SEM Replication: Indirect effect of sleep on abdominal pain through daytime dysfunction in adults with irritable bowel syndrome

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Abstract

The study aimed to examine the potential indirect effects of sleep on abdominal pain symptoms simultaneously through psychological distress and daytime dysfunction in adults with irritable bowel syndrome (IBS). Daily symptoms of sleep, psychological distress, daytime dysfunction, and abdominal pain were collected from 332 adults with IBS. The study found that poor sleep had a strong indirect effect on abdominal pain via daytime dysfunction but not psychological distress. These findings suggest that optimizing personalized and hybrid behavioral interventions for adults with IBS should focus on addressing daytime dysfunction and sleep behaviors. Further studies integrating symptoms with biological markers are needed to explore the underlying mechanisms accounting for these symptoms. I will attempt to replicate the study findings...

Keywords: irritable bowel syndrome, sleep, pain, daytime dysfunction, psychological distress

Word count: X

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This project focuses on irritable bowel syndrome (IBS), a chronic functional bowel disorder that affects a significant proportion of the population worldwide. IBS is characterized by abdominal pain or discomfort related to defecation or changes in bowel habits. Individuals with IBS experience gastrointestinal symptoms like abdominal pain, constipation or diarrhea, abdominal bloating, as well as nongastrointestinal symptoms, such as sleep deficiency, psychological distress, and daytime dysfunction. Sleep deficiency is a well-known issue that affects approximately 37.6% of the population with IBS.

Poor sleep quality is a crucial modifiable risk factor for IBS symptom flare-ups, particularly abdominal pain. However, little is known about the roles of psychological distress and daytime dysfunction in the sleep-pain relationship in adults with IBS. Previous studies have suggested the indirect effect of sleep on pain through psychological distress; nonetheless, no studies have evaluated the indirect effect of sleep on pain through both psychological distress and daytime dysfunction. The purpose of this study is to examine the potential indirect effects of sleep on pain through psychological distress and/or daytime dysfunction using a structural equation modeling (SEM) approach among adults with IBS. SEM allows for the inclusion of multiple indicators and analyses of multiple relationships simultaneously.

Methods

We report how we determined our sample size, all data exclusions (if any), all manipulations, and all measures in the study.

Participants

Material

Procedure

Data analysis

```
# Declare vector with names of variables
full_names <- c("Abdominal pain", "Abdominal pain after eating", "Abdominal distention",
    "Intestinal gas", "Diminished sleep quality", "Unrefreshed sleep", "Fatigue",
    "Sleepiness during the day", "Hard to concentrate", "Anxiety", "Stress", "Depressive

names <- c("ab_pain", "ab_pain_after_eat", "ab_dist", "intest_gas", "dim_sleep_qual",
    "unrefresh_sleep", "fatigue", "sleepiness_day", "hard_concent", "anxiety", "stress",
    "dep_mood")

# Import correlation matrix
cor_matrix <- as.matrix(read_csv("../../files/data/cor_matrix.csv", col_names = FALSE))

# Create vector with standard deviations for each variable
sds <- c(26.05, 26.01, 31.82, 30.05, 27.18, 27.15, 27.25, 25.79, 20.77, 22.41, 25.44,
    16.51)

# Convert correlation matrix to covariance matrix using standard deviations
cov_matrix <- cor2cov(cor_matrix, sds = sds, names = names)
```

Creating Sample-Covariance Matrix.

Model Specification.

```
measurement_model <- '
  # latent variables ||  Y1 is measured by X1 + X2 + X3
    abdominal_discomfort =~ ab_pain + ab_pain_after_eat + ab_dist + intest_gas

    nightime_sleep =~ dim_sleep_qual + unrefresh_sleep

    day_dysfunction =~ fatigue + sleepiness_day + hard_concent

    psych_distress =~ anxiety + stress + dep_mood

  # regressions || Y1 regressed on X1

    psych_distress ~ nightime_sleep
    day_dysfunction ~ nightime_sleep + psych_distress
    abdominal_discomfort ~ day_dysfunction + nightime_sleep + psych_distress

'

fit <- sem(measurement_model,
           sample.cov = cov_matrix,
           sample.nobs = 332)
summary(fit, standardized = TRUE)
```

Measurement Model.

```
## lavaan 0.6.14 ended normally after 249 iterations
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of model parameters                        30
##
##   Number of observations                           332
##
## Model Test User Model:
##
##   Test statistic                               173.087
##   Degrees of freedom                                48
##   P-value (Chi-square)                           0.000
##
## Parameter Estimates:
##
##   Standard errors                             Standard
##   Information                                 Expected
##   Information saturated (h1) model          Structured
##
## Latent Variables:
##                          Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   abdominal_discomfort =~
##     ab_pain                 1.000                               23.044    0.886
##     ab_pain_aftr_t          0.997    0.048   20.925    0.000   22.966    0.884
##     ab_dist                 1.067    0.062   17.132    0.000   24.585    0.774
##     intest_gas              0.866    0.063   13.693    0.000   19.966    0.665
```

```
##   nightime_sleep =~
##     dim_sleep_qual           1.000                              23.921    0.881
##     unrefresh_slep           1.041    0.087   11.998    0.000   24.912    0.919
##   day_dysfunction =~
##     fatigue                  1.000                              24.987    0.918
##     sleepiness_day           0.921    0.040   22.824    0.000   23.015    0.894
##     hard_concent             0.575    0.038   15.035    0.000   14.369    0.693
##   psych_distress =~
##     anxiety                  1.000                              19.303    0.863
##     stress                   1.145    0.062   18.365    0.000   22.106    0.870
##     dep_mood                 0.649    0.041   15.682    0.000   12.519    0.759
##
## Regressions:
##                        Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   psych_distress ~
##     nightime_sleep          0.215    0.049    4.343    0.000    0.266    0.266
##   day_dysfunction ~
##     nightime_sleep          0.327    0.052    6.341    0.000    0.313    0.313
##     psych_distress          0.759    0.068   11.094    0.000    0.586    0.586
##   abdominal_discomfort ~
##     day_dysfunctin          0.445    0.080    5.561    0.000    0.483    0.483
##     nightime_sleep          0.038    0.059    0.650    0.516    0.040    0.040
##     psych_distress          0.091    0.093    0.977    0.328    0.076    0.076
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .ab_pain         145.553   18.979    7.669    0.000  145.553    0.215
```

```
##    .ab_pain_aftr_t  147.024   18.981    7.746    0.000  147.024    0.218
##    .ab_dist         405.029   37.289   10.862    0.000  405.029    0.401
##    .intest_gas      501.627   42.403   11.830    0.000  501.627    0.557
##    .dim_sleep_qual  164.290   44.995    3.651    0.000  164.290    0.223
##    .unrefresh_slep  114.302   47.630    2.400    0.016  114.302    0.156
##    .fatigue         115.979   19.106    6.070    0.000  115.979    0.157
##    .sleepiness_day  133.453   17.777    7.507    0.000  133.453    0.201
##    .hard_concent    223.624   18.923   11.818    0.000  223.624    0.520
##    .anxiety         128.105   16.616    7.710    0.000  128.105    0.256
##    .stress          156.572   21.218    7.379    0.000  156.572    0.243
##    .dep_mood        115.038   10.850   10.602    0.000  115.038    0.423
##    .abdmnl_dscmfrt  366.932   39.069    9.392    0.000    0.691    0.691
##     nightime_sleep  572.237   70.479    8.119    0.000    1.000    1.000
##    .day_dysfunctin  287.565   32.696    8.795    0.000    0.461    0.461
##    .psych_distress  346.157   37.471    9.238    0.000    0.929    0.929
```

I used R (Version 4.2.2; R Core Team, 2022b) and the R-packages *car* (Version 3.1.1; Fox & Weisberg, 2019; Fox, Weisberg, & Price, 2022), *carData* (Version 3.0.5; Fox et al., 2022), *dplyr* (Version 1.1.0; Wickham, François, Henry, Müller, & Vaughan, 2023), *forcats* (Version 1.0.0; Wickham, 2023), *foreign* (Version 0.8.84; R Core Team, 2022a), *ggplot2* (Version 3.4.1; Wickham, 2016), *ggpubr* (Version 0.6.0; Kassambara, 2023a), *haven* (Version 2.5.1; Wickham, Miller, & Smith, 2022), *lavaan* (Version 0.6.14; Rosseel, 2012), *lme4* (Version 1.1.31; Bates, Mächler, Bolker, & Walker, 2015), *lmerTest* (Version 3.1.3; Kuznetsova, Brockhoff, & Christensen, 2017), *Matrix* (Version 1.5.3; Bates, Maechler, & Jagan, 2022), *pacman* (Version 0.5.1; Rinker & Kurkiewicz, 2018), *papaja* (Version 0.1.1; Aust & Barth, 2022), *purrr* (Version 1.0.1; Wickham & Henry, 2023), *readr* (Version 2.1.4; Wickham, Hester, & Bryan, 2023), *readxl* (Version 1.4.2; Wickham & Bryan, 2023), *rstatix* (Version 0.7.2; Kassambara, 2023b), *stringr* (Version 1.5.0; Wickham, 2022), *tibble* (Version

3.1.8; Müller & Wickham, 2022), *tidyr* (Version 1.3.0; Wickham, Vaughan, & Girlich, 2023), *tidyverse* (Version 1.3.2; Wickham et al., 2019), and *tinylabels* (Version 0.2.3; Barth, 2022) for all analyses.

Results

Discussion

References

Aust, F., & Barth, M. (2022). *papaja: Prepare reproducible APA journal articles with R Markdown*. Retrieved from https://github.com/crsh/papaja

Barth, M. (2022). *tinylabels: Lightweight variable labels*. Retrieved from https://cran.r-project.org/package=tinylabels

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software*, *67*(1), 1–48. https://doi.org/10.18637/jss.v067.i01

Bates, D., Maechler, M., & Jagan, M. (2022). *Matrix: Sparse and dense matrix classes and methods*. Retrieved from https://CRAN.R-project.org/package=Matrix

Fox, J., & Weisberg, S. (2019). *An R companion to applied regression* (Third). Thousand Oaks CA: Sage. Retrieved from https://socialsciences.mcmaster.ca/jfox/Books/Companion/

Fox, J., Weisberg, S., & Price, B. (2022). *carData: Companion to applied regression data sets*. Retrieved from https://CRAN.R-project.org/package=carData

Kassambara, A. (2023a). *Ggpubr: 'ggplot2' based publication ready plots*. Retrieved from https://CRAN.R-project.org/package=ggpubr

Kassambara, A. (2023b). *Rstatix: Pipe-friendly framework for basic statistical tests*. Retrieved from https://CRAN.R-project.org/package=rstatix

Kuznetsova, A., Brockhoff, P. B., & Christensen, R. H. B. (2017). lmerTest package: Tests in linear mixed effects models. *Journal of Statistical Software*, *82*(13), 1–26. https://doi.org/10.18637/jss.v082.i13

Müller, K., & Wickham, H. (2022). *Tibble: Simple data frames*. Retrieved from https://CRAN.R-project.org/package=tibble

R Core Team. (2022a). *Foreign: Read data stored by 'minitab', 's', 'SAS', 'SPSS', 'stata', 'systat', 'weka', 'dBase', ...* Retrieved from https://CRAN.R-project.org/package=foreign

R Core Team. (2022b). *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing. Retrieved from https://www.R-project.org/

Rinker, T. W., & Kurkiewicz, D. (2018). *pacman: Package management for R*. Buffalo, New York. Retrieved from http://github.com/trinker/pacman

Rosseel, Y. (2012). lavaan: An R package for structural equation modeling. *Journal of Statistical Software*, *48*(2), 1–36. https://doi.org/10.18637/jss.v048.i02

Wickham, H. (2016). *ggplot2: Elegant graphics for data analysis*. Springer-Verlag New York. Retrieved from https://ggplot2.tidyverse.org

Wickham, H. (2022). *Stringr: Simple, consistent wrappers for common string operations*. Retrieved from https://CRAN.R-project.org/package=stringr

Wickham, H. (2023). *Forcats: Tools for working with categorical variables (factors)*. Retrieved from https://CRAN.R-project.org/package=forcats

Wickham, H., Averick, M., Bryan, J., Chang, W., McGowan, L. D., François, R., ... Yutani, H. (2019). Welcome to the tidyverse. *Journal of Open Source Software*, *4*(43), 1686. https://doi.org/10.21105/joss.01686

Wickham, H., & Bryan, J. (2023). *Readxl: Read excel files*. Retrieved from https://CRAN.R-project.org/package=readxl

Wickham, H., François, R., Henry, L., Müller, K., & Vaughan, D. (2023). *Dplyr: A grammar of data manipulation*. Retrieved from https://CRAN.R-project.org/package=dplyr

Wickham, H., & Henry, L. (2023). *Purrr: Functional programming tools*. Retrieved from https://CRAN.R-project.org/package=purrr

Wickham, H., Hester, J., & Bryan, J. (2023). *Readr: Read rectangular text data*. Retrieved from https://CRAN.R-project.org/package=readr

Wickham, H., Miller, E., & Smith, D. (2022). *Haven: Import and export 'SPSS', 'stata' and 'SAS' files*. Retrieved from https://CRAN.R-project.org/package=haven

Wickham, H., Vaughan, D., & Girlich, M. (2023). *Tidyr: Tidy messy data*. Retrieved from https://CRAN.R-project.org/package=tidyr