**Title**: Role of Leisure and Sleep in Promoting Daily Physical Activity in Adults with Down Syndrome

**Authors**: Melissa R. Jenkins1, Victoria L. Fleming1, Emily K. Schworer1, Yiwen Dong2, Dana Tudorascu3, & Sigan L. Hartley1 for the Alzheimer Biomarker Consortium-Down syndrome

**Introduction**: Relative to the adult general population, adults with Down syndrome (DS) engage in low levels of moderate-to-vigorous physical activity (MVPA) and spend more time in sedentary behaviors such as lying or sitting (Oreskovic et al., 2020; Shields et al., 2018). To-date research suggests that adults with DS who are less physically active have lower cognitive performance (Fleming et al., 2021; Pape et al., 2021), and a higher risk for endocrine and cardiovascular problems (Fleming et al., 2022). Societal and lifestyle barriers such as access to adaptive fitness programs, transportation, and lack of support have been identified as impeding physical activity engagement in MVPA (Barr & Shields, 2011; Mahy et al., 2010). There is a critical need to identify factors that promote healthy lifestyles in adults with DS. Although leisure activity participation and sleep quality are associated with physical activity in the general population (Kredlow et al., 2015; Mota et al., 2008), little is known about the role of daily leisure and sleep in promoting or impeding physical activity in adults with DS.

**Method**: The current study included 109 cognitively healthy adults with DS (*M* age = 39.83, *SD* = 8.80). For seven consecutive days, the adult with DS and a study partner were asked to jointly record information about the study participant’s engagement in leisure. Specifically, 17 cognitively stimulating activities (e.g., cooking, writing) and five social activities (e.g., visiting friends, attending club meetings) in the past 24 hours were inquired about. Leisure variables included time spent in and total count of cognitively stimulating activity, and time spent in and total count of social activity. Participants also wore a GT9X ActiGraph accelerometer wristwatch to collect movement and sleep data. Physical activity variables were measured as time (in minutes) spent in sedentary, light, and MVPA. Sleep variables were measured as total sleep time (TST) and sleep efficiency (SE). Linear mixed models were conducted using SAS to examine: (a) prior night’s sleep predicting next day physical activity, (b) physical activity predicting same night’s sleep, and (c) leisure predicting same day physical activity. All models included random intercepts and a one-day lagged effect controlling for prior-day outcomes. Lead variables shifted one day (e.g., TST at time *t*+1) were created when sleep quality was the outcome. For all predictors, fixed effects included within-subject (each person’s mean subtracted from their daily value) and between-subject (sample mean subtracted from each person’s mean). All models were adjusted for covariates, including age, premorbid intellectual disability, body mass index [BMI], and biological sex. Variables for diary day and weekend were also included.

**Results**: On average, participants who had higher TST engaged in more sedentary behavior at the between-person level (*b =* 0.01, *p =* .02). This same pattern held when examining sedentary behavior and that night’s TST. Less TST predicted more time spent in MVPA (*b =* -0.02, *p <*.001) and light physical activity (*b =* -0.39, *p <*.001). At a within-person level, nights in which participants had less TST (*b =* -0.36, *p <*.001) than their own average spent more time in light physical activity the next day. Days in which participants performed more light physical activity (*b =* 0.25, *p <*.01) and MVPA (*b =* 9.53, *p <*.001) than they typically do had more TST that night. Across the seven days, participants with less SE (*b =* -1.28, *p <*.001) spent more time sedentary, and more SE was positively associated with light physical activity (*b =* 19.62, *p =*.04), and MVPA (*b =* 0.83, *p =*.01). When participants spent more than their average time sedentary, they had more SE (*b =* 0.15, *p <*.001) that night. At the within-person level, individuals who spent more than their average time in social leisure had more light physical activity (*b =* 1.55, *p <*.01). There were also significant within-person positive effects of cognitively stimulating leisure on same-day light physical activity (*b =* 5.10, *p =*.04) and MVPA (*b =* 0.07, *p <*.01).

**Discussion:** This is the first study that we are aware of that examines both the between-person and within-person, day-to-day, associations between sleep, physical activity, and leisure in adults with DS. Overall, adults with DS who engaged in more physical activity across the week had lower TST but better SE, mirroring findings from the general population (Atoui et al., 2021). At the within-person level, engaging in more social and cognitively-stimulating leisure corresponded with days with more physical activity. Findings can inform the development of programs and interventions to improve health in the DS population.

**References:**

Atoui, S., Chevance, G., Romain, A. J., Kingsbury, C., Lachance, J. P., & Bernard, P. (2021). Daily associations between sleep and physical activity: A systematic review and meta-analysis. *Sleep Medicine Reviews*, *57*, 101426. https://doi.org/10.1016/j.smrv.2021.101426

Barr, M. A. S. N., & Shields, N. (2011). Identifying the barriers and facilitators to participation in physical activity for children with Down syndrome. *Journal of Intellectual Disability Research*, *55*(11), 1020-1033. https://doi.org/10.1111/j.1365-2788.2011.01425.x

Fleming, V., Piro-Gambetti, B., Patrick, A., Zammit, M., Alexander, A., Christian, B. T., Handen, B., Cohen, A., Klunk, W., Laymon, C., Ances, B.M, Plante, D.T., Okonkwo, O.& Hartley, S. L. (2021). Physical activity and cognitive and imaging biomarkers of Alzheimer's disease in Down syndrome. *Neurobiology of Aging*, *107*, 118-127. https://doi.org/10.1016/j.neurobiolaging.2021.07.016

Fleming, V., Piro‐Gambetti, B., Handen, B., Christian, B. T., Cohen, A., Tudorascu, D., Plante, D.T., Okonkwo, O., & Hartley, S. L. (2022). Physical activity and physical and mental health in middle‐aged adults with Down syndrome. *Journal of Policy and Practice in Intellectual Disabilities*, *19*(4), 408-418. https://doi.org/10.1111/jppi.12434

Kredlow, M. A., Capozzoli, M. C., Hearon, B. A., Calkins, A. W., & Otto, M. W. (2015). The effects of physical activity on sleep: A meta-analytic review. *Journal of Behavioral Medicine*, *38*, 427-449. https://doi.org/10.1007/s10865-015-9617-6

Mahy, J., Shields, N., Taylor, N. F., & Dodd, K. J. (2010). Identifying facilitators and barriers to physical activity for adults with Down syndrome. *Journal of Intellectual Disability Research*, *54*(9), 795-805. https://doi.org/10.1111/j.1365-2788.2010.01308.x

Mota, J., Santos, M. P., & Ribeiro, J. C. (2008). Differences in leisure-time activities according to level of physical activity in adolescents. *Journal of Physical Activity and Health*, *5*(2), 286-293. https://doi.org/10.1123/jpah.5.2.286

Oreskovic, N. M., Cottrell, C., Torres, A., Patsiogiannis, V., Santoro, S., Nichols, D., Moore, C., & Skotko, B. G. (2020). Physical activity patterns in adults with Down Syndrome. *Journal of Applied Research in Intellectual Disabilities*, *33*(6), 1457-1464. https://doi.org/10.1111/jar.12773

Pape, S. E., Baksh, R. A., Startin, C., Hamburg, S., Hithersay, R., & Strydom, A. (2021). The association between physical activity and CAMDEX-DS changes prior to the onset of Alzheimer’s disease in Down Syndrome. *Journal of Clinical Medicine*, *10*(9), 1882. https://doi.org/10.3390/jcm10091882

Shields, N., Plant, S., Warren, C., Wollersheim, D., & Peiris, C. (2018). Do adults with Down syndrome do the same amount of physical activity as adults without disability? A proof of principle study. *Journal of Applied Research in Intellectual Disabilities*, *31*(3), 459-465. https://doi.org/10.1111/jar.12416

Waisman Center, University of Wisconsin-Madison

2Department of Biostatistics and Health Data Science, University of Pittsburgh

3Department of Psychiatry, University of Pittsburgh