## **An approach to investigate the effect of daily step count and age on sleep quality**

***Aims***

The aim of this approach is to determine any effects of daily step counts and age on sleep quality in individuals ranging from 18 to 64.

***Introduction***

Sleep is an important pillar of health in humans with each of us spending approximately one third of our lives asleep. Sleep is essential for both cognitive and physical wellbeing (Hirshkowitz *et al.*, 2015; Troynikov, Watson and Nawaz, 2018), allowing the body to recover from daily activity and return to optimum functioning (Vyazovskiy and Delogu, 2014). Despite the importance of sleep, many individuals in society struggle to obtain high quality sleep, with approximately 12-35% of adults reporting poor quality sleep with regular disruptions (Mollayeva *et al.*, 2016). It has been found that exercise can improve sleep duration and reduce sleep interruptions in the general population (Driver and Taylor, 2000; Kline *et al.*, 2013; Wang and Youngstedt, 2014; Chennaoui *et al.*, 2015), but the term ‘exercise’ in previous work often refers to higher intensity activities which are not accessible to all individuals. Conversely, low-intensity activities such as walking are typically manageable for most of the population making them factors of interest. Another factor known to impact sleep quality is age. Research has shown that sleep quality typically declines with age (Landry, Best and Liu-Ambrose, 2015), with both sleep duration and quality being impacted. Previous research has reported that walking positively correlates with sleep quality (Bisson, Robinson and Lachman, 2019), and this approach aims to determine how this effect of walking on sleep quality changes with age.

***Variables***

For the purposes of this approach, sleep quality will be measured by how many disturbances or sleep interruptions are detected in a night of sleep. Previous research has validated interruptions as a metric of sleep quality that can be reliably and accurately measured (Mollayeva *et al.*, 2016; Berryhill *et al.*, 2020). Furthermore, this objective measure of sleep quality was selected over possible subjective measures such as the Pittsburgh Sleep Quality Index (PSQI) (Buysse *et al.*, 1989) because it is not prone to the same inaccuracies of self-reporting (Schacter and Addis, 2007). Data on sleep interruptions for each participant will be collected by a WHOOP strap. Whilst polysomnography (PSG) is generally considered the gold standard for the objective measuring of sleep quality, validation experiments of the WHOOP strap determined that it was accurate in comparison to PSG in healthy individuals (Berryhill *et al.*, 2020). Additionally, the sleep laboratory requirements and invasive nature of PSG can make it impractical and expensive (Landry, Best and Liu-Ambrose, 2015), especially when compared with using a WHOOP strap. Moreover, the unusual sleeping situation imposed by PSG is likely to itself reduce sleep quality which is highly for small wearable devices such as a WHOOP strap.

Step count category will be one of the two explanatory variables for this approach. Step count is being used as a measure of low-intensity activity and walking because of the ease with which it can be measured, the way steps can be integrated into normal life (increasing adherence) and the ease with which the results can be communicated. The step counts for the participants will be measured by a Fitbit Zip due to the ease with which it can be used and its successful use in previous research where it was found to be accurate and reliable (Diaz *et al.*, 2015; Bisson, Robinson and Lachman, 2019).

The other explanatory variable being investigated in this procedure is age. This experiment will recruit participants in an age range of 18 to 64. This age range was selected because these individuals have the same general sleep recommendations from National Sleep Foundation (Hirshkowitz *et al.*, 2015), reducing the variance in sleep quality from factors outside the scope of this experiment.

***Procedure***

No previous research was found investigating the effect of step count and age on sleep quality so 198 participants were recruited and evenly split into three groups, each allocated a different minimum and maximum daily step count. This sample size was selected to ensure effects will be detected.

The 198 participants will then be recruited through online advertisements, flyers, word of mouth and through public presentations. Participants would only be deemed eligible if they are healthy with no pre-existing health conditions, able to walk and between the ages of 18 and 64. Moreover, participants would only be eligible for recruitment if their daily average step count is below 10,000 steps per day as it would be unethical to ask participants to reduce their daily step count for any prolonged period. Following recruitment, the participants will then be randomly assigned to the three different daily step count groups of 66 participants each. The three daily step count groups will be: <10,000 steps (control group), 10,000-15,000 steps and >15,000 steps.

Before the study starts participants would be given the Fitbit step counter and asked to wear it for a week so that their baseline daily step count can be checked to ensure it is below 10,000 steps. Following this, the two increased step count groups will be asked to gradually increase their daily step counts for two weeks until they reach the minimum daily step count for their assigned group. This will be done to allow them to adapt to the increased number of steps in a safe way. During this two-week period the control group will be asked to continue as normal. After checking the baseline step counts and allowing participants to adapt to their daily step count goal, the one-week study can begin. During this time, participants in the 10,000-15,000 and >15,000 step groups would be asked to meet their step goals every day and participants in the control group would be asked to continue with their usual activity levels. Participants would be asked to wear their WHOOP strap and Fitbit to record sleep quality and step counts.

Both the sleep quality data and the step count data will sync to apps on the phones of the participants and will then be transferred to a cloud platform where the researchers could access the data. At the end of the 7 days, the WHOOP strap and the Fitbit would provide a mean sleep-interruption count and mean daily step count respectively for each participant. It is these mean values for each patient which would then be used for data analysis.

***Data Analysis***

An ANCOVA analysis would be carried out on the data in R to determine if there is a significant interaction effect between age and step count on sleep quality or if there are main effects of the two explanatory variables. Using a Normal Q-Q plot and residuals vs fitted plot the model would be checked for normality of residuals, homogeneity of variance and linearity of the data. If the data fits these assumptions, then the ANCOVA model can then be used to determine the relationship between the variables in question. If there is a significant interaction effect between age and step count on sleep quality, then the size of the effect can be extracted. Moreover, the equations of the regression lines for each step count group and age can be calculated and plotted on a scatterplot to display the data. These lines can be used to predict how quality of sleep is affected given a daily step count and age.

I think this was really good. You outlined the gap in the literature and addressed it in a reasonable way. You considered statistical, ethical and logistical problems well. I think you could have done with a formal power analysis, and to outline if you are rewarding people for participation. Would there be different uptake in the experiment between age groups? IE will you just get a load of students? Are you ensuring you get a good age range? Also remember that a picture speaks a thousand words, so some kind of summary of your experimental design would be great. That said you described it all very clearly.

A-

**References**

Berryhill, S. *et al.* (2020) ‘Effect of wearables on sleep in healthy individuals: a randomized crossover trial and validation study’, *Journal of Clinical Sleep Medicine : JCSM : Official Publication of the American Academy of Sleep Medicine*, 16(5), pp. 775–783. doi:10.5664/jcsm.8356.

Bisson, A.N.S., Robinson, S.A. and Lachman, M.E. (2019) ‘Walk to a Better Night of Sleep: Testing the Relationship Between Physical Activity and Sleep’, *Sleep health*, 5(5), pp. 487–494. doi:10.1016/j.sleh.2019.06.003.

Buysse, D.J. *et al.* (1989) ‘The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research’, *Psychiatry Research*, 28(2), pp. 193–213. doi:10.1016/0165-1781(89)90047-4.

Chennaoui, M. *et al.* (2015) ‘Sleep and exercise: A reciprocal issue?’, *Sleep Medicine Reviews*, 20, pp. 59–72. doi:10.1016/j.smrv.2014.06.008.

Diaz, K.M. *et al.* (2015) ‘FITBIT®: AN ACCURATE AND RELIABLE DEVICE FOR WIRELESS PHYSICAL ACTIVITY TRACKING’, *International journal of cardiology*, 185, pp. 138–140. doi:10.1016/j.ijcard.2015.03.038.

Driver, H.S. and Taylor, S.R. (2000) ‘Exercise and sleep’, *Sleep Medicine Reviews*, 4(4), pp. 387–402. doi:10.1053/smrv.2000.0110.

Hirshkowitz, M. *et al.* (2015) ‘National Sleep Foundation’s sleep time duration recommendations: methodology and results summary’, *Sleep Health*, 1(1), pp. 40–43. doi:10.1016/j.sleh.2014.12.010.

Kline, C.E. *et al.* (2013) ‘Consistently High Sports/Exercise Activity Is Associated with Better Sleep Quality, Continuity and Depth in Midlife Women: The SWAN Sleep Study’, *Sleep*, 36(9), pp. 1279–1288. doi:10.5665/sleep.2946.

Landry, G.J., Best, J.R. and Liu-Ambrose, T. (2015) ‘Measuring sleep quality in older adults: a comparison using subjective and objective methods’, *Frontiers in Aging Neuroscience*, 7, p. 166. doi:10.3389/fnagi.2015.00166.

Mollayeva, T. *et al.* (2016) ‘The Pittsburgh sleep quality index as a screening tool for sleep dysfunction in clinical and non-clinical samples: A systematic review and meta-analysis’, *Sleep Medicine Reviews*, 25, pp. 52–73. doi:10.1016/j.smrv.2015.01.009.

Schacter, D.L. and Addis, D.R. (2007) ‘The cognitive neuroscience of constructive memory: remembering the past and imagining the future’, *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, 362(1481), pp. 773–786. doi:10.1098/rstb.2007.2087.

Troynikov, O., Watson, C.G. and Nawaz, N. (2018) ‘Sleep environments and sleep physiology: A review’, *Journal of Thermal Biology*, 78, pp. 192–203. doi:10.1016/j.jtherbio.2018.09.012.

Vyazovskiy, V.V. and Delogu, A. (2014) ‘NREM and REM Sleep: Complementary Roles in Recovery after Wakefulness’, *The Neuroscientist*, 20(3), pp. 203–219. doi:10.1177/1073858413518152.

Wang, X. and Youngstedt, S.D. (2014) ‘Sleep quality improved following a single session of moderate-intensity aerobic exercise in older women: Results from a pilot study’, *Journal of sport and health science*, 3(4), pp. 338–342. doi:10.1016/j.jshs.2013.11.004.