Proposal Master Thesis

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The impact of Physical Activity (PA) on mental wellbeing has been the topic of much recent literature, both in empirical studies (Noetel et al., 2024; Mahindru, Patil & Agrawal, 2023), and through mechanistic research (Smith & Merwin, 2021). However, while cross-sectional studies consistently find a strong association between the two, Chekroud et al. (2018) note that the causal effect of PA on mental health as studied in randomised control trials has been inconsistent. Chalder et al. (2012) for instance find a highly insignificant change in the Beck's depression inventory score of -0.54 ($p = 0.68$), while Philippot et al. (2022) find a signifiacnt decrease in the Hospital Anxiety and Depression Scale of 3.8 ($p = 0.016$). Due to this inconsistency, review articles only draw tentative conclusions, f.i. that PA "is probably [beneficial] for psychiatric diseases" (Peluso & De Andrade, 2005), "hold(s) promise in the treatment [...] of mental health conditions" (Smith & Merwin, 2021), et cetera.

I posit that longitudinal observational studies to date have not been powered to draw conclusions about the causal effect of PA on mental health, in part because they have not explicitly modelled the reverse effect, namely that individuals with poor mental health are less likely to engage in PA. Azevedo Da Silva et al. (2012) and Jerstad, Boutelle, Ness and Stice (2010) find empirical evidence for this reverse relationship, though other work is inconclusive (Birkeland, Torsheim & Wold, 2009; Ku, Fox, Chen & Chou, 2012). Nevertheless, combined with the mechanistic argument that exercise increases self-efficacy (Smith & Merwin, 2021), the assumption that engagement in PA is not influenced by mental health seems tenuous at best. A violation of this assumption leads to endogeneity when regressing mental health on PA and therethrough to inconsistent estimation of the causal effect, a fact that Leszczensky and Wolbring (2022) note is often neglected in longitudinal research.

The aim of this work is then to remedy the discrepancy between on the one hand the consistent association found in cross-sectional studies, and the inconsistent findings of trials on the other hand. This is done by applying a statistical model that accomodates for the potentially mutual influence (simultaneity) between PA and mental health. Inspired by the excellent statistical properties of Structural Equation Modelling (SEM) in this context, namely its unbiasedness and significantly greater efficiency than Arellano-Bond (GMM) estimation (Leszczensky & Wolbring, 2022), the present study follows the procedures outlined by Allison, Williams and Moral-Benito (2017) for modelling reciprocal causation. SEM allows for modelling arbitrary (linear) interactions between variables, including dynamic panel regressions, which makes it possible to flexibly compare model specifications through e.g. likelihood ratio tests. SEM thus lends itself well to a statistical study of the relationships between variables. Data from the LISS panel is studied, which is a representative (invite-only) panel of 7500 Dutch individuals aged sixteen and above (Scherpenzeel & Das, 2010). The panel comprises a broad range of questions on the topics of PA and mental wellbeing, but also manifold other variables that can therefore be controlled for in the analysis. Because the panel follows individuals for multiple years, it provides insight into the temporal nature of interactions between PA and mental health. In order to demonstrate the importance of properly modelling reverse causality, I first aim to closely follow the analysis done by Chekroud et al. (2018) to corroborate their main result that exercising decreases incidence of poor mental health by 43%. Then, the same question will be analysed in the SEM-framework to determine how much of this association can be attributed to a causal effect. However, due to

the measurement error in questionnaire responses, this study will not be powered to accurately estimate the exact effect size (Pereira, Geoffroy & Power, 2014). As such, it is early to draw practical conclusions, but the data should nevertheless be sufficient to find significant effects and to study if the potential reverse causality appreciably influences parameter estimates.

A major challenge in doing so will be to find the appropriate lag structure, as the validity of the results heavily relies on the correct specification of the lag structure. However, not only is this structure not known a priori, it is also likely in general that the temporal effect of the predictor on the outcome does not align with the sampling frequency (i.e. the time interval between panel waves) and the present literature has not established how SEM modelling may then be effectively applied (Leszczensky & Wolbring, 2022). It is additionally important to appropriately control for individual-specific effects, as for instance physical health makes a significant confounder, as it may preclude physical activity while also having a well-established impact on mental health (Ohrnberger, Fichera & Sutton, 2017), thus leading to endogeneity. However, as panel regressions naturally allow for controlling for individual-specific effects, that problem is readily solved.

The present study aims to guide further research, both through contributing to a better understanding of the potentially complicated interdependence between mental health and PA, as well as by establishing the importance of considering this interdependence when studying the topic.

Time frame

I aim to finish the initial analysis halfway through March, working out practical difficulties in working with the LISS panel data in the process. Subsequently developing the SEM model will take much longer, as that is a more complicated model that relies on more assumptions and will be more heavily influenced by missing data. I hope to be done with it during the course of May, leaving the rest of May and June, perhaps running into early July, for writing and integrating feedback. I thus aim to submit the thesis around the end of June or start of July. If the process of developping the SEM model goes smoother than expected, I might use the freed up time to expand the study, for instance by considering the moderating role of the type of exercise, or studying the mechanisms for the effect of PA on mental health in a mediation analysis.

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