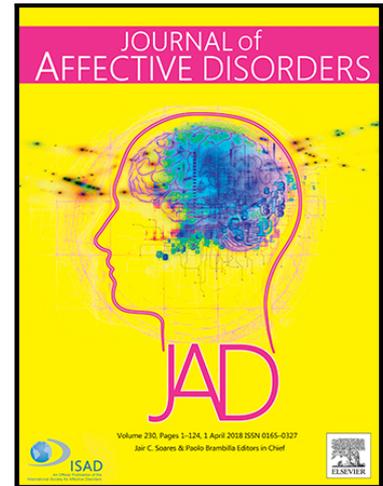


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### Highlights

- More severe insomnia predicted greater perceived burdensomeness post-Cyberball
- More severe insomnia predicted lower desire for emotional support post-Cyberball
- Insomnia symptoms were not significantly related to thwarted belongingness post-Cyberball
- Findings were not explained by social anxiety symptoms

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### Abstract

**Background.** Research suggests that insomnia is associated with elevated perceptions of loneliness and social disconnection; however, few quasi-experimental studies have tested the relationship between these constructs. This study examined whether insomnia symptom severity predicts changes in perceptions of interpersonal connectedness and desire for emotional support following in-laboratory participation in a social exclusion paradigm.

**Methods.** Young adults ( $N=70$ ) completed self-report measures assessing constructs of interest before and after engaging in a social exclusion paradigm (Cyberball). Linear regression analyses were used to evaluate whether baseline insomnia symptom severity predicted perceived burdensomeness, desire for emotional support, and thwarted belongingness after playing Cyberball; analyses controlled for baseline perceived burdensomeness, desire for emotional support, and thwarted belongingness, respectively, as well as baseline social anxiety and depression symptoms.

**Results.** Greater insomnia symptom severity significantly predicted greater feelings of perceived burdensomeness following Cyberball participation, beyond baseline perceived burdensomeness and social anxiety and depression symptoms ( $\beta=.26, p=.001$ ). More severe insomnia symptoms also significantly predicted lower desire for emotional support after playing Cyberball, beyond baseline desire for emotional support and social anxiety symptoms ( $\beta=-.14, p=.03$ ) but not beyond depression symptoms ( $\beta=-.16, p=.07$ ). Insomnia symptoms were not significantly associated with thwarted belongingness after Cyberball ( $\beta=-.05-.08, p=.27-.57$ ).

**Limitations.** Replication in larger samples and using other sleep disturbance indices is needed.

**Conclusions.** Findings suggest that individuals with more severe insomnia symptoms in the past two weeks experience greater perceptions of being a burden on others and less desire for emotional support in response to social exclusion.

*Keywords.* insomnia; loneliness; perceived burdensomeness; emotional support; Cyberball

Insomnia is a common problem in the general population. Approximately one-third of individuals experience at least one insomnia symptom (i.e., difficulties falling asleep, staying asleep, or waking up too early) at any given time (Morin et al., 2006). Not only may the

experience of insomnia itself be inherently distressing (American Psychiatric Association[APA], 2013), but a growing body of research also indicates that insomnia is associated with a range of other negative physical and mental health consequences, including elevated risk for heart disease (Taylor et al., 2007), depression (Baglioni et al., 2011), and suicide (Bernert et al., 2015). One notable domain that insomnia also appears to negatively impact is interpersonal functioning.

Numerous studies suggest that insomnia may be associated with greater interpersonal problems, loneliness, and feelings of social disconnection. For instance, in Roberts and colleagues' (2002) study of 3,136 adolescents, more severe insomnia at baseline significantly predicted worse parental relationships, lower perceived social support, and more problems with peers one year later, even after controlling for baseline interpersonal functioning. A six-sample investigation conducted by Hom and colleagues (2017b) found that insomnia was both cross-sectionally and longitudinally associated with greater perceptions of loneliness and thwarted belongingness (i.e., lack of meaningful social connection; Joiner, 2005; Van Orden et al., 2010) among undergraduate students, adult psychiatric outpatients, and individuals at elevated suicide risk; these associations remained significant after accounting for the effects of some (e.g., anxiety symptoms), but not all (e.g., depression symptoms) associated psychiatric domains. Significant associations between insomnia and loneliness have also been observed in cross-sectional studies of military service members and veterans (Hom et al., 2017a), cross-sectional and prospective studies of community samples (Chu et al., 2017), and cross-sectional studies of non-Western populations (Chu et al., 2016). Together, this compendium of work indicates that insomnia is significantly related to greater interpersonal problems across populations.

These observational studies, though useful in supporting the existence of a relationship between insomnia and interpersonal problems, also have critical limitations. First, a cross-

sectional approach limits our ability to draw conclusions regarding the temporal relationship between insomnia and interpersonal problems. Furthermore, the existing prospective studies follow individuals over relatively long periods of time (e.g., several months, one year). Though, in these instances, the temporal ordering of constructs can be evaluated, these studies do not provide information regarding whether insomnia may be a near-term risk factor for the development of interpersonal problems. Finally, previous studies have focused on establishing relationships between insomnia and *self-reported* interpersonal problems. Little is known regarding how individuals experiencing more severe insomnia symptoms react, in real-time, to stressful interpersonal dynamics with which they may be confronted.

To address these limitations, studies that allow for a degree of real-time evaluation of the relationship between insomnia and interpersonal functioning are needed. Such research may help illuminate whether insomnia predicts difficulties in interpersonal functioning over an acute period. To our knowledge, only one in-laboratory study has sought to specifically examine the relationship between sleep deprivation and social exclusion experiences. This study randomly assigned 96 healthy young adults screened for chronotype and sleep hygiene to either a sleep-deprivation or well-rested condition (Liu et al., 2014). Participants then completed Cyberball, a computerized ball-tossing laboratory task that simulates social exclusion. In this task, participants were either included or excluded (unbeknownst to them) by two other computerized players (Williams and Jarvis, 2006; Hartgerink et al., 2015). That is, participants were either passed a virtual ball periodically throughout the game (included) or not passed the virtual ball throughout the game (excluded). In Liu and colleague's (2014) study, participants who experienced exclusion reported poorer mood and decreased sense of belonging, control, self-

esteem, and meaningful existence; however, one night of sleep deprivation did not appear to influence the effects of Cyberball on participants.

Although Liu and colleagues' (2014) findings may appear to suggest sleep deprivation does not impact responses to social exclusion, it is important to note that this study included only healthy young adults and not individuals with chronic insomnia. It is possible that individuals with clinically significant insomnia symptoms (long-term reduced sleep duration, marked functional impairment and distress) and comorbid psychiatric problems may be more negatively impacted by social exclusion. Indeed, an observational study found that insomnia sufferers rated the impact of daily minor stressors and intensity of major negative life events higher than good sleepers (Morin et al., 2003). Therefore, it may be that individuals with longstanding insomnia, in particular, have differential reactions to negative life experiences as compared to good sleepers or good sleepers following a brief bout of sleep deprivation. Studies are thus needed to empirically investigate whether endogenous insomnia (rather than acute sleep deprivation) impacts how individuals respond to social stressors in controlled, laboratory social stressor paradigms. In so doing, we may better understand how insomnia confers increased risk for the development of other psychiatric problems with bases in interpersonal difficulties, such as depression (Hames et al., 2013).

### **Present Study**

The overarching goal of this study was to evaluate whether individuals with more severe insomnia symptoms might be more negatively impacted by an experience of social exclusion. Specifically, we aimed to evaluate if insomnia symptom severity would predict thwarted belongingness, perceived burdensomeness (i.e., feeling that others would be better off if one were dead; Joiner, 2005; Van Orden et al., 2010), and desire for emotional support after

completing an in-laboratory social exclusion paradigm. Data for this study were obtained from a larger investigation that did not assign a comparison group to the social *inclusion* condition. Thus, the present study represents an initial exploration of this topic. Based on prior research, we hypothesized that more severe insomnia symptoms would predict significantly: (1) *greater* thwarted belongingness; (2) *greater* perceived burdensomeness; and (3) *less* desire for emotional support following participation in Cyberball, controlling for depression and social anxiety symptom severity. We examined these hypotheses in a sample of young adults given this group's high rates of insomnia (Owens, 2014) and the robust associations between insomnia, loneliness, and depression found in other young adult samples (Buysse et al., 2008; Hom et al., 2017b).

Research on the association between sleep and psychopathology has primarily focused on insomnia symptoms as a broad construct and greater emphasis on specific sleep measures is needed (Alvaro et al., 2013). As recommended by Alvaro and colleagues (2013), we conducted exploratory analyses to determine whether specific sleep behaviors—sleep onset latency (difficulties falling asleep), wake after sleep onset (difficulties staying asleep), and early morning wakening—would impact thwarted belongingness, perceived burdensomeness, and desire for emotional support after experiencing social exclusion. This approach may not only elucidate specific mechanisms linking sleep and daytime social behaviors, but also reveal aspects of sleep that are most important for intervention. These analyses are considered exploratory as this study was limited to one self-report measure of insomnia symptoms.

Of note, we elected to control for baseline depression and social anxiety symptoms to examine whether insomnia symptom severity, specifically, and not general distress or related psychiatric problems (APA, 2013), might explain possible changes in perceptions of and desires for interpersonal connection. Additionally, prior research has been equivocal regarding whether

insomnia remains significantly associated with social disconnection after controlling for psychiatric symptoms (e.g., Hom et al., 2017b). Thus, we aimed to further elucidate the relationship between these constructs. In the Methods and Results, thwarted belongingness and perceived burdensomeness were abbreviated as TB and PB, respectively, for brevity.

## Method

### Participants and Procedures

Young adults ( $N=70$ ) were recruited from a university in the Southeastern United States (U.S.) and the surrounding community; however, the majority were undergraduate students (94.3%,  $n=66$ ) with an average age of 20.4 years ( $SD=5.8$ , range=18-57). Most were single/never married (88.6%,  $n=62$ ). The majority identified as female (75.7%,  $n=53$ ), White (82.9%,  $n=58$ ), and Non-Hispanic (67.1%,  $n=47$ ). See Table 1 for details.

Study data were obtained from a quasi-experimental study examining suicide risk factors within social and biological domains (Chu et al., under review). The insomnia symptom measure was added after the start of data collection for the original investigation, thus, only participants who were administered the insomnia symptom measure were included in this study (70.0% of original  $N$ ). Participants were recruited via flyers and the University's research recruitment website. Approximately one-third of the original study participants reported current depression symptoms and at least one prior suicide attempt and another third of the participants only reported current depression symptoms. Eligible participants were at least 18 years old and had no history of cognitive deficits precluding informed consent; participants who (1) had been pregnant or nursing in the last six months, (2) had previously participated in the social exclusion paradigm, (3) reported a history of cognitive impairments, and (4) reported a significant fear of blood, injections, or needles were excluded.

Interested individuals attended an in-laboratory study visit where they first reviewed the consent form, study procedures and possible risks. During this process, participants were informed that this study aimed to better understand psychological and biological reactions to online games. Enrolled participants completed a battery of self-report measures (see Measures). Participants then played Cyberball—a virtual ball-throwing task that has been extensively validated as a laboratory-based social exclusion paradigm (Hartgerink et al., 2015; Williams and Jarvis, 2006). Subsequently, participants completed the two measures of interpersonal connectedness (Interpersonal Needs Questionnaire, Interpersonal Orientation Scale) that were also completed prior to Cyberball. All measures and tasks were completed on a computer in a private laboratory room. Upon completion, all participants were debriefed regarding study goals and provided with mental health resources and compensation for participation (research participation credits for a psychology course or \$30). Of note, for the original investigation, blood samples were collected from participants' non-dominant arm via venipuncture prior to and following Cyberball; however, biological data were not included in this manuscript as they are peripheral to our study aims.

### **Cyberball**

Cyberball is a computerized task requiring approximately 5-10 minutes to complete. In this task, participants passed a virtual ball to other players in the game. Participants were informed that they are playing with two students from other universities; however, participants were, in reality, passing the ball to players controlled by a computer program. To enhance participants' beliefs that they were indeed playing against other students, prior to starting the task, participants were asked to select an avatar from five options of personalized display pictures and told that this avatar will be visible to other players. Avatars for the two fictitious

players also appear on the screen. After instructions were presented, the Cyberball program displayed three characters and the images of the two other players with whom the participant is playing; the players were labeled “Player A,” “Player B,” and “You.” Participants pass to other players by clicking the other players’ avatar. Cyberball was set for 40 throws. Given the original study’s aims, all participants were allotted to the exclusion condition—participants received the ball twice at the beginning and were excluded by the other two players for the rest of the game. During debriefing, participants were informed that the other players were computerized and the game was used to simulate the experience of social exclusion.

**Cyberball Manipulation Check** (Williams et al., 2002). Three items were included to determine whether participants experienced feelings of social exclusion during Cyberball. Participants estimated the percentage of throws they received during the game and rated the following two statements on a 5-point Likert scale ranging from 0 (*strongly disagree*) to 4 (*strongly agree*): “I was ignored,” and “I was excluded.” Higher scores indicate greater perceived exclusion.

## Measures

**Insomnia Severity Index (ISI; Morin et al., 2003).** The ISI is a 7-item measure of insomnia symptom severity in the past two weeks. Items assess difficulties falling asleep (sleep onset latency; item 1), staying asleep (wake after sleep onset; item 2), waking up too early (early morning waking; item 3), and the impact of sleep problems (items 5-7). Items are rated on Likert scales with varying item responses, and total scores are obtained by summing the scores from all items (range=0-28). Total scores of 8 to 14 indicate subthreshold insomnia symptoms, and total scores of 15 to 21 and 22 to 28 indicate clinical insomnia of moderate and severe severity, respectively. In this study, the ISI total score was used as an index of overall insomnia

symptom severity. To evaluate the relationship between specific sleep behaviors and social functioning, exploratory analyses were conducted with ISI items 1 to 3 entered as predictor variables. The ISI has adequate internal consistency and construct validity for use in adult populations (Morin et al., 2003). Individually, items 1 to 3 have demonstrated adequate correlations with sleep diary measures of sleep onset latency, wake after sleep onset, and total wake time ( $r_s=.56-.59$ ; Morin et al., 2003). Although test-retest reliabilities for individual items were not examined in the original psychometrics study (Morin et al., 2003), our research group found adequate item-level retest reliability in a sample of 259 undergraduate students evaluated at baseline and one-month follow-up (item 1  $r=.62$ , item 2  $r=.62$ , item 3  $r=.59$ , all  $p_s<.01$ ; Hom et al., in preparation). In this sample, ISI total score showed good internal consistency ( $\alpha =.88$ ).

**Interpersonal Needs Questionnaire-15 (INQ; Van Orden et al., 2012).** The INQ is a 15-item measure of TB and PB. According to the interpersonal theory of suicide, these constructs represent unmet interpersonal needs that may contribute to suicidal desire (Joiner, 2005; Van Orden et al., 2010). Nine items measure TB, and 6 items measure PB. Participants were asked to rate these perceptions on a 7-point Likert scale ranging from 1 (*not at all true for me*) to 7 (*very true for me*) based on “recent” beliefs and experiences. For this study, the instructions were modified such that participants rated their feelings in the present moment. Total scores were obtained by summing items for each subscale. Higher scores indicated greater severity; the range was 9 to 63 for TB and 6 to 42 for PB. The INQ has demonstrated good internal consistency in young adult samples (Van Orden et al., 2012). To our knowledge, there is no psychometric data on the sensitivity of the INQ over time; however, both scales exhibited excellent internal consistency at pretest (both  $\alpha_s=.94$ ) and posttest (TB  $\alpha=.92$ ; PB  $\alpha=.96$ ).

**Interpersonal Orientation Scale (IOS; Hill, 1987).** The IOS is a 26-item measure of dimensions that motivate social affiliation, including desire for emotional support, desire for positive social stimulation, engagement in social comparisons, and desire for attention. In this study, only the desire for emotional support scale (IOS-ES) was included because the IOS-ES subscale is most strongly correlated with motivation to affiliate with others (Hill, 1987), which aligns with study goals. On the 6-item IOS-ES subscale, items are rated on a 5-point Likert scale ranging from 1 (*not at all true*) to 5 (*completely true*), with higher scores indicating greater desire for emotional support (range=1-30). The IOS-ES has exhibited excellent internal consistency in young adult samples (Hill, 1987), and in this sample, it also demonstrated good internal consistency at pretest ( $\alpha=.89$ ) and posttest ( $\alpha=.94$ ).

**Brief Fear of Negative Evaluation-Straightforward (BFNE-S; Carleton et al., 2011).** The BFNE-S is an 8-item measure of fears of negative evaluation. This measure is composed of all the items from the original BFNE that were *not* reverse-scored (Leary, 1983) and has demonstrated excellent reliability and validity as a proxy measure of social anxiety symptom severity in young adult samples (Rodebaugh et al., 2004). Items are rated on a 5-point Likert scale ranging from 0 (*not at all characteristic of me*) to 4 (*extremely characteristic of me*), and higher scores indicate greater severity. In this study, the BFNE-S demonstrated excellent internal consistency at pretest ( $\alpha=.94$ ).

**Beck Depression Inventory-II (BDI-II; Beck et al., 1996).** The BDI-II is a 21-item measure of depression symptom severity in the past two weeks. Items are rated on 4-point Likert scales with varying item responses; greater total scores indicate more severe symptoms (range=0-63). Reliability and validity has been supported in young adult college student samples

(Storch et al., 2004). In this study, the BDI-II exhibited excellent internal consistency at pretest ( $\alpha=.93$ ).

### **Statistical Analyses**

**Preliminary Analyses.** First, descriptive statistics were conducted to examine the characteristics of all variables; outliers and skew were also examined. Linear regression analyses were conducted to examine the relationship between insomnia symptoms (ISI-total) and the following baseline variables: TB (INQ), PB (INQ), and desire for emotional support (IOS). Finally, items used to evaluate Cyberball's efficacy were examined descriptively and in relation to insomnia symptoms.

**Main Analyses.** Multiple hierarchical regression analyses were conducted to examine the relationship between insomnia symptoms (ISI-total) and social functioning after playing Cyberball. The following models were tested: (1) insomnia symptoms as the predictor and posttest PB as the dependent variable, controlling for pretest PB, (2) insomnia symptoms as the predictor and posttest desire for emotional support as the dependent variable, controlling for pretest desire for emotional support, and (3) insomnia symptoms as the predictor and posttest TB as the dependent variable, controlling for pretest TB.

**Exploratory Analyses.** Given calls for greater specificity in sleep research (Alvaro et al., 2013), we evaluated the impact of specific sleep behaviors on each measure of social connectedness post-Cyberball. The following exploratory models were examined in relation to PB: (1) sleep onset latency (ISI-item 1) as the predictor and posttest PB as the dependent variable, controlling for pretest PB, (2) sleep onset latency as predictor and posttest desire for emotional support as the dependent variable, controlling for pretest desire for emotional support, and (3) sleep onset latency as predictor and posttest TB as dependent variable, controlling for

pretest TB. Subsequently, we tested the aforementioned three models with wake after sleep onset (ISI-item 2) as the predictor. Lastly, early morning wakening (ISI-item 3) was entered as the predictor in these three models. Given the exploratory nature of these analyses, we used a conservative Bonferroni correction (.05/12 tests) was used to set the criterion for rejecting the null hypothesis ( $\alpha=.004$ ).

**Covariates.** In addition to pretest variables, social anxiety (BFNE-S) and depression (BDI-II) symptoms were covaried stepwise into analyses given that these symptoms may also contribute to social withdrawal (Maner et al., 2007) and loneliness (Fung et al., 2017).

**Analytical Approach.** All regression models were hierarchical—insomnia symptoms (ISI-total, ISI-items 1 to 3) and pretest variables (pretest INQ TB/PB, IOS-ES) were entered in Step 1, social anxiety symptoms (BFNE-S) were covaried in Step 2, and depression symptoms (BDI-II) were covaried in Step 3. Covariates were entered at different steps to determine the individual impact of each covariate on the hypothesized relationships, particularly given past research covarying depression has yielded inconsistent findings (Hom et al., 2017). Tolerance and variance inflation factor (VIF) values were examined for all regressions to evaluate multicollinearity. Suppression was also examined for all regressions. Power analyses, conducted using G\*Power, indicated adequate power (.81) to detect small-to-moderate effects ( $f^2=.12$ ) with a sample of 70 using regression analyses with 1 tested predictor (insomnia) and 4 total predictors (insomnia; pretest TB, PB, or desire for emotional support; depression symptoms; and social anxiety symptoms). Analyses were conducted using SPSS 23.

## Results

Descriptive information for study variables is presented in Table 2. All variables evidenced acceptable skew; no outliers were identified. Based on ISI clinical cutoffs, 54.3% of

participants reported non-clinically-significant insomnia symptoms ( $n=38$ ), 10.0% reported subthreshold insomnia symptoms ( $n=7$ ), 34.3% reported moderately severe symptoms ( $n=24$ ), and 1.4% reported severe symptoms ( $n=1$ ) in the past two weeks. At baseline, ISI insomnia symptoms were significantly associated with greater pretest INQ TB ( $r=.60, p<.001$ ) and INQ PB ( $r=.33, p<.05$ ); however, ISI insomnia severity was not significantly related to pretest IOS desire for emotional support ( $r=-.14, p=ns$ ).

After playing Cyberball, participants estimated that they received 10.3% of throws, which is consistent with previous studies (Williams et al., 2002). As expected, the majority of participants reported that they felt ignored ( $M=2.7$ , range=1-3) with the modal response being “agree” (73.1%) and most reported feeling excluded (mean=2.8, range=1-3) with the modal response being “agree” (80.6%). These findings support the efficacy of the social exclusion paradigm. ISI insomnia severity was significantly correlated with perceptions of being ignored during Cyberball ( $r=.36, p=.002$ ), but not significantly related to participants’ estimated percentage of throws received ( $r=-.07, p=ns$ ) or perceptions of being excluded ( $r=.22, p=ns$ ).

Results of main analyses are detailed in Table 3; the results of the exploratory analyses are summarized below and detailed in the Supplementary Materials (Appendix A). For all models, tolerance and VIF values were within acceptable ranges ( $>.10$  or  $<10$ , respectively);  $\beta$  values were also within appropriate ranges ( $\beta < \text{zero-order correlation}$ ) and did not indicate suppression effects.

### Main Analyses

First, we examined whether individuals with more severe overall insomnia symptoms would be more greatly impacted by the experience of social exclusion than those with less severe insomnia symptoms. More severe insomnia symptoms was significantly associated with greater

PB after playing Cyberball, beyond pretest PB and social anxiety and depression symptoms ( $\beta=.24, p<.001$ ). More severe insomnia symptoms were also significantly related to lower desire for emotional support following Cyberball, beyond pretest desire for emotional support and social anxiety symptoms ( $\beta=-.14, p=.029$ ); however, this effect was no longer significant after controlling for depression ( $\beta=-.16, p=.068$ ). Beyond pretest TB and social anxiety and depression symptoms, overall insomnia symptoms were not significantly related to TB following Cyberball ( $\beta=-.05, p=.569$ ).

### Exploratory Analyses

Next, we conducted exploratory analyses to examine whether specific sleep behaviors predicted changes in social functioning following the experience of social exclusion. Greater sleep onset latency ( $\beta=.16, p<.004$ ) and early morning waking ( $\beta=.17, p<.004$ ) were significantly related to higher PB following Cyberball, beyond pretest PB but not beyond social anxiety and depression symptoms (Table 2, Supplementary Materials). Additionally, none of the specific sleep parameters investigated in this study were significantly related to desire for emotional support (Table 3, Supplementary Materials) and thwarted belongingness (Table 4, Supplementary Materials) after Cyberball.

### Discussion

In this investigation, support for our hypotheses was mixed. Nevertheless, our findings are empirically and clinically relevant in multiple ways. First, in line with existing work linking insomnia symptoms and perceived burdensomeness (Chu et al., 2017; Hom et al., 2017a), preliminary findings indicated that participants with more severe insomnia symptoms reported greater perceived burdensomeness after completing a laboratory-based social exclusion task. These results should be interpreted with caution as participants only completed a social exclusion

task and it is unclear whether results would differ if participants had experienced social *inclusion* in the laboratory.

There are multiple possibilities for why these preliminary findings indicated that perceived burdensomeness was the most strongly linked to insomnia. For one, prior research has shown that sleep disruptions are associated with increased reactivity to daily stressors (Minkel et al., 2012; Zohar et al., 2005), difficulties regulating and processing emotions (Gruber and Cassoff, 2014; Kyle et al., 2014; Mauss et al., 2013), and greater negative affect (Baum et al., 2014). Thus, when individuals with poor sleep health are faced with social stressors, these difficulties may lead to more intense negative emotions and cognitive distortions that one is a burden on others (Anestis and Joiner, 2011), which reinforces distance from others. Second, recent research suggests that insomnia symptoms are also related to lower levels of optimism and poorer self-esteem even beyond the effects of depression (Lemola et al., 2013). Given that low self-esteem is one of the two dimensions of perceived burdensomeness (Van Orden et al., 2010), it is also possible that individuals in this study reporting more difficulties with sleep also had lower self-esteem. The experience of a social stressor in this study may have reinforced feelings of low self-esteem. This may explain why insomnia symptom severity was more robustly related to perceived burdensomeness than thwarted belongingness. However, we were unable to test this hypothesis in this study. Future studies may benefit from including potential third variables, such as self-esteem, to better understand the nature of these results.

Consistent with prior work (Maner et al., 2007), results also indicated that more severe insomnia symptoms predicted less desire to seek emotional support after experiencing social exclusion. We were unable to examine the underlying mechanisms of this relationship; however, it is plausible that the numerous negative consequences associated with insomnia may contribute

to more frequent experiences of unrewarding social interactions. Insomnia has been linked to diminished daytime alertness, greater fatigue and negative mood, cognitive impairments (e.g., poorer decision-making ability, memory, and executive functioning), and difficulties navigating interpersonal stressors (Buysse et al., 2007; Fortier-Brochu et al., 2012; Gunn et al., 2014). Insomnia and its associated impairments may diminish ability to use effective interpersonal skills and form meaningful connections. Consequently, there may be little reward value in social support and diminished desire to seek out (previously unrewarding) social connections.

Strikingly, these findings emerged beyond the effect of social anxiety—a known to contributor to sleep problems (Buckner et al., 2008), perceptions that one is burdening others (Arditte et al., 2016), and sensitivity to interpersonal rejection (Harb et al., 2002), which was a salient experience during Cyberball. Although studies have accounted for general anxiety symptoms (Chu et al., 2017; Hom et al., 2017b), no work in this area has accounted for social anxiety symptoms specifically. As such, researchers were unable to determine whether the link between sleep and social functioning may be due to greater fear of social situations. This study was the first to our knowledge to show that this link exists beyond anxiety in social situations. This is especially important given the focus of prior work on college students (Chu et al., 2016; 2017; Hom et al., 2017b)—a population with high rates of social anxiety symptoms (Hakami et al., 2017; Russell and Shaw, 2009).

When depression was included as a covariate, we obtained mixed results. While the relationship between insomnia symptoms and perceived burdensomeness remained significant beyond depression symptoms, that between insomnia and desire for emotional support did not. Similarly, studies in this topic area that have accounted for depression have also obtained contrasting results. For example, Hom and colleagues (2017b) controlled for depression in five

of their six-sample investigation of insomnia and loneliness; in all five samples, this relationship was significant beyond anxiety but not depression. However, others have reported the relationship between loneliness and self-reported and actigraphy-based measures of sleep impairments remains significant beyond the effects of depression (Hawkley et al., 2010; Hayley et al., 2017, Kurina et al., 2011; Segrin and Burke, 2015). Altogether, the role of depression in the association between sleep and social functioning is unclear.

It is important to note that insomnia and depression overlap significantly and their relationship appears to be bidirectional, such that there is greater risk for developing insomnia when depression is present (odds ratio[OR]=6.2) and vice versa (OR=6.7; Sivertsen et al., 2012). Thus, covarying for depression may have contributed to over-adjustment and there may be little conceptual significance when variance from depression is removed from insomnia (cf. controlling for depression in analyses with suicidal ideation; Rogers et al., 2016). Depression also overlaps with perceived burdensomeness and thwarted belongingness (Silva et al., 2015), and (lower) desire for social support (APA, 2013); in our study, depression was highly correlated with insomnia and interpersonal variables ( $r_s=.57-.75$ ). Therefore, results with depression covaried should be interpreted with caution. To determine whether sleep and social functioning are linked outside of depression, future research could examine these variables in a quasi-experimental study of depressed patients and controls using ecological momentary assessment approaches.

Our results contrasted those reported by Liu and colleagues (2014). They found that the effect of social exclusion did not differ significantly based on acute sleep deprivation. One explanation is a difference in clinical severity—Liu and colleagues' (2014) did not recruit individuals with sleep problems; however, nearly half of our sample reported clinically

significant insomnia symptoms. Individuals with longstanding insomnia symptoms may be more greatly impacted by interpersonal challenges than those who experience temporary sleep deprivation with generally good sleep health. Further, given that longstanding insomnia is also correlated with poorer mental and physical well-being and increased stress among young adults (Taylor et al., 2013), another compatible explanation is that this link is impacted by third variables that were neither evaluated in this study nor that of Liu and colleagues (2014). To address these gaps, future studies may include potential moderating factors, such as stress and interpersonal coping abilities (Morin et al., 2003; Taylor et al., 2013) or substance use (e.g., stimulants, caffeine, alcohol). It is also noteworthy that Liu and colleagues' (2014) study was conducted in Singapore while this study was U.S. based given that Singapore's culture is more collectivistic while that of the U.S. is more individualistic (Galovan et al., 2010). Prior work has found that Cyberball participants from collectivistic cultural backgrounds show less psychological distress and physiological response during social exclusion. This may explain Liu and colleagues' (2014) results. Replication of these studies across cultural backgrounds is needed to determine whether the link between sleep and social functioning is culturally specific.

In contrast, insomnia symptoms were not significantly related to thwarted belongingness following social exclusion. Multiple studies across diverse samples, including this study, have reported a link between sleep difficulties and thwarted belongingness cross-sectionally (Chu et al., 2017). As no studies have examined the impact of social exclusion on thwarted belongingness, it is difficult to draw conclusions regarding the discrepancy between this study and prior research. One explanation is that in Cyberball, participants do not know and are not intimately connected to other "players." As such, being socially excluded in this computer-based paradigm may not markedly impact sense of connection with others (as assessed by the INQ). To

enhance connection with other players, researchers could invite a participant and a member of the participant's social network to a Cyberball study at the same time; this way, participants may be led to believe that they are being excluded by someone with whom they are connected. Given that thwarted belongingness is already high at baseline among participants reporting recent sleep difficulties, another possibility is that there is a ceiling effect—levels of thwarted belongingness remain high and do not change dramatically in response to a brief exclusion experience.

Finally, exploratory analyses largely did not indicate that specific sleep disturbances, including difficulties with wake after sleep onset, early morning wakening, and sleep onset latency, were associated with changes in interpersonal connectedness and desires for affiliation following social exclusion. Only sleep onset latency and early morning wakening significantly predicted of post-Cyberball perceived burdensomeness beyond pretest levels of burdensomeness, but not beyond depression and social anxiety symptoms. Sleep onset latency and early morning wakening have been linked to circadian rhythm disruptions, which have been hypothesized to increase susceptibility to experiencing negative outcomes in response to stressors (Karatsoreos, 2013). However, given the effects were no longer significant after accounting for other psychiatric symptoms and these preliminary findings were based on only one ISI item for each sleep behavior, it is likely that depression and anxiety also contributed to these results and more work is needed to understand these results. Overall, the present study findings suggest that it may be valuable for future studies in this area to distinguish the relationship between specific sleep indices and psychosocial variables. In so doing, we may not only better understand how sleep impacts social functioning, but also reveal specific components of disrupted sleep that may benefit from intervention.

### **Clinical Implications**

This work has several implications for clinical settings, particularly those treating college students. For one, as this work suggests a link between insomnia and negative reactions to social exclusion, it may be important for clinicians treating patients with difficulties in social contexts to consider and evaluate sleep health. Psychoeducation about sleep hygiene and the role of sleep in social connection may also be helpful. For example, insomnia can contribute to difficulties regulating emotions (Kyle et al., 2014), thus making it difficult to manage stressors. Increased awareness of the impact of sleep may provide patients with additional tools to manage cognitive distortions and negative emotions. Additionally, it may be important for patients presenting with sleep disruptions to be monitored with regard to their social well-being—social isolation and disconnection from others may be important treatment targets. Both sleep and social disruptions are significant risk factors for mood disorders, anxiety, and suicidality (Baglioni et al., 2011; Bernert et al., 2015; Buckner et al., 2008; Chu et al., 2017; Hom et al., 2017a), and as such, the presence of both may also have important implications for patients' overall psychiatric health. Lastly, sleep difficulties negatively impact learning. REM sleep that dominates later sleep cycles is important for learning and consolidation of memories (Walker and Stickgold, 2004). Thus, treatment of sleep issues may be a helpful prelude and/or adjunct to Cognitive Behavioral Therapy for interpersonal problems and social skills training.

### **Limitations and Future Directions**

Several limitations should be noted. First, as noted above, this study did not include an in-laboratory experimental manipulation of social inclusion. Future studies could be strengthened by including a comparison group that is exposed to a social inclusion paradigm. Relatedly, given that a recent meta-analysis of the effects of Cyberball indicated less sensitivity to changes in interpersonal factors (Hartgerink et al., 2015), future studies could consider other interpersonal

paradigms, such as that reported by George and colleagues (2017). Additionally, given that Cyberball is a virtual task, future studies may also find the use of confederates to simulate rejection in the laboratory to be more potent and effective. Third, all variables were assessed using self-report measures, which are vulnerable to retrospective recall bias. Self-reported sleep behaviors, in particular, have been shown to only modestly correlate with objective sleep measures (Silva et al., 2007). Future studies including additional indices of sleep behavior, including daily sleep diaries and objective measures of each specific sleep behavior (Shiffman et al., 2008), are indicated. Fourth, our sample was relatively homogenous; thus, our sample and results may not be representative of other sociodemographic groups. Relatedly, our sample size was relatively small, which also limits generalizability and increases the probability that our results were the consequence of an overestimated effect (Button et al., 2013). Although insomnia and psychiatric symptoms were clinically significant for many participants in this study, research using larger, demographically diverse samples with greater symptom severity is needed.

### **Conclusions**

This represents one of the first laboratory investigations showing that greater insomnia symptom severity significantly predicts greater perceived burdensomeness and lower desire for emotional support following Cyberball, beyond social anxiety symptoms. Replication of these findings in larger, demographically diverse samples using objective sleep measures is needed. This study contributes to the growing literature linking sleep and social functioning, adding to the substantial body of evidence for the negative psychological impact of sleep problems.

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ACCEPTED MANUSCRIPT

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**Table 1. Participant Demographics (n, %)**

	<b>Total N = 70</b>
<b>Age</b>	
Mean ( <i>SD</i> )	20.4 years (5.8)
Range	18-57 years
<b>Gender</b>	
Female	53, 75.7%
Male	17, 24.3%
<b>Race</b>	
White/Caucasian	58, 82.9%
Black/African American	4, 5.7%
Southeast Asian	1, 1.4%
Asian	2, 2.9%
Other	5, 7.1%
<b>Ethnicity</b>	
Mexican/Mexican American/Chicano	2, 2.9%
Puerto Rican	3, 4.3%
Cuban	5, 7.1%
Other	13, 18.6%
Non-Hispanic/Latino(a)/Spanish	47, 67.1%
<b>Marital Status</b>	
Single/Never Married	62, 88.6%
Married	1, 1.4%
Living with Another	6, 8.6%
Widowed	1, 1.4%

**Table 2. Study Variable Means and Intercorrelations**

<b>Pre-Cyberball Variables</b>	<b>1.</b>	<b>2.</b>	<b>3.</b>	<b>4.</b>	<b>5.</b>	<b>6.</b>	<b>7.</b>	<b>8.</b>	<b>9.</b>
1. ISI Insomnia SX	-								
2. INQ Thwarted Belongingness	.60**	-							
3. INQ Perceived Burdensomeness	.33*	.64**	-						
4. IOS Emotional Support	-.14	-.32**	-.22*	-					
<b>Post-Cyberball Variables</b>	<b>1.</b>	<b>5.</b>	<b>6.</b>	<b>7.</b>	<b>10.</b>	<b>11.</b>	<b>12.</b>	<b>13.</b>	<b>14.</b>
5. INQ Thwarted Belongingness	.58**	.88**	.63**	-.45**	-				
6. INQ Perceived Burdensomeness	.49**	.67**	.90**	-.21*	.70**	-			
7. IOS Emotional Support	-.26*	-.41**	-.35**	.88**	-.56**	-.38**	-		
<b>Covariates</b>	<b>1.</b>	<b>5.</b>	<b>6.</b>	<b>7.</b>	<b>10.</b>	<b>11.</b>	<b>12.</b>	<b>13.</b>	<b>14.</b>
8. BDI-II Depression SX	.75**	.70**	.57**	-.34**	.73**	.61**	-.39**	-	
9. BFNE-S Social Anxiety SX	.38**	.48**	.38**	.09	.43**	.51**	.01	.43**	-
<i>N</i>	70	70	70	70	70	70	70	70	70
<i>Mean</i>	7.97	22.59	9.27	20.16	22.69	9.18	20.42	10.18	33.25
<i>Standard Deviation</i>	5.08	11.75	4.63	5.66	11.86	5.31	6.30	9.45	7.55
<i>Range</i>	1-23	9-53	6-24	6-30	9-55	6-30	6-30	0-38	18-50
<i>Skew</i>	0.57	0.69	1.63	-0.28	0.89	1.03	-0.28	1.05	-0.07

*Note.* \* <.05 \*\* ≤.001. ISI = Insomnia Severity Index. SX = Symptoms. INQ = Interpersonal Needs Questionnaire. IOS = Interpersonal Orientation Scale, Desire for Emotional Support. BDI-II = Beck Depression Inventory-II. BFNE-S = Brief Fear of Negative Evaluation Scale-Straightforward.

**Table 3. Insomnia Severity as Predictors of Posttest Interpersonal Connection**

Dependent Variable	Step	<i>F</i> (df)	<i>R</i> <sup>2</sup>	Predictor / Covariates	<i>b</i> (SE)	<i>t</i>	$\beta$	Partial <i>r</i> <sup>2</sup>	<i>p</i>	
Perceived Burdensomeness	1	185.58(2)**	.85	<b>Insomnia Symptoms</b>	.24 (.05)	4.35	.22	.22	<.001	
	INQ-PB	-	-	Pretest PB	.90 (.06)	16.29	.82	.80	<.001	
		2	139.06(3)**	.86	<b>Insomnia Symptoms</b>	.19 (.05)	3.57	.18	.16	.001
		-	-	Pretest PB	.86 (.06)	15.58	.78	.79	<.001	
	-	-	Social Anxiety Symptoms	.11 (.04)	2.81	.15	.11	.007		
	3	105.48(4)**	.87	<b>Insomnia Symptoms</b>	.26 (.08)	3.42	.24	.15	.001	
		-	-	Pretest PB	.90 (.06)	14.30	.82	.76	<.001	
		-	-	Social Anxiety Symptoms	.11 (.04)	2.94	.15	.12	.003	
		-	-	Depression Symptoms	-.06 (.05)	-1.23	-.10	.02	.223	
	Desires for Emotional Support	1	128.40(2)**	.79	<b>Insomnia Symptoms</b>	-.16 (.06)	-2.53	-.14	.09	.014
IOS-ES		-	-	Pretest DES	.95 (.06)	15.34	.86	.78	<.001	
		2	84.38(3)**	.79	<b>Insomnia Symptoms</b>	-.16 (.07)	-2.24	-.14	.07	.029
		-	-	Pretest DES	.95 (.06)	15.09	.86	.77	<.001	
-		-	Social Anxiety Symptoms	-.01 (.05)	-0.20	-.01	<.001	.844		
3		62.51(4)**	.79	<b>Insomnia Symptoms</b>	-.19 (.10)	-1.86	-.16	.05	.068	
		-	-	Pretest DES	.97 (.07)	13.76	.87	.74	<.001	
		-	-	Social Anxiety Symptoms	-.02 (.05)	-.31	-.02	.002	.755	
		-	-	Depression	.02	.39	.04	.002	.695	

				Symptoms	(.06)				
<b>Thwarted Belongingness</b>	1	120.68(2)**	.78	<b>Insomnia Symptoms</b>	.18 (.16)	1.10	.08	.02	.274
INQ-TB	-	-	-	Pretest TB	.86 (.07)	11.78	.84	.67	<.001
	2	79.26(3)**	.79	<b>Insomnia Symptoms</b>	.18 (.17)	1.08	.08	.02	.286
	-	-	-	Pretest TB	.86 (.08)	10.98	.83	.65	<.001
	-	-	-	Social Anxiety Symptoms	.01 (.110)	.08	.005	<.001	.938
	3	66.38(4)**	.80	<b>Insomnia Symptoms</b>	-.11 (.19)	-.57	-.05	.005	.569
	-	-	-	Pretest TB	.77 (.08)	9.20	.74	.57	<.001
	-	-	-	Social Anxiety Symptoms	-.02 (.10)	-.18	-.01	<.001	.858
	-	-	-	Depression Symptoms	.31 (.12)	2.61	.25	.09	.011

**Note.** \*\* <.001. In all analyses, main predictor was insomnia symptom severity (Insomnia Severity Index). Baseline measures, social anxiety symptoms (Brief Fear of Negative Evaluation Scale-Straightforward), and depression symptoms (Beck Depression Inventory) were included as covariates. INQ-PB = Interpersonal Needs Questionnaire - 15, Perceived burdensomeness scale. INQ-TB = Interpersonal Needs Questionnaire - 15, Thwarted belongingness scale. IOS-ES = Interpersonal Orientation Scale, Desire for Emotional Support.