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## Article

# Is Consumption of Ginger in Daily Life Associated with Sexual Response?

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**Abstract:** Sexual dysfunction, a globally widespread concern, is associated with numerous negative outcomes. While some evidence indicates the potential of ginger supplementation to enhance sexual function, comprehensive research in this area remains scarce and the potential mechanism behind is unclear. The current study aimed to explore if and how consumption of ginger as part of a daily diet is associated with sexual desire, frequency of sexual behavior, as well as sexual arousal and disgust experienced during these behaviors. Chinese participants ( $N = 499$ ; 250 women) from an online sample service (Credamo) answered a cross-sectional survey regarding their consumption of ginger, sexual behavior, and sexual desire. Ginger consumption was associated with higher sexual desire, and more frequent sexual behaviors, as well as feelings of sexual arousal during them. Sexual desire and feelings of sexual arousal during specific sexual activities mediated the association between the ginger consumption and the frequency of sexual behaviors, indicating potential pathways of the effects of ginger on sexual behavior. Interestingly, while ginger consumption showed no direct relationship with feelings of disgust during sexual behavior, sexual arousal during these behaviors did positively mediate the association between ginger consumption and feelings of disgust. The findings imply that ginger shows potential as an intervention for enhancing sexual behavior, but further experimental and longitudinal research is needed to fully understand the causal mechanisms underlying the effects of ginger on sexual health.



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## 1. Introduction

### 1.1. Disgust, Sexual Arousal, and Sexual Dysfunction

Sexual dysfunction is a common complaint among individuals and leads to negative outcomes, such as decreased sexual frequencies and difficulties, including physical and mental health problems (e.g., depression), particularly in women and long-term relationships [1–8]. Therefore, it is vital to explore the risk factors of sexual dysfunction and identify effective, safe methods to assist individuals and couples facing sexual challenges.

Disgust is a key component of the behavioral immune system and serves to protect humans from potential harm [9]. However, recent research has revealed that it also has a close association with sexual behavior and sexual dysfunctions [10,11]. For instance, women with sexual interest/arousal disorder showed more disgust-related facial expressions, reported higher subjective disgust, and recorded greater heart rate deceleration in response to erotic stimuli compared to healthy controls [12]. Women with vaginismus and sexual intercourse difficulties also showed more automatic associations between sexual intercourse insertion and disgust (implicit associations) [13], and women with vaginismus reported higher disgust propensity, stronger facial disgust reactions to sexual stimuli, and higher subjective disgust perception [13,14].

Recently, de Jong and colleagues proposed a theoretical hypothesis of sexual behavior and dysfunctions, explaining how disgust and sexual arousal affect sexual responses [15]. This model suggests that sexual stimuli can elicit not only feelings of sexual arousal but also disgust due to the potential risk of contagion associated with body fluids. Sexual arousal functions as a goal-directed emotional state and motivates sexual approach behavior, while disgust assumes an essential role within the behavioral immune system, acting as safeguard against potential harm during sexual behavior by activating sexual avoidance behavior [9].

Also, this hypothesis suggests a complex and bidirectional relationship between sexual arousal and disgust, and their coaction can affect sexual function and behavior [15]. Specifically, the model suggests that when sexual arousal intensity overwhelms disgust, individuals may enter a healthy sexual functional loop in which sexual arousal stimulates sexual approach behavior (i.e., sexual contact), further enhancing sexual arousal and reducing the impact of disgust, thus promoting the maintenance of sexual desire and arousal. Conversely, when the intensity of disgust overwhelms sexual arousal, individuals may enter a sexual dysfunctional loop in which disgust interferes with sexual arousal and elicits avoidance behavior, which can reinforce disgust and interfere with the normal functioning of sexual response, leading to sexual dysfunction [15]. Consistent with this model, empirical evidence has demonstrated that feelings of sexual arousal and disgust have a strong negative relationship, with disgust upregulation inhibiting self-reported sexual arousal for both men and women as well as men's erectile response [16–19].

### 1.2. Consumption of Ginger and Improvement in Sexual Behavior

Ginger (*Zingiber officinale*; Z) may hold potential as an inexpensive but effective treatment to improve sexual behavior of human. Z has been perceived as a treatment for "sexual frigidity" by practitioners of traditional herbal medicine with anecdotal success for this purpose [20–22].

Recent evidence from studies with humans has also shown that Z consumption may improve sexual function. For example, in a sample of older men with mild erectile dysfunctions, 30-day treatment with a Z extract significantly improved their erectile function and intercourse satisfaction [23]. However, due to a lack of a control group, no causal conclusion about ginger's effect can be drawn from this study. In the only placebo-controlled study to date, Shabanian and co-workers [22] recruited 140 depressed women with decreased sexual desire and found that Z was associated with improved self-reported sexual desire, sexual arousal, lubrication, orgasm function, sexual satisfaction, and reduced pain associated with intercourse. However, improvements in sexual arousal, lubrication, and sexual satisfaction were also observed in the placebo group. Two separate studies—one including men and the other women—provide preliminary evidence that Z may improve sexual function in both genders. However, empirical evidence remains limited. In addition, studies with experimental animal models have demonstrated that Z consumption has an impact on the sexual behavior of animals. For example, research has shown that Z consumption improved sperm motility in male rats [24] and sexual performance, and increased the number of successful mating in male sterile medflies [25].

### 1.3. Potential Pathways of Z Consumption on Sexual Desire and Sexual Behaviors

The mechanism by which ginger affects sexual behavior and function is not yet fully understood. However, according to the sexual arousal–disgust rival hypothesis [15], there are two potential targets for specific interventions to enhance human sexual behavior and function: (1) decreasing the disgust response and (2) increasing the sexual arousal response. Z may work through these pathways to produce its effects.

Z may improve individuals' sexual arousal and sexual desire, and subsequently increase their frequency of sexual behavior and improve sexual function. As mentioned earlier, limited studies have found that Z can improve sexual arousal and sexual desire in depressed women and increase physiological sexual arousal in elderly men [22,23].

Wen and colleagues [26] conducted a laboratory-based study in which participants were asked to smell and touch sexual body fluids and then viewed erotic stimuli in sequence to explore the suppressing effect of disgust on sexual arousal and sexual engagement. Their study found that consumption of 1.5 g of Z one hour before the tasks was associated with increased feelings of sexual arousal in both men and women in response to erotic stimuli.

In addition, one of the ways in which Z impacts sexual behaviors is by exerting an inhibiting effect on feelings of disgust induced by sexual stimuli, given the negative bidirectional relationship between sexual arousal and disgust [15]. Specifically, by reducing feelings of disgust, Z may facilitate sexual approach behavior and decrease sexual avoidance behavior. Tracy's research has demonstrated that Z can reduce self-reported subjective feelings of disgust toward disgusting materials, and consequently weaken moral condemnation, which may be partially driven by moral disgust [27]. Additionally, research has shown that individuals' stomach reactions to disgusting stimuli are closely linked to their subjective feelings of disgust, with stimuli that induce stomach upset and rejection often being used to elicit feelings of disgust [28]. Z is an effective antiemetic, with consumption of 1000–2000 mg having demonstrated a capacity to reduce both the incidence and severity of postoperative nausea and vomiting involving gynecological/laparoscopic surgery, pregnancy, and chemotherapy [29–31]. This reduction in nausea and vomiting resulting from Z consumption may also indicate a reduction in feelings of disgust, which could impact sexual behavior.

#### 1.4. Aims and Hypotheses

The current study aimed to explore the associations between daily consumption of Z, sexual desire, sexual behaviors, and feelings of sexual arousal and disgust during sexual behaviors. This investigation was undertaken to augment existing evidence and explore the potential influence of Z consumption on sexual behavior, along with its underlying pathways. We expected the following.

**H1.** *Consumption of Z would be positively associated with sexual desire, frequency of sexual behaviors, and experienced sexual arousal during sexual behaviors, while Z would be negatively associated with feelings of disgust when engaging in sexual behaviors.*

**H2.** *Sexual desire and feelings of sexual arousal during sexual behavior would positively mediate the relationship between Z consumption and frequency of sexual behaviors, while disgust during sexual behavior would negatively mediate this relationship.*

## 2. Materials and Methods

### 2.1. Participants

A total of 500 participants including 250 men and 250 women answered our questionnaires via Credamo (an online professional survey website). The inclusion criteria were: (1) adult; (2) Chinese (nationality); (3) not a psychology student or researcher; (4) not pregnant or breastfeeding; and (5) without severe physical or mental illness. One response from an intersex person was removed from the analyses. The final sample, therefore, included 499 participants (249 men). Other background information is presented in Table 1. Sensitivity analysis showed that with  $\alpha = 0.05$  and  $1 - \beta = 0.80$ , a sample of 499 could reliably detect a correlation of at least  $r = 0.125$  (two-sided test).

**Table 1.** Demographic variables of the sample ( $N = 499$ ).

		N	%
Age ( $M \pm SD$ )		28.72 (5.22)	5.22
The number of sex partners ( $M \pm SD$ )		1.88 (1.73)	1.73
Sex			
	Men	249	49.9
	Women	250	50.1
Relationship status			
	Single (including divorce)	78	15.6
	In committed relationship	421	84.4
Education			
	Primary school	1	0.2
	Junior school	2	0.4
	Senior school	16	3.2
	College	418	83.8
	Postgraduate and above	62	12.4
Sexual orientation			
	Heterosexual	487	97.6
	Homosexual	6	1.2
	Bisexual	6	1.2
Relationship length			
	Single	75	15
	<1 month	6	1.2
	1–3 months	8	1.6
	4–6 months	14	2.8
	7–12 months	25	5
	1–2 years	69	13.8
	3–5 years	151	30.3
	6–10 years	112	22.4
	>10 years	39	7.8
Monthly income (¥)			
	No	14	2.8
	<5 k	114	22.8
	5~8 k	160	32.1
	9~15 k	168	33.7
	16~30 k	40	8
	31~50 k	2	0.4
	>50 k	1	0.2
General physical health			
(“In general, would you say your physical health is”)			
	Excellent	157	31.5
	Very good	224	44.9
	Good	82	16.4
	Fair	32	6.4
	Poor	4	0.8

## 2.2. Measures

### 2.2.1. Background Information

Background information asked the participants about their sex, age, relationship status, sexual orientation, education, relationship length, monthly income, general physical health, and their number of sexual partners (see Table 1 for response options).

### 2.2.2. Sex Drive Questionnaire

SDQ was used to measure the participants' sexual desire [32]. This is a 4-item scale measuring individuals' sexual interest or wish for sexual activity last month. The sample item included "How often do you experience sexual desire" and participants reported their responses on a 7-point scale. Higher scores indicate higher sexual desire. The first author translated the questionnaire from English into Chinese. Subsequently, the initial Chinese version was back-translated into English by another researcher. An English-Chinese bilingual Ph.D. student then assessed the linguistic equivalence between the original English version and the back-translated version, identifying no discrepancies. The SDQ showed good internal consistency in the previous study (0.79 for men and 0.83 for women) [32]. In the current study, Cronbach's  $\alpha$  for the Chinese version of the SDQ was 0.77.

### 2.2.3. Frequency of Sexual Behaviors

The frequency of sexual behaviors was assessed using a modified version of The Desired and Actual Sexual Activity Scale (DASA) [7], which was generated on the basis of the Derogatis Sexual Functioning Inventory [33]. The DASA measured the actual and desire frequency of six types of sexual behaviors. We used the actual frequency of sexual behaviors subscale including “Sexual Fantasy”, “Masturbating”, “Kiss and petting”, “Oral sex”, “Vaginal sex”, “Anal sex”, and added additional two items (“Fingering or hand jobs”, “Genital-genital rubbing”). “Fingering or Hand jobs” and “Oral sex” are broken into two items (“Fingering or hand jobs-giving/receiving”; “Oral sex-giving/receiving”). Participants were asked how many times they engaged in each type of behavior during the preceding week. In addition, we asked them to rate how sexually aroused and how disgusted they felt during each type of behavior using a 9-point scale (0 not at all ~8 extremely strong) for the behaviors they actually reported. Except for Sexual Fantasy and Masturbating, other dyadic sexual behaviors were combined into one variable (Dyadic Sex). We also added three items related to condom use for three of the behaviors: Oral sex-giving/receiving, Vaginal sex, and Anal sex. Participants reported the exact number of condom usages during these behaviors. The condom use subscale was not used in the current study. The translation methodology for this questionnaire mirrored that utilized for the Sexual Drive Questionnaire. This Chinese version of the scale showed acceptable Cronbach’s  $\alpha$ s: 0.86 (frequency of sexual behaviors), 0.79 (feelings of disgust), and 0.77 (feelings of sexual arousal).

### 2.2.4. Consumption of Ginger Inventory

The Consumption of Ginger Inventory developed by the author was used to measure the daily ginger consumption of participants due to the absence of a standardized ginger measurement. The inventory was developed based on two most widely used tools in international diet and health research: the Food Frequency Questionnaire (FFQ) and the dietary recall method. The FFQ measured individuals’ average consumption or frequency (e.g., daily/weekly/monthly/yearly consumption) of various types of food (25–172 kinds) and diet over a certain period of time, whereas the dietary recall method (e.g., 7-day Dietary Records and 24-Hour Dietary Recall) measured detailed information about the food and beverages participants consumed [34,35].

The Consumption of Ginger inventory, formulated in Chinese and translated into English for the purposes of this research report, measured the participants’ frequency of ginger consumption along three dimensions. Among them, weekly consumption of ginger ( $Z_{wk}$ ), akin to the commonly used “gold standard” method of a reliable 7-day Dietary Recall [35], was the main measurement part measuring the amount of Z consumed by the participants in the past week on three aspects including meals with Z, consumption of Z additives, and consumption of drinks with Z (e.g., “How many times have you eaten ginger additives last week”). Participants reported exact numbers for weekly Z consumption. If the participant did not know if their meals had had Z added, a missing value was inserted.

This inventory also measured the frequency of ginger consumption during the last five years ( $Z_{5y}$ ) in these three aspects (e.g., “How often have you eaten ginger additives in the last five years”) as an auxiliary measurement on a 6-point Likert scale (1 = never, 6 = always), with higher scores indicating more consumed Z. This subscale aligned with the content commonly associated with FFQ.

In addition, given that Z is a commonly used spice in China, four items ( $Z_{co}$ ; e.g., “On average, how much ginger do you add in one meal (lunch or dinner) generally?”) were used to measure their general consumption of Z when they cooked as an auxiliary measurement. The participants needed to answer on a 10-point Likert scale (1 = never add ginger, 9 = always add ginger; 0 = never cook by yourself). Data from participants who did not cook were not included in analyses involving this variable.

The FFQs used test-retest reliability (intra-class correlation coefficient or Spearman correlation coefficient) as their reliability index, and the correlation coefficient (Spearman

or Pearson correlation) between the FFQ and the dietary recall method to assess its validity. Meta-analytic results show that the reliability coefficient for FFQ ranges from 0.42 to 0.80, while the validity coefficient spans from 0.22 to 0.77 (median = 0.42; reliability and validity  $\geq 0.70$  is high, 0.40~0.69 is moderate to high, <0.40 is poor) [35–38]. Since this study did not measure the participants' Z consumption multiple times, test-retest reliability could not be calculated for this study. However, the reliability tests highlighted that the Cronbach's  $\alpha$  values for  $Z_{wk}$ ,  $Z_{5y}$ ,  $Z_{co}$ , and  $Z_{tot}$  stood at 0.57, 0.72, 0.84, 0.81, respectively, indicating acceptable reliability. Moreover, a high correlation ( $r = 0.63$ ,  $p < 0.001$ ) between  $Z_{wk}$  (akin to the 7-day Dietary Recall) and  $Z_{5y}$  (akin to the FFQ), coupled with high correlations ( $rs = 0.40$ ~0.81) among  $Z_{wk}$ ,  $Z_{5y}$ ,  $Z_{co}$ , and  $Z_{tot}$  (mean of all ten items), showcased a moderate to high (0.40~0.69) validity index according to Willett and Lenart's criteria for validity of food frequency questionnaires [38]. Given that there was a high correlation between the weekly Z consumption subscale and the total scale ( $r = 0.81$ ), and the fact that most measures of the participants' sexual behaviors or feelings referred to the last week or last month, we used the  $Z_{wk}$  in the main analyses.

### 2.3. Procedures

An online survey was advertised on Credamo ([www.credamo.com](http://www.credamo.com); accessed on 9 November 2021) exploring the interaction between different emotions. Participants were informed that only part of the research purpose of the current study was explained to them, but the nature (demographic variables, sexual behaviors, and sexual desire) of all measurements was provided before they agreed to participate in the study. After giving informed consent, participants first completed background questionnaires which allowed for us to screen only eligible participants to continue the study. Then, they finished the measures of sexual behaviors frequency, sexual desire, and finally Z consumption scale. The survey prevented participants from returning to previous pages once they moved to the next page and disallowed re-entry if they exited before completion. Participants were debriefed about the research purpose after the completion of the questionnaire and data submission. No identifiable information was collected. Three attention check questions (e.g., "What is the color of a cloud? Please select "Blue" directly") were used and responses were removed from analyses if a participant failed to pass at least two of them. Given the estimated completion time of 7–10 min, participants received a compensation of 5 CNY upon survey completion.

### 2.4. Data Analyses

All data analyses were conducted using IBM SPSS 25.0 (IBM, Armonk, NY, USA) and PROCESS macro v3.5.3 developed by Hayes [39]. Specifically, correlation was conducted to analyze the relationship between background variables,  $Z_{wk}$ , sexual behavior-related variables, and sexual desire. Then, mediation analyses using SPSS PROCESS subroutine was conducted to explore whether (1) the feelings of sexual arousal, disgust, and sexual desire played mediating roles in the relationship between  $Z_{wk}$  and the sexual behaviors. Exploratory mediation analyses were used to explore if the feelings of sexual arousal (from Sexual Fantasy, Masturbation, and Dyadic Sex) mediated the association between  $Z_{wk}$  and feelings of disgust. To limit the number of analyses, all dyadic sexual behaviors (sexual behaviors except Sexual Fantasy and Masturbation) were combined into a new variable (Dyadic Sex), and only Sexual Fantasy, Masturbation, and Dyadic Sex were included in these mediating analyses. One response from an intersex person was not included in the analyses, as our original data analysis plan aimed to investigate sex differences in sexual behavior-related variables, which were not included in the current manuscript.

## 3. Results

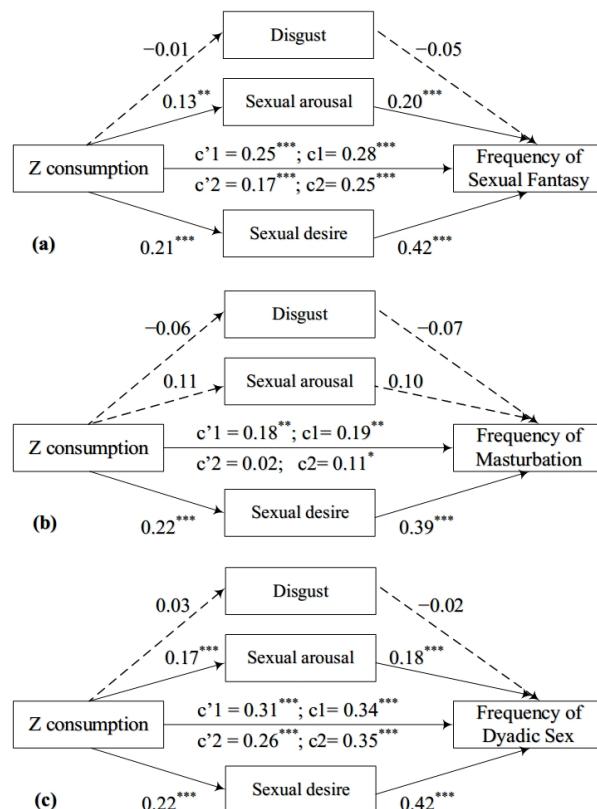
### 3.1. Correlations between Consumption of Z, Sexual Desire, and Sexual Behavior-Related Variables

Table 2 shows that  $Z_{wk}$  was positively associated with higher levels of sexual desire; the frequency of Sexual Fantasy, Masturbation, and Dyadic Sex.  $Z_{wk}$  was also positively

associated with feelings of sexual arousal during both Sexual Fantasy and Dyadic Sex. In addition, we also examined the association between  $Z_{wk}$  and frequency of each kind of dyadic sexual behavior (e.g., kissing–petting) and the results showed that all correlations were positive and significant ( $r_s = 0.138\text{--}0.334$ ,  $p < 0.01$ ). In addition, sexual desire was positively associated with the participants' frequency of Sexual Fantasy, Masturbation, Dyadic Sex, and feelings of sexual arousal during these three behaviors, whereas sexual desire was also negatively related to feelings of disgust during Sexual Fantasy. In addition, there was a negative correlation between feelings of sexual arousal and disgust during Sexual Fantasy ( $r = -0.207$ ,  $p < 0.001$ ), Masturbation ( $r = -0.236$ ,  $p < 0.001$ ), and Dyadic Sex ( $r = -0.258$ ,  $p < 0.001$ ).

### 3.2. Associations between $Z$ Consumption and Sexual Behavior: Mediating Effects of Sexual Arousal, Disgust, and Sexual Desire

To explore the potential pathways on how  $Z_{wk}$  affects participants' sexual behaviors, we conducted a series of mediation analyses with feelings during sexual behaviors and sexual desire as mediators. First, we conducted the mediation analyses for feelings of sexual arousal as well as disgust (Mediation model 1) and sexual desire (Mediation model 2) separately (see Figure 1 for details of these two mediation models) and then included all these potential mediators in one mediating regression.



**Figure 1.** The mediation analyses for the association between  $Z$  consumption and the frequency of sexual behavior: (a) Mediating analyses for the association between  $Z$  consumption and the frequency of sexual fantasy; (b) Mediating analyses for the association between  $Z$  consumption and the frequency of masturbation; (c) Mediating analyses for the association between  $Z$  consumption and the frequency of dyadic sex; Standardized regression coefficients were used;  $* p < 0.05$ ,  $^{**} p < 0.01$ ,  $^{***} p < 0.001$ ;  $C'_1$  and  $C_1$  = Standardized direct and total effect when using feelings of sexual arousal and disgust as mediators;  $C'_2$  and  $C_2$  = Standardized direct and total effect when using sexual desire as mediator.

**Table 2.** Correlations between Z consumption, sexual desire, and sexual behavior-related variables.

	<i>M</i>	<i>SD</i>	1	2	3	4	5	6	7
1. Sex	-	-	1						
2. Age	28.72	5.22	0.076	1					
3. Relationship length	6.03	2.48	0.057	0.676 ***	1				
4. The number of sexual partners	1.88	1.73	0.191 ***	0.234 ***	0.222 ***	1			
5. Health condition <sup>a</sup>	2.00	0.90	-0.04	-0.100 *	-0.151 ***	-0.072			
6. Z <sub>wk</sub>	2.36	1.85	0.01	0.215 ***	0.224 ***	0.169 **	-0.086	1	
7. Sexual desire	3.75	0.94	0.306 ***	0.190 ***	0.300 **	0.284 **	-0.239 ***	0.215 ***	1
Frequency of Sexual Fantasy	2.14	2.26	0.214 ***	-0.017	-0.001	0.260 **	-0.065	0.254 ***	0.453 ***
Frequency of Masturbation	0.70	1.37	0.086	-0.108 *	-0.103 *	0.062	0.04	§ 0.107 *	0.397 ***
Frequency of Dyadic Sex	1.09	1.27	0.148 ***	0.148 ***	0.275 ***	0.281 **	-0.157 ***	0.350 ***	0.473 ***
Disgust during Sexual Fantasy	1.89	1.47	0.005	-0.099 *	-0.076	-0.099 *	0.135 **	-0.006	-0.156 **
Disgust during Masturbation	2.16	1.61	0.085	-0.016	0.001	-0.129	0.033	-0.06	-0.079
Disgust during Dyadic Sex	1.42	1.22	-0.029	-0.082	-0.043	-0.047	0.093	0.03	-0.043
Sexual arousal during Sexual Fantasy	5.39	1.61	0.041	0.199 ***	0.220 ***	0.085	-0.144 **	0.129 **	0.405 ***
Sexual arousal during Masturbation	5.87	1.64	-0.101	-0.012	0.043	-0.148 *	0.029	§ 0.113	0.177 *
Sexual arousal during Dyadic Sex	6.26	1.31	0.082	0.208 ***	0.262 ***	0.151 **	-0.241 ***	0.170 ***	0.428 ***

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ ; <sup>a</sup> = Higher scores indicate poorer health condition; Z<sub>wk</sub> = Weekly ginger consumption; § refers that the significance of interaction has changed from "significant" to "nonsignificant" or "nonsignificant" to "significant" via using Z<sub>tot</sub> as the independent variable.

### 3.2.1. Mediating Analyses for the Relationship between $Z_{wk}$ and the Frequency of Sexual Fantasy

Feelings of sexual arousal during Sexual Fantasy mediated the relationship between  $Z_{wk}$  and the frequency of Sexual Fantasy ( $B = 0.032$ ,  $SE = 0.015$ , 95% CI [0.01, 0.07]), whereas there was no mediating effect of feelings of disgust during Sexual Fantasy ( $B = 0.001$ ,  $SE = 0.006$ , 95% CI [-0.01, 0.02]). Also, sexual desire ( $B = 0.108$ ,  $SE = 0.024$ , 95% CI = [0.06, 0.16]) mediated the association between  $Z_{wk}$  and the frequency of Sexual Fantasy (see Figure 1a). The mediating effects of feelings of sexual arousal disappeared after controlling for covariates and sex, whereas the mediating effect of sexual desire was stable after controlling for the covariates and sex.

### 3.2.2. Mediating Analyses for the Relationship between $Z_{wk}$ and the Frequency of Masturbation

The mediating effects of the feelings of disgust and sexual arousal during Masturbation were not significant ( $B = 0.004$ ,  $SE = 0.005$ , 95% CI [-0.01, 0.02];  $B = 0.010$ ,  $SE = 0.012$ , 95% CI [-0.01, 0.04]). Sexual desire ( $B = 0.063$ ,  $SE = 0.018$ , 95% CI [0.03, 0.10]) mediated the relationship between  $Z_{wk}$  and the frequency of Masturbation (see Figure 1b). The mediating effect of sexual desire was stable after controlling for covariates and sex.

### 3.2.3. Mediating Analyses for the Relationship between $Z_{wk}$ and the Frequency of Dyadic Sex

Feelings of sexual arousal during Dyadic Sex mediated the relationship between  $Z_{wk}$  and the frequency of Dyadic Sex ( $B = 0.021$ ,  $SE = 0.006$ , 95% CI [0.01, 0.04]), whereas there was no mediating effect of feelings of disgust ( $B < 0.001$ ,  $SE = 0.002$ , 95% CI [-0.01, 0.003]). Also, sexual desire ( $B = 0.062$ ,  $SE = 0.016$ , 95% CI = [0.03, 0.10]) mediated the association between  $Z_{wk}$  and the frequency of Dyadic Sex (see Figure 1c). The mediating effects of feelings of sexual arousal and sexual desire were stable after controlling for covariates and sex.

In addition, after including all mediators (feelings of sexual arousal, feelings of disgust, and sexual desire) in one mediation model, we found that only sexual desire was a stable mediator for the association between  $Z_{wk}$  and the frequency of Sexual Fantasy ( $B = 0.088$ ,  $SE = 0.024$ , 95% CI = [0.05, 0.14]), the frequency of Masturbation ( $B = 0.10$ ,  $SE = 0.043$ , 95% CI = [0.04, 0.20]), and the frequency of Dyadic Sex ( $B = 0.077$ ,  $SE = 0.023$ , 95% CI = [0.04, 0.13]).

### 3.3. Exploratory Mediation Analyses

In addition to the significant association between  $Z_{wk}$  and feelings of sexual arousal during sexual behavior as well as the negative relationship between sexual arousal and disgust,  $Z_{wk}$  may have an indirect impact on feelings of disgust via its enhancing effect on sexual arousal. Thus, to explore how consumption of Z was associated with feelings of disgust during each sexual behavior further, a series of exploratory mediation analyses were conducted. The results show that feelings of sexual arousal during Sexual Fantasy completely mediated the association between  $Z_{wk}$  and feelings of disgust during Sexual Fantasy ( $B = -0.022$ ,  $SE = 0.012$ , 95% CI = [-0.05, -0.003]), and feelings of sexual arousal during Dyadic Sex completely mediated the association between  $Z_{wk}$  and feelings of disgust during Dyadic Sex ( $B = -0.030$ ,  $SE = 0.009$ , 95% CI = [-0.05, -0.02]). Feelings of sexual arousal during Masturbation could not mediate the association between  $Z_{wk}$  and feelings of disgust during Masturbation ( $B = -0.023$ ,  $SE = 0.024$ , 95% CI = [-0.08, 0.01]).

## 4. Discussion

The current study was the first cross-sectional study to explore if and how consumption of Z as part of one's daily diet is associated with sexual desire, sexual behavior, feelings of sexual arousal, and disgust during sexual behavior. We found significant positive associations between the consumption of Z, sexual desire, and sexual behavior-related variables. Also, the results show that sexual desire and sexual arousal mediated the

associations between consumption of Z and sexual behaviors, whereas it did not lend clear support for a model where the effects of Z are mediated by its disgust-reducing properties.

#### *4.1. The Association between Z Consumption, Sexual Desire, and Sexual Behaviors-Related Variables*

As expected, our findings showed that Z consumption was significantly associated with sexual desire, as well as the frequency of sexual fantasy, masturbation, and dyadic sexual behaviors. Additionally, there was a significant correlation between Z consumption and feelings of sexual arousal during sexual fantasy and dyadic sexual behaviors, consistent with H1. These findings were also in line with the limited empirical evidence suggesting an effect of Z on sexual function in humans [22,23], which suggested that Z may be a potential intervention to improve the sexual behavior of individuals and couples.

#### *4.2. Potential Pathways behind Association between Z Consumption and Sexual Behaviors*

Z has traditionally been used as a herbal aphrodisiac [20,21]. However, its effect on sexual behavior in humans has not yet been investigated systematically, whereas the sexual arousal-disgust rival hypothesis has pointed out two possible pathways for how the consumption of Z could influence human sexual activity.

Z might potentially improve sexual behaviors via suppressing feelings of disgust elicited by sexual stimuli (D model). However, our findings revealed that Z consumption showed no significant relationship with feelings of disgust during sexual behaviors. This finding is partly in line with the study conducted by Wen et al. in which it was found that temporary Z consumption (1.5 g) could not suppress feelings of disgust induced by sexual body fluids but did alleviate the suppressing effects of disgust on sexual arousal in women [26].

A reason why the effect of Z on disgust is not stable could be that Z acts on disgust in ways that are not reflected in the conscious experience of disgust. Z and its compounds, 6-gingerol and 6-shogaol, interact with the 5-HT3 signaling pathway and inhibit 5-HT3 receptor (resulting in physical vomiting and nausea) activation and then reduce nausea and vomiting symptoms [40,41]. Additionally, most of the participants in the current study were in a committed relationship so they may be reluctant to report information involving feelings of disgust during their sexual behaviors with their partner. Despite numerous studies having indicated that Z consumption can effectively alleviate nausea and vomiting symptoms [40,41], the research focusing on the direct effect of ginger on subjective feelings of disgust remains limited. Only two experiments have been conducted by Wen [26] and Tracy [27] previously. Thus, further experimental work is needed to explore if and how the consumption of Z has a direct effect on feelings of disgust and sexual behavior.

Another potential pathway is that Z consumption may improve sexual behaviors by positively influencing sexual arousal and desire. Previous studies have shown that long-term use of Z can enhance psychological sexual arousal and desire in women as well as physical erectile function in men [22,23]. Moreover, temporary consumption of 1.5 g of Z has been found to increase feelings of sexual arousal in response to erotic stimuli [26]. Consistent with these findings, the present study suggests that Z consumption is associated with higher levels of sexual desire and arousal during sexual behavior, and then these factors mediate the relationship between Z consumption and sexual behaviors.

The mechanism behind the effects of Z consumption on improvements in sexual desire and sexual arousal would be that Z consumption may increase testosterone levels in humans. Testosterone has been repeatedly found to be positively associated with sexual desire [8,42–44] and has been used to treat low sexual desire in endocrine conditions with testosterone deficiency in women [43]. For instance, women in menopause with low sex desire reported higher sexual desire, more satisfying sexual events, and lower personal distress after receiving testosterone injections [45,46]. Testosterone therapy can be used to treat low sexual desire also in men with low to normal testosterone levels [47] and improve men's erectile and ejaculatory function in the long term, though individual responsivity

varies [48–50]. Despite the lack of evidence regarding the effects of Z on testosterone in humans, some preliminary findings with rats have found that administration of Z increased testosterone levels via increasing serum testosterone, and testicular weight, and then improved male rats' sperm motility and sexual performance [24,51]. Thus, Z consumption may increase testosterone levels in men and women, which then increases their sexual desire, arousal, and frequency of sexual behaviors.

In addition to hormones, neurochemical studies have suggested that neurotransmitters play essential roles in sexual desire and behavior of human beings. For example, Pfaus's review [52] suggested that serotonin augmented sexual inhibition and reduced sexual behavior, whereas dopamine and norepinephrine exerted their effects in hypothalamic and limbic brain regions, intensifying sexual excitation, arousal, and augmenting sexual desire and behavior. Considering the potential role of Z as serotonin receptor antagonists, it may also contribute to reducing sexual inhibition and thereby enhancing sexual desire, arousal, and sexual behavior. Recent research also indicates that Z and its compounds may enhance the production of nitric oxide, a vasodilator [51]. This elevation in nitric oxide can augment blood circulation in the testes, potentially raising testosterone levels, and in the penis, promoting erections [51,53]. The physiological mechanisms underlying the influence of Z on human sexual responses are likely to be multifaceted. However, the current study had no direct measurements regarding the effects of Z consumption on testosterone or neurotransmitters, experimental interventions that investigate neurochemical changes are needed to verify this hormonal and neurochemical model in the future.

Finally, the lack of observed suppressing effects of Z consumption on disgust and the failure to mediate the relationship between Z consumption and the frequency of sexual behaviors, consistent with the findings of Wen et al.'s study [26], suggest that the Disgust model may not be the primary pathway through which Z consumption influences sexual behaviors. Contrary to the Disgust model that Z consumption decreased feelings of disgust during sexual behaviors, resulting in improvement in sexual arousal during sexual behaviors and increases in the frequency of sexual behaviors, exploratory mediating analyses revealed a different pattern. Specifically, feelings of sexual arousal completely mediated the associations between Z consumption and feelings of disgust during sexual fantasy and dyadic sexual behaviors, suggesting a more possible way that Z consumption first increases feelings of sexual arousal and sexual desire to sexual behaviors, whereas elevated sexual arousal and sexual desire inhibits feelings of disgust and might have an effect on human sexual behavior.

#### 4.3. Strengths and Limitations

Our study is the first cross-sectional study to explore if and how consumption of Z as part of one's daily diet was related to one's sexual life. The results from the current study augment existing evidence on this area, but experimental investigations and long-term interventions are indicated.

The present study also had some limitations. First, mediation analysis is causal relation and implies a temporal ordering of the variables involved. Given that the study is correlational, it is not possible to establish the direction of causation even if the mediating effects are statistically significant. However, it is not immediately clear how increased sexual activity and arousal would result in increased consumption of Z. A more likely direction of causation is that Z consumption results in changes in sexual behavior and arousal, while the temporal precedence of mediators and outcomes is not clear. Also, current mediation analysis had no control for the covariates, not only confounding the effect between independents, mediators, and outcomes, but also the possibility of a third variable increasing both consumption of Z, sexual behavior, and arousal cannot be excluded. We found that general physical health which has previously been found to be associated with sexual behavior was positively related to Z consumption and could be a potential third variable explaining the association between Z consumption and sexual function without there being a causal relationship [5]. However, results regarding the relationship

between  $Z_{wk}$  and sexual behavior did not change whether general physical health was included as a covariate or not. Therefore, to explore the potential pathways underlying the association between  $Z$  consumption and sexual behavior, longitudinal and experimental intervention studies should be conducted. Then, the current survey did not distinguish individuals with healthy sexual function from those with sexual difficulties. However, given that sexual difficulties are quite prevalent [5,6,54], many participants likely had some level of sexual problems. Future studies should assess sexual dysfunctions as well. In addition, participants were recruited through online platforms and the features of the participants such as young age and well education may bias the results of the study. Finally, there was no standardization in the measurement of  $Z$  consumption. Consequently, future research endeavors should use or develop methodologies that enable a more precise quantification of  $Z$  consumption (e.g., 24 h or 7-day Dietary Recall measuring the quantity of  $Z$  consumption).

## 5. Conclusions

Complementing experimental evidence suggesting that  $Z$  can improve sexual function in both men and women, the current study investigates how daily  $Z$  consumption is associated with sexual behavior-related variables and the potential pathways behind this effect. The results show that  $Z$  consumption was positively associated with the frequency of sexual behaviors, feelings of sexual arousal during sexual behaviors, and sexual desire, suggesting that  $Z$  could have been used in the treatment to improve sexual behaviors and function via its enhancing effects on sexual desire and sexual arousal. Intervention studies and longitudinal research are needed to provide causal evidence of the effect of  $Z$  on sexual behavior in both men and women.

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