



Questionable prospective effect of physical activity on mental health: A simulated reanalysis and comment on Rodeiro et al. (2025)

Kimmo Sorjonen^{*}, Bo Melin

Department of Clinical Neuroscience, Karolinska Institutet, Stockholm, Sweden

ARTICLE INFO

Keywords:

Cross-lagged panel model
Loneliness
Mediated effect
Mental health
Physical activity
Reanalysis
Simulated data

ABSTRACT

Based on findings from analyses with cross-lagged panel models, Rodeiro et al. (2025) concluded that physical inactivity had an effect on mental disorders mediated by loneliness. However, contrary to convention, Rodeiro et al. did not seem to adjust for the predictor (i.e., initial physical inactivity) when estimating the effect of the mediator (i.e., loneliness) on the outcome (i.e., subsequent mental disorders) or to estimate the statistical significance of the mediated effect. Here, we simulated data to resemble the data used by Rodeiro et al. A longitudinal mediation model showed no statistically significant mediated (via loneliness) or total effect of initial physical inactivity on subsequent mental disorders. Consequently, the conclusions by Rodeiro et al. appear not to be supported by their own data.

Rodeiro et al. (2025) analyzed longitudinal data (three waves of measurement, approximately four years apart) on physical inactivity, loneliness, and mental disorders in a representative community sample of individuals aged 50 years or older in Spain (average age at baseline = 67.2 years, 54 % females, $N = 1973$) with cross-lagged panel models. Rodeiro et al. reported statistically significant positive cross-lagged effects of initial physical inactivity on subsequent loneliness and of loneliness on subsequent mental disorders (corresponding to the effects of PI_1 on LO_2 and of LO_2 on MD_3 , but omitting the effect of PI_1 on MD_3 , in Fig. 1, respectively). Based on these effects Rodeiro et al. concluded that “the improvement of mental health through physical activity is facilitated by the mediation of loneliness”. However, Rodeiro et al.’s mediation analysis appeared somewhat unorthodox. They did not seem to adjust for the predictor (initial physical inactivity) when estimating the effect of the mediator (loneliness) on the outcome (subsequent mental disorders), something that is usually required (Baron & Kenny, 1986). Moreover, Rodeiro et al. did not, as far as we can judge, report the statistical significance of the mediated effect or check for the presence of a total (i.e., mediated plus direct) effect of initial physical inactivity on subsequent mental disorders.

It has been recommended that when assessing if a predictor X (e.g., physical inactivity) has an effect on an outcome Y (e.g., mental disorders) mediated by M (e.g., loneliness) one should start by establishing that there is something to mediate, i.e., a total (unadjusted) effect of X on Y (Baron & Kenny, 1986; Preacher & Hayes, 2004). Others have noted

that indirect/mediated paths, via different mediators, with different signs can cancel each other out, resulting in a non-significant total effect of X on Y . Hence, a significant total effect should not be a requisite for testing mediation (Hayes, 2009). However, the conclusion by Rodeiro et al. that mental health is improved by physical activity clearly shows that they assumed a positive total effect of physical inactivity on mental disorders.

Moreover, a statistically significant effect of X on M (usually labeled a) and a statistically significant effect of M on Y when adjusting for X (usually labeled b) does not automatically mean that we have a statistically significant ab product, which corresponds to the mediated effect. It can be noted that with standardized effects between -1 and 1 , the ab product, i.e., the mediated effect, will always be closer to zero than both a and b . Consequently, significant effects of X on M and of M on Y when adjusting for X do not suffice to claim mediation. Instead, statistical significance of the mediated effect has to be established separately.

Rosen et al. (2020) and Santini et al. (2020) conducted similar analyses with cross-lagged mediation as did Rodeiro et al. However, differently from Rodeiro et al., Rosen et al. and Santini et al. estimated the statistical significance of the mediated effect. Moreover, as required by Baron and Kenny, they adjusted for the predictor (sexual disclosure and social disconnectedness at time 1, respectively) when estimating the effect of the potential mediator (perceived partner responsiveness and perceived isolation at time 2, respectively) on the outcome (relationship/sexual satisfaction and affective disorders at time 3, respectively).

^{*} Corresponding author at: Division of Psychology, Department of Clinical Neuroscience, Karolinska Institutet, 171 65 Solna, Sweden.

E-mail addresses: kimmo.sorjonen@ki.se (K. Sorjonen), bo.melin@ki.se (B. Melin).

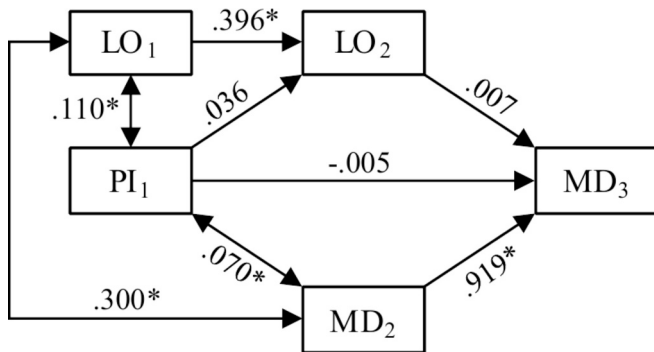


Fig. 1. Standardized associations between physical inactivity (PI), loneliness (LO), and mental disorders (MD) at three waves of measurement (the subscripts 1–3). * $p < .05$.

We fitted the longitudinal mediation model in Fig. 1 on data simulated to resemble the empirical data used by Rodeiro et al., with the same sample size and correlations between variables. We used simulated data as Rodeiro et al. did not have permission to share the empirical data. However, it should be noted that the standardized effect of X on Y when adjusting for M is a function of correlations between the variables (Eq. 1, Cohen et al., 2003). Consequently, this effect will be the same in data, empirical or simulated, with the same correlations between variables and simulated data can be used to estimate what the effect would have been in corresponding empirical data. Analyses and the simulation for the present study were conducted with R 4.4.0 statistical software (R Core Team, 2025) using the MASS (Venables & Ripley, 2002) and lavaan (Rosseel, 2012) packages. The analytic script, which also generates the simulated data, is available at the Open Science Framework at <https://osf.io/uqd2m/>.

$$E(\beta_{X,Y,M}) = \frac{r_{X,Y} - r_{X,M}r_{Y,M}}{1 - r_{X,M}^2} \quad (1)$$

The longitudinal mediation model in Fig. 1 had good fit ($\chi^2 = 25.8$, $DF = 10$, $CFI = 0.996$, $TLI = 0.996$, $RMSEA = 0.028$ [90 % CI: 0.015; 0.042]). However, neither the effect of physical inactivity at time 1 on loneliness at time 2 ($\beta = 0.036$ [−0.004; 0.077], $p = .079$) nor the effect of loneliness at time 2 on mental disorders at time 3 ($\beta = 0.007$ [−0.010; 0.025], $p = .403$) were statistically significant. Consequently, the mediated longitudinal effect of physical inactivity at time 1 on mental disorders at time 3 via loneliness at time 2 was also statistically non-significant ($\beta = 0.000$ [−0.000; 0.001], $p = .450$). Moreover, the total effect of physical inactivity at time 1 on mental disorders at time 3 was non-significant ($\beta = -0.005$ [−0.022; 0.013], $p = .600$). These non-significant effects suggest that the conclusions by Rodeiro et al., that an effect of physical activity on mental health is mediated by loneliness and, more fundamentally, that physical activity has an effect on mental health, were not supported by their own data and can be challenged. We do not claim that a hypothesis of an effect of physical activity on mental

health has been falsified once and for all. However, we do claim that the present findings suggest that the hypothesis was not supported by the data analyzed by Rodeiro et al. We recommend researchers to estimate the statistical significance of mediated effects, and to, in agreement with Baron and Kenny (1986), adjust for the predictor when estimating the effect of the potential mediator on the outcome, before claiming mediation.

CRedit authorship contribution statement

Kimmo Sorjonen: Writing – original draft, Visualization, Software, Project administration, Methodology, Investigation, Formal analysis, Conceptualization. **Bo Melin:** Writing – review & editing, Validation, Supervision, Methodology, Investigation, Conceptualization.

Declaration of competing interest

The authors declare no conflict of interests.

Data availability

The analytic script, which also generates the simulated data, is available at the Open Science Framework at <https://osf.io/uqd2m/>.

References

- Baron, R. M., & Kenny, D. A. (1986). The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology*, 51(6), 1173–1182. <https://doi.org/10.1037/0022-3514.51.6.1173>
- Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. (2003). *Applied multiple regression/correlation analysis for the behavioral sciences (third edition)*. Lawrence Erlbaum Associates.
- Hayes, A. F. (2009). Beyond Baron and Kenny: Statistical mediation analysis in the new millennium. *Communication Monographs*, 76(4), 408–420. <https://doi.org/10.1080/03637750903310360>
- Preacher, K. J., & Hayes, A. F. (2004). SPSS and SAS procedures for estimating indirect effects in simple mediation models. *Behavior Research Methods, Instruments, & Computers*, 36(4), 717–731. <https://doi.org/10.3758/BF03206553>
- R Core Team. (2025). *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing. <https://www.R-project.org/>.
- Rodeiro, J., Olaya, B., Haro, J. M., Gabarrell-Pascuet, A., Ayuso-Mateos, J. L., Francia, L., ... Domènech-Abella, J. (2025). The longitudinal relationship among physical activity, loneliness, and mental health in middle-aged and older adults: Results from the Edad con Salud cohort. *Mental Health and Physical Activity*, 28, Article 100667. <https://doi.org/10.1016/j.mhpa.2024.100667>
- Rosen, N. O., Williams, L., Vannier, S. A., & Mackinnon, S. P. (2020). Sexual intimacy in first-time mothers: Associations with sexual and relationship satisfaction across three waves. *Archives of Sexual Behavior*, 49(8), 2849–2861. <https://doi.org/10.1007/s10508-020-01667-1>
- Rosseel, Y. (2012). Lavaan: An R package for structural equation modeling. *Journal of Statistical Software*, 48(2), 1–36. <https://www.jstatsoft.org/v48/i02/>.
- Santini, Z. I., Jose, P. E., York Cornwell, E., Koyanagi, A., Nielsen, L., Hinrichsen, C., ... Koushede, V. (2020). Social disconnectedness, perceived isolation, and symptoms of depression and anxiety among older Americans (NSHAP): A longitudinal mediation analysis. *The Lancet. Public Health*, 5(1), e62–e70. [https://doi.org/10.1016/S2468-2667\(19\)30230-0](https://doi.org/10.1016/S2468-2667(19)30230-0)
- Venables, W. N., & Ripley, B. D. (2002). *Modern applied statistics with S (4th ed.)*. New York: Springer.