

Title: The Influence of Sleep on Verbal Skills in School-Age Children and Young Adults with Down Syndrome

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Introduction: Down syndrome (DS) is the most common intellectual disability of chromosomal origin, affecting 1 in 700 live births (Mai et al., 2019). DS is associated with craniofacial abnormalities, intellectual disabilities, delayed speech, and sleep problems. Up to 70% of persons with DS reported sleep abnormalities, including obstructive sleep apnea, fragmented sleep, daytime sleepiness, parasomnias, and bedtime resistance (Maris et al., 2016; Simpson et al., 2018; Breslin et al., 2011). Children with DS have some of the highest sleep disturbance rates of any intellectual or developmental disability. Actigraphy and polysomnography studies revealed sleep disturbance in 95% of children with DS, compared to 67% in William's syndrome and 57% in typical development (Ashworth et al., 2013). These sleep abnormalities are significantly correlated with maladaptive behavior, lower IQ, memory deficits, and deficits in language acquisition (Edgin et al., 2015; Breslin et al., 2014, Churchill et al., 2015; Cotton & Richdale, 2010, Diomedi et al., 1999). While few have assessed the relation between sleep and language development in children with DS, one study found that disrupted daytime sleep, particularly Rapid-eye Movement (REM) sleep, may interfere with word learning in toddlers with DS, but aid word learning in typically-developing (TD) controls (Spanò et al., 2018). Another two studies investigating the influence of sleep on language acquisition and integration in toddlers with DS found that sleep quality may correlate to language learning (Desouza et al. 2020; Arias-Trejo et al., 2020). However, the current body of literature lacks research in sleep's role in language learning on school-aged children with DS. The present study aimed to investigate the influence of sleep quality on language development in children with DS across development. Our lab compiled Actigraphy data and the Kaufman Brief Intelligence Test-2nd Edition (KBIT-II) to assess sleep and verbal skills in over 80 participants with DS. It is hypothesized that poor sleep will be associated with poor language outcomes in individuals with DS. Future analyses will include toddlers with DS who completed the MacArthur Bates Communicative Development Inventories.

Method: Actigraphy and KBIT-II data from five studies conducted in the Memory Development and Disorders Lab were analyzed. Participants were included in the analysis if they have at least four days of consecutive actigraphy data and completed the KBIT-II assessment. KBIT-II Verbal and Riddles raw scores were used for the analysis, and all analyses were conducted in R.

Results: 82 individuals in DS (age range: 6.49-28.13) and 110 TD controls (age range: 3.07-17.50) completed the KBIT-2 and with complete sleep data. After adjustment for age, there was a statistically significant difference in sleep efficiency between children with DS and TD controls, $F(1, 439) = 70.030$, $p < 0.0001$. Despite significant differences in KBIT Verbal Subdomain Raw scores between TD and DS, these differences did not correlate with sleep efficiency after statistical control for age ($r = -0.009-0.077$, $p > 0.05$). Here we focus on sleep efficiency as it has been a key variable in previous studies of sleep in DS, but future analyses will describe the sleep profile in relation to a larger set of language and sleep outcomes.

Discussion: Previous studies have suggested correlations between sleep and expressive language and sleep and memory in DS. Our current study is the largest reported sample that we know of to date that includes objective measures of sleep and cognitive outcomes in DS. In the context of previous studies, these results suggest that actigraphy-measured sleep efficiency may not correlate with verbal scores in children with DS beyond the years of language acquisition. The subsequent analysis will include a cohort of toddlers with and without DS who have completed the MacArthur Bates Communicative Development Inventories to assess the influence of sleep on language development during critical language learning periods. It is possible that sleep may play a more significant role in verbal skills and language acquisition in younger individuals with DS than in older children. Future research should evaluate the differences in language-learning mechanisms in DS compared to TD across critical developmental periods. Doing so will identify key points for intervention.

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