of experienced sexual coercion, and lower relationship satisfaction. Having a live-in romantic partner predicted lower solitary and dyadic sexual desire, lower frequency of solitary and higher frequency of dyadic sexual behavior, and higher sexual compliance as compared to not having a live-in partner.

For solitary desire and coercion, the main effects were qualified by a significant interaction of stress and live-in partner status. Higher stress was associated with higher desire for solitary sex for people with a live-in partner but there was no such association for people without a live-in partner (simple effects: b = .70, p = .006 and b = .03, p = .898, respectively). Higher stress was also associated with higher experience of sexual coercion for people with a live-in partner but there was no such association for people with a live-in partner but there was no such association for people without a live-in partner but there was no such association for people without a live-in partner (simple effects: b = 1.15, p < .001 and b = -.30, p = .407, respectively).

Longitudinal fluctuations in sexual outcomes and COVID-19 related stress

Seven linear mixed models with random intercepts, and time as a categorical variable were conducted to examine changes in sexual outcomes and pandemic related stress across the four assessment points (baseline T1; and three monthly intervals; T2, T3, T4). The potential moderating effect of live-in partner status was also examined by adding it and its interaction with time to each model. Detailed statistics are reported in Table 4.

There was no significant effect of time on solitary sexual desire, sexual compliance, and experience of sexual coercion. Compared to T1, dyadic

			-				
			SBF				
	SDI	SDI	solitary	SBF	Sexual		RAS relationship
	solitary desire	dyadic desire	behaviors	dyadic behaviors	compliance ^a	Sexual coercion	satisfaction
Model with control variables only	r ² =	$r^{2} =$	$r^{2} =$	r ² =	r ² =	$r^2 = .012 F =$	r ² =
	.069 F = 9.91	.055 F = 7.87	.114 F = 16.10	.016 F = 1.95	.020 F = 2.25	.91 $p = .484$.001 F = 1.08
	p < .001	p < .001	p < .001	p = .070	p = .037		p = .376
Ethnicity (White = 0, POC = 1) $B(SE)$.066 (.450)	.536 (.878)	034 (.129)	125 (.146)	.039 (.128)	173 (.606)	050 (.070)
Sex (Male = 0, Female = 1) $B(SE)$	-2.375	-5.349	-1.005	082 (.151)	415 (.133)**	-1.163 (.627)	.041 (.074)
	(.463)***	(.905)***	(.133)***				
Education B(SE)	.102 (.155)	.073 (.303)	034 (.044)	.045 (.050)	.011 (.045)	042 (.213)	.017 (.024)
Income B(SE)	039 (.061)	210 (.120)	037 (.018)*	.023 (.020)	.005 (.018)	066 (.085)	.020 (.010)
Sexual orientation B(SE)	2.323 (.625)***	838 (1.222)	.528 (.176)**	588 (.202)**	016 (.176)	.605 (.871)	.033 (.105)
(Heterosexual $= 0$, Gay/Lesbian $= 1$)							
Sexual orientation B(SE)	1.076 (.447)*	-1.447 (.874)	.330 (.127)**	116 (.144)	100 (.127)	.269 (.603)	.029 (.070)
(Heterosexual $= 0$, Other $= 1$)							
Model with control variables, COVID-19 related	$\Delta r^2 = .008$	$\Delta r^2 = .052$	$\Delta r^2 = .054$	$\Delta r^2 = .171$	$\Delta r^2 = .010$	$\Delta r^2 = .026$	$\Delta r^2 = .029$
stress and live-in partner status	$\Delta F = 3.47$	$\Delta F = 23.62$	$\Delta F = 24.22$	$\Delta F = 75.89 \ p$	$\Delta F = 3.37$	$\Delta F = 6.24$	$\Delta F = 8.19$
	p = .032	p < .001	p < .001	< .001	p = .035	p = .002	р < .001
Stress B(SE)	.304 (.167)	1.364 (.317)***	.062 (.046)	094 (.049)	.028 (.047)	.635 (.224)**	097 (.026)***
Live-in partner B(SE)	—.859 (.425)*	-4.597	—.816 (.118)***	1.541 (.125)***	—.308 (.120)*	1.113 (.575)	.124 (.066)
(No= 0, Yes = 1)		(.812)***					
Model with control variables, COVID-19 related stress and live-in	$\Delta r^2 = .005$	$\Delta r^2 = .001$	$\Delta r^2 = .001$	$\Delta r^2 = 000 \ \Delta F =$	$\Delta r^2 = .000 \; \Delta F$	$\Delta r^2 = .021$	$\Delta r^2 = .001 \ \Delta F$
partner status and their interaction	$\Delta F = 4.17$	$\Delta F = 14.60$	$\Delta F = 1.28$.02 $p = .897$	$= .24 \ p = .628$	$\Delta F = 10.15$	$=.63 \ p = .428$
	p = .042	р < .001	p = .258			p = .002	
Stress $ imes$ Live-in partner status	.673 (.330)*	511 (.629)	.104 (.091)	.013 (.098)	045 (.092)	1.45 (.455)**	043 (.054)
SDI: Sexual Desire Inventory; SBF: Sexual Behavior Frequency; RAS:	Relationship Assessm	ent Scale; B(SE): Unsta	indardized beta coef	ficient and standard en	rror.		
^a Higher scores indicate lower compliance.							
p < .05, **p < .01, ***p < .001.							

Table 3. Unstandardized beta coefficients from regression models of COVID-19 related stress predicting sexual outcomes and relationship satisfaction at T1.

Variable	b	SE	р	d	95% CI for b
Model for solitary sexual desire: SDI-	solitary				
Constant	12.235	.325	<.001***		11.60, 12.87
Time $(t_2 - t_1)$	-0.181	.170	.288	0.03	-0.51, 0.15
Time $(t_3 - t_1)$	-0.081	.184	.659	-0.01	-0.44, 0.28
Time $(t_4 - t_1)$	-0.018	.205	.929	-0.00	-0.42, 0.38
Live-in partner	0.746	.398	.061	0.12	-0.04, 1.53
Time $(t_2 - t_1) \times$ Live-in partner	0.013	.425	.976	0.00	-0.82, 0.85
Time $(t_3-t_1) \times$ Live-in partner	0.137	.383	.720	0.02	-0.61, 0.89
Time (t_4-t_1) × Live-in partner	0.371	.352	.293	0.06	-0.32, 1.06
Model for dyadic sexual desire: SDI-d	lyadic				
Constant	38.193	.392	<.001***		37.42, 38.96
Time $(t_2 - t_1)$	-1.705	.356	<.001***	-0.15	-2.40, -1.01
Time $(t_3 - t_1)$	-2.317	.388	<.001***	-0.20	-3.08, -1.56
Time (t_4-t_1)	-1.877	.431	<.001***	-0.16	-2.72, -1.03
Live-in partner	3.647	.775	<.001***	0.31	2.13. 5.17
Time $(t_2 - t_1) \times$ Live-in partner	0.260	.740	.725	0.02	-1.19, 1.71
Time $(t_3-t_1) \times$ Live-in partner	-0.498	.804	.536	-0.04	-2.08, 1.08
Time $(t_4-t_1) \times$ Live-in partner	0.190	.894	.832	0.02	-1.56, 1.94
Model for frequency of solitary sexual	behaviors				
Constant	3.282	.057	<.001***		3.17, 3.39
Time (t_2-t_1)	-0.098	.050	.052	-0.06	-0.20, 0.00
Time $(t_2 - t_1)$	-0.133	.055	.015*	-0.08	-0.24, -0.03
Time $(t_4 - t_1)$	-0.143	.060	.018*	-0.09	-0.26, -0.03
live-in partner	0.658	.112	< .001***	0.40	0.44, 0.88
Time $(t_2 - t_1) \times 1$ ive-in partner	-0.198	.103	.056	-0.12	-0.40, 0.01
Time $(t_2, t_1) \times 1$ ive-in partner	-0.043	.112	.702	-0.03	-0.26, 0.18
Time $(t_4, t_1) \times 1$ ive-in partner	-0.491	124	< 001***	-0.30	-0.73 -0.25
Model for frequency of dvadic sexual h	nehaviors		<	0.50	0.75, 0.25
Constant	1 781	060	< 001***		1 66 1 90
Time (t_{2}, t_{3})	0.064	065	330	0.04	-0.07 0.19
Time (t_2, t_1)	0 173	071	016*	0.10	0.03 0.31
Time (t_2, t_1)	0.383	.071	< 001***	0.73	0.03, 0.51
Live-in partner	_1 314	107	< 001***	_0.25	_1 52 _1 10
Time $(t_{2}-t_{1}) \times 1$ ive-in partner	0.411	131	002**	0.73	0.15 0.67
Time $(t_2, t_1) \times \text{Live in partner}$	0.638	1/13		0.25	0.15, 0.07
Time $(t_3, t_1) \times \text{Live-in partner}$	0.000	157	< 001***	0.50	0.50, 0.52
Model for sexual compliance	0.909	.157	<.001	0.52	0.00, 1.22
Constant	5 782	053	~ 001***		5 68 5 80
Time $(t_{-}t_{-})$	0.020	.033	<.001 807	0.01	01/ 018
Time $(t_2 - t_1)$	0.020	.000	807	0.01	-0.14, 0.18
Time (t_3, t_1)	0.022	.000	163	0.01	0.05 0.32
live in partner	0.131	.094	.105	0.09	
Time $(t, t) \times 1$ is a partner	0.142	.050	270	0.19	0.09, 0.47
Time $(t_2 - t_1) \times \text{Live-in partner}$	0.145	.102	.379	0.10	-0.18, 0.40
Time $(t_3 - t_1) \times \text{Live-in partner}$	-0.093	.170	.392	-0.00	-0.43, 0.23
Model for sevual coercises SCIPS total	0.154	.190	.461	0.09	-0.24, 0.31
Constant	1 606	206	~ 001***		1 10 2 20
$T_{imp}(t, t)$	0.117	.500	<.001	0.02	1.10, 2.30
Time $(l_2 - l_1)$ Time $(t_1 - t_1)$	-0.117	.594	./0/	-0.02	-0.69, 0.00
Time $(l_3 - l_1)$	0.042	.410	.920	0.01	
$\lim_{t \to \infty} e^{(l_4 - l_1)}$	0.027	.471	.955	0.00	
Live-in partner	-0.810	.545	.155	-0.14	-1.69, 0.25
Time $(l_2 - l_1) \times$ Live in partner	-0.573	./94	.471	-0.10	-2.13, 0.99
Time $(l_3 - l_1) \times$ Live-in partner	0.180	.835	.830	0.03	-1.40, 1.82
Time $(t_4-t_1) \times$ Live-in partner	1.431	.947	.131	0.25	-0.43, 3.29
Model for COVID-19 related stress	2.002	0.40	* * *		2.01.4.07
	3.983	.040	<.001***		3.91, 4.06
$IIMe (t_2 - t_1)$	-0.195	.043	<.001***	-0.16	-0.28, -0.11
$\lim_{t \to \infty} e(t_3 - t_1)$	-0.151	.04/	.001**	-0.12	-0.24, -0.06
lime (t_4-t_1)	-0.118	.052	.025*	-0.09	-0.22, -0.02
Live-in partner	0.005	.079	.951	0.00	-0.15, 0.16
Time $(t_2-t_1) \times$ Live-in partner	0.108	.089	.225	0.09	-0.07, 0.28
Time $(t_3-t_1) \times$ Live-in partner	0.153	.098	.117	0.12	-0.04, 0.34
Time $(t_4-t_1) \times$ Live-in partner	0.138	.108	.205	0.11	-0.08, 0.35

Note. SDI: Sexual Desire Inventory; SCIRS: Sexual Coercion in Intimate Relationship Scale; CI: confidence interval; d: Cohen's d based on the multi-level model estimates. All models have random intercepts. *p < .05, **p < .01, ***p < .001.

sexual desire level was significantly lower at each subsequent time point assessed. Post-hoc tests indicated no additional differences between T2, T3, and T4. Compared to T1, solitary sexual behavior was significantly less frequent at T3 and T4. There were no differences between T2, T3, and T4 on that measure. Dyadic sexual behavior increased in frequency at T3 as compared to T1, and increased again at T4 as compared to all three previous time points.

COVID-19 related stress was significantly higher at T1 than at each of the following time points. There were no differences in COVID stress between T2, T3, and T4 measurements.

The main effect of time was qualified by significant interaction of time and live-in partner status for the frequency of solitary and dyadic sexual behavior. The frequency of solitary behavior went down between T1 and T4 for people without a live-in partner but it did not change for people with a live-in partner (simple effects: b = -.32, p < .001 and b = .17, p = .090, respectively). The frequency of dyadic behavior increased between T1 and each of the following times for people without a live-in partner (simple effects for T1–T2, T1–3, and T1–4: b = .22, p =.006, b = .42, p < .001, and b = .73, p < .001, respectively) but it did not change (and actually showed a somewhat decreasing trend) for people with a live-in partner (simple effects for T1-T2, T1-3, and T1-4: b = -.19, p = .070, b = -.22, p = .052, and b = -.18, p = .154, respectively)

Discussion

Baseline characteristics of stress

There has been considerable interest in population-based levels of stress, anxiety, and depression since the beginning of the COVID-19 pandemic. We collected self-report measures of COVID-19 related stress during Phase 1 of the pandemic, which corresponded in Canada to the highest levels of pandemic lockdown measures. These data were based on 1,019 Canadians who participated from all provinces and territories, with the predominance participation from British of Columbia, Ontario, and Quebec. The average score of the sample paralleled stress

approximately moderate levels of stress, which is consistent with published data on stress levels of the population early in the pandemic (Stanton et al., 2020; Taylor et al., 2020). In particular, items reflected a moderate degree of worry over participants' own physical health, others' physical health, one's financial situation, and economic stability. These moderate levels of stress were not impacted by participants' gender, sex, or age. However, sexual orientation was associated with baseline COVID-19 stress such that individuals identifying with the "other" category (i.e., bisexual, pansexual, asexual, and demisexual) saw higher rates of stress, consistent with what would have been predicted, and existing data (Peterson et al., 2021), consistent with minority stress theory (Meyer, 2003). Furthermore, participants of color had higher levels of COVID-related stress, consistent with available data (Fortuna et al., 2020) which point to the role of systemic racism in explaining these observed racialized differences due to COVID-19. Finally, higher education and income mitigated these COVID stress findings across the various subgroups.

How does COVID stress impact sexuality outcomes?

Focusing on our sexuality outcomes, we found that men reported higher levels of solitary and partnered sexual desire than women, and higher rates of solitary sexual behaviors (i.e., masturbation) consistent with established gender differences in desire (Dawson & Chivers, 2014) and behavior (Petersen & Hyde, 2011). The genders did not differ in their rates of partnered sexual activities. We next evaluated the association of COVID-19 stress levels with these outcomes and found, somewhat contrary to predictions, that higher levels of stress were associated with higher levels of dyadic sexual desire. This was similar to the findings of a study of 1,000 Americans led by the Kinsey Institute which found that stress was associated with increased likelihood of engaging in new sexual behaviors, likely as a means of coping with such stress (Lehmiller et al., 2021). If stress is usually understood as impacting sexual desire in a negative way (Ferreira et al., 2014), it is important to consider the possible mechanisms

by which more COVID-related stress may have translated into higher desire for sex with a partner. For example, it is possible that stress may have elevated the sympathetic nervous system response, and may have elicited excitation transfer (Cantor et al., 1975) thereby increasing sexual response (Meston, 2000). It is also possible that there may be a third variable explanation such as availability of a partner that is accounting for both the increased levels of stress and the increased levels of desire. For example, for individuals who could not see their sexual partners due to pandemic control measures, this may have increased stress, and independently increased desire for sex with a (distant) partner (if physical contact was not permitted). Another possible explanation is that this association between stress and desire is accounted for by those not in a relationship in that those who experienced more COVID-related stress may have ceased efforts to engage in sexual activity with possible or even casual sexual partners, due to fear of virus transmission, and thus experienced a heightening of sexual desire as a result. This possibility is consistent with other studies that found significantly less casual or hookup sex early in the pandemic (Doring, 2020; Sanchez et al., 2020). The lack of a relationship between COVID stress and sexual activity would certainly support this explanation if increases in desire were not met with an increase in sexual behaviors.

In addition to stress being associated with more dyadic desire, higher COVID stress predicted higher self-reported sexual coercion, as indexed by the Sexual Coercion in Intimate Relationships Scale. Although overall rates of sexual coercion were very low in this study, the finding that stress was associated with more coercion is consistent with existing data (Morgan & Boxall, 2020). While it might be possible that increased experiences of sexual coercion could result in higher levels of COVID stress, our findings that higher COVID stress predicted sexual coercion are consistent with previous work. COVID-related economic stress and lockdown orders have been found to increase rates of sexual and psychological abuse among couples, including those who had not experienced intimate partner violence before the pandemic (Arenas-Arroyo

et al., 2021). These results are alarming with regards to the possible long-term effects if stress continues to persist post-pandemic.

How do sexuality outcomes change over the phases of the pandemic?

We used Linear Mixed Models to examine changes in sexuality outcomes over four phases of the pandemic: T1-when pandemic lockdown measures were at their peak, and then at four monthly intervals thereafter-T2, T3, and T4, which corresponded with progressively loosened public health guidelines. Firstly, COVID-19 related stress was highest at T1 and decreased at all subsequent time points, consistent with predictions. These peak levels of stress aligned with the highest phase of pandemic lockdown measures, and were seen around the world. There were no changes in solitary sexual desire over time suggesting that interest in masturbation was neither hampered, nor boosted, by easing restrictions around social distancing. Given that this is a solitary activity that does not depend on the availability of a partner, and can continue regardless of whether social distancing is enforced or not, it is not surprising that desire for masturbation was not affected by time over the course of COVID-19. On the other hand, solitary sexual behavior decreased over the course of the pandemic, with significant differences between Phase 1 and the T3 assessment as well as Phase 1 to the T4 assessment. This finding mirrors the findings from the Kinsey Institute survey which collected data only during Phase 1 of the pandemic, and compared that to retrospective recall of solitary sexual activity prior to COVID-19 (Lehmiller et al., 2021). The finding that desire for masturbation did not change but solitary sexual behaviors decreased over the same span of time suggests that there may be factors unrelated to desire that are accounting for the decrease in masturbation. For example, lack of privacy may explain fewer opportunities to act on solitary sexual desire. It is also possible that an increase in work hours, secondary to working from home (Friedman, 2020), may also provide fewer opportunities to engage in solitary sex.

With regards to dyadic sexual desire and behavior, we found a similar discrepancy between desire and behavior in that dyadic sexual desire decreased at every assessment point over the course of the pandemic whereas dyadic sexual behaviors increased at T3 and T4 compared to baseline. Of note, pandemic stress was associated with more dyadic desire at baseline, but over subsequent phases of the pandemic, both stress and dyadic desire decreased. There may be multiple explanations to account for this finding. It is possible that in light of the positive effects of pandemic stress on dyadic desire, as stress decreased so did dyadic desire as a result. There may be other explanations as well independent of the stress-desire relationship. For example, other studies (Fuchs et al., 2020) have also found decreased dyadic desire with the pandemic and this may be secondary to couples working from home, and not benefiting from the phenomenon of "distance makes the heart grow fonder" (Perel, 2007). It is interesting that despite these falling rates of dyadic desire, dyadic sexual behavior rates actually increased at T3 and T4. Since the increased activity is not accounted for by increased desire, we must consider the possibility that other factors are accounting for the increase in behavior. For example, T3 and T4 corresponded with the summer months of June-August 2020, when pandemic control measures were at their lowest due to a plateau in the number of cases of COVID-19 in Canada, and as such, more social activity. It is possible that some of this increase in dyadic sexual activity might reflect new or familiar partners reengaging in sexual activity after a period of social distancing. Importantly, the effects of the pandemic phases on dyadic desire and behavior were moderated by live-in partner status such that the increase in dyadic sexual activity was seen only among those without a live-in partner, whereas those with a live-in partner actually saw a decrease in their sexual activity. These findings highlight the importance of considering relational context when examining the impact of stress, or other external influences, on sexual behavior. We did not find any changes in sexual compliance over time, with mean rates of sexual compliance being rather low at baseline and remaining low with

each subsequent testing period. We cannot attribute the increased rates of dyadic sexual activity to increases (or decreases) in sexual compliance.

Sexual coercion over phases of the pandemic

As noted earlier, sexual coercion was predicted by higher levels of pandemic stress at T1. Of note, however, there were no changes in selfreports of sexually coercive behaviors over the four assessment periods. We would have predicted that the declining rates of COVID stress with each assessment point might have contributed to lowering rates of sexual coercion; however, given that the absolute value of those coercion rates was very low in our sample, it is possible that there was a floor effect. In contrast to several other documented reports of increasing prevalence of intimate partner violence over the course of the pandemic (Jetelina et al., 2021; Muldoon et al., 2021), we did not see any increase in sexual coercion in our sample.

Implications of the findings and for future pandemics

A significant strength of our study was the prospective data collection over four time points, corresponding to different phases of the COVID-19 pandemic associated with progressive loosening of social restrictions. Despite predictions of a baby boom and the implication that the COVID-19 pandemic would be associated with increasing rates of sexual desire and activities for all individuals, we did not see this reflected in our data. Instead, we saw significant decreases in partnered sexual desire and in solitary sexual behaviors over phases of the pandemic. We also saw an increase in dyadic sexual activities only among those without live-in partners, whereas those with live-in partners actually had a decrease in their dyadic sexual activity (as well as a decrease in sexual desire). These findings contribute to an already well-established literature showing that the relationship between sexual desire and sexual behavior is not linear and positive, but rather complex and probably multi-determined, and impacted by the environment (Santtila et al., 2007). This assists with understanding existing models of sexual activity and emphasizes that sexual activity is not a direct consequence of sexual desire given that, as we have seen here, both solitary and dyadic desire-behavior relationships were not found. Importantly, while we would have expected sexual desire to resume as pandemic stress lessened (which it did over the four assessment points), in fact we saw a decrease in dyadic desire and no change in solitary sexual desire. This also suggests that there are factors contributing to sexual desire above and beyond the contribution of stress that need to be considered in the context of COVID-19. Of interest also is the finding that dyadic sexual behavior increased but this was not attributable to changes in sexual compliance (or people engaging in more consensual but unwanted sex), as the latter did not change over the course of the pandemic. Again, it is likely that the motivators for engaging in dyadic sexual activity may have little to do with desire and compliance, and perhaps more to do with the availability of a partner.

In terms of the possible clinical implications of the findings, many expert predictions suggest long-lasting effects of COVID-19 and the associated lockdown measures on a variety of psychosocial and economic variables (Douglas et al., 2020). We might predict that some of the observed negative consequences on sexuality (i.e., reduced dyadic desire and reduced solitary sexual activity) might follow a similar pattern with a lengthy period of decline even long after a return to normal. It may be necessary to increase the availability of sexual health supports if such declines translate into longer term sexual distress or sexual dysfunction. Of note, the latter were not evaluated in this study.

Limitations and conclusion

There were some limitations of this study that need to be considered. Firstly, the sample was recruited via social media (primarily through Facebook groups), thus limiting access to individuals who are not consumers of social media. This was also a highly educated sample, with over 90% having at least some college education. In terms of ethnicity, 70% of the participants identified as White. Additionally, almost half of participants were gay/lesbian, or indicated that their sexual orientation was not heterosexual, which is overrepresentative of Canadian LGBTQ + population estimates. Given that sexual minority groups are found to face disproportionately greater amounts of stress (Mattei et al., 2020) compared to their heterosexual counterparts our findings may not generalize to the broader Canadian population. That said, we did have a wide age range of participants from 19 to 81, and representation from every Canadian province and territory, bolstering the generalizability of our sample. Since the periods of data captured corresponded with Canadian pandemic control actions, the current findings might not be generalized to countries who followed very different rules with regards to social distancing.

In conclusion, we found COVID-related stress to be associated with higher levels of dyadic desire as well as higher levels of experienced sexual coercion during Phase 1 of the pandemic. Over time, and with easing public health restrictions, we found significant decreases in COVIDrelated stress, decreases in dyadic sexual desire, decreases in solitary sexual behavior, and increases in dyadic sexual behavior. These findings add to the growing body of literature documenting the complex effects of COVID-19 pandemic measures different on facets of sexuality.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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