Lifestyle and Cognitive Processing Speed in Adults Aged 60+: Evidence from NHANES 2011–2014

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Abstract

Alzheimer's disease currently has no cure, making the identification of factors associated with cognitive health a key priority in ageing research. Lifestyle behaviours, including sleep, physical activity, alcohol consumption, and smoking, alongside body mass index (BMI), may be associated with cognitive functioning; however, these relationships must be examined in the context of demographic differences. This study investigates these associations among adults aged 60 and older using data from the National Health and Nutrition Examination Survey (NHANES) 2011–2014. The Digit Symbol Substitution Test (DSST) was used to measure cognitive processing speed; hierarchical linear regression analysis was applied to compare the results of testing lifestyle factors before and after adjusting for age, gender, and education. Unadjusted analyses indicated that higher alcohol consumption ($\beta = -.22$, $p = .016$) and higher moderate recreational activity ($\beta = -.23$, $p = .010$) were associated with lower DSST scores. The variance in cognitive performance explained by lifestyle factors was 11.4% ($p = .045$), while adding age, gender, and education explained a further 25.1% ($p < .001$). After adjustment, none of the lifestyle factors remained independently significant, but age, gender and education each were independently significant. These findings do not establish a direct causal relationship between lifestyle factors and cognitive processing speed. Rather, the observed associations were attenuated after adjustment for demographic characteristics, suggesting that demographic differences may partly account for the relationships between lifestyle and cognition. Demographic differences, therefore, should be taken into consideration when interpreting the results of studies looking at lifestyle and cognition, before making any conclusions about direct effects. Further research using larger and more representative samples is required to determine factors uniquely connected to processing speed, and to develop strategies for healthy ageing.

Keywords: Alzheimer's disease, cognitive processing speed, Digit Symbol Substitution Test (DSST), NHANES, lifestyle factors, healthy ageing, physical activity, sleep, alcohol consumption, BMI, hierarchical linear regression.

Introduction

With population ageing throughout the world, cognitive function in older age is becoming an important public health priority. Cognitive decline can make older adults less independent, less fulfilled in their lives, and place a burden on other people, carers and health systems. With no cure for dementia yet, there is a focus on prevention and on factors that might help to maintain cognitive function as we grow older. Lifestyle habits are of interest because, unlike characteristics one is born with, they can be changed. In the context of these common activities, sleeping, being physically active, limiting alcohol, not smoking and controlling body weight are all often cited as potential avenues to promote brain health in older adults. More than 55 million people were living with dementia across the world in 2023, and the Lancet Commission on dementia prevention has suggested that almost half of dementia cases could potentially be prevented or delayed by addressing modifiable risk factors (World Health Organization [WHO], 2023;

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Livingston et al., 2024). One of the earliest cognitive abilities to deteriorate as age increases is the processing speed with which a person can take in and respond to information (Salthouse, 1996), which is commonly measured with a short timed test especially sensitive to changes in cognitive function, the Digit Symbol Substitution Test (DSST) (Jaeger, 2018). Various lifestyle factors are related to cognitive performance. Several dementia risk factors, such as physical inactivity, smoking and excess alcohol consumption are known (Livingston et al., 2024), and exercise has been shown to benefit brain health (Bull et al., 2020) and is recommended for older people. There are other studies that have shown a relationship between sleep duration and cognition; both shorter and longer sleep durations are linked to higher levels of cognitive decline in older adults (Ma et al., 2020), and body weight has been associated with cognitive performance on the DSST in older adults in the National Health and Nutrition Examination Survey (NHANES) (Zhou et al., 2020). But education and age also have a significant impact on cognitive performance, and the scores obtained on the DSST vary significantly across ages and levels of education (Brody et al., 2019). The association between a lifestyle habit and cognition might reflect differences between people rather than effects of the lifestyle habit on cognition, because lifestyle habits differ by age, gender, and education. For instance, Corley et al. (2011) reported that the majority of the associations between alcohol consumption and cognitive functioning among older adults were eliminated or greatly reduced when they controlled for intelligence assessed in childhood and social class. While most previous studies have examined individual lifestyle factors, there is limited understanding of how much variance in cognition lifestyle factors explain when examined together and whether lifestyle factor associations are independent of demographic factors. Overestimating the effects of lifestyle can lead to targeting the wrong people for prevention. The present study, therefore, tests for the individual association of the following lifestyle factors (sleep duration, reported trouble sleeping, vigorous and moderate physical activity, alcohol intake, smoking status, and BMI) with processing speed, and for the combined association of these lifestyle factors with processing speed, before and after controlling for age, gender and education. In particular, it poses the question: In NHANES 2011–2014, among adults aged 60 and older, are lifestyle factors associated with cognitive processing speed as assessed by the DSST, and do these relationships persist after adjusting for age, gender, and education? Null hypothesis: There is no association between DSST performance and lifestyle factors, either individually or after adjustment. Study hypothesis: DSST performance is associated with lifestyle factors, and these associations persist after adjustment. The findings could be incorporated into studies that account for the role of demographic differences, suggest ways to maximise the impact of lifestyle on cognitive health, and help health policymakers avoid overestimating lifestyle in prevention programs. This study included adults aged 60 and older who participated in the DSST and reported alcohol consumption and level of recreational activity (moderate or vigorous), and excluded non-drinkers and physically inactive older adults, as well as clinical diagnosis and other cognitive testing; because the study is cross-sectional, cause and effect and measurement of change over time could not be determined. Processing speed (higher scores indicate faster processing) is the number of correct symbols completed in 2 minutes on the DSST (Brody et al., 2019); lifestyle factors are modifiable behaviours and health characteristics that are likely to affect cognitive risk (Livingston et al., 2024); body mass index (BMI) (higher scores indicate increased BMI) is the weight in kilograms divided by the height in metres squared (WHO, 2024); and associations are adjusted for age, gender and education. The primary research question guiding this study is therefore: Among adults aged 60 and older in NHANES 2011–2014, are lifestyle factors (sleep duration, physical activity, alcohol consumption, smoking, and BMI) associated with cognitive processing speed as

measured by the Digit Symbol Substitution Test, and do these associations persist after adjustment for age, gender, and education?

Literature Review

Previous research has shown that early detection of cognitive decline allows individuals to prepare for future challenges and may help slow disease progression (Nabosne et al., 2024). One of the earliest abilities to change with age is processing speed, the rate at which a person takes in and responds to information, and its slowing is thought to underlie declines in memory and reasoning (Salthouse, 1996). Existing literature indicates that cognitive ageing shows gradual declines after age 60 (Zelinski et al., 2011), with significant drops in processing speed from the early 70s (Matsui et al., 2025), making processing speed a valuable early marker of cognitive decline. Several studies have examined the Digit Symbol Substitution Test (DSST) as a measure of processing speed (Segev et al., 2024). The test is sensitive to small cognitive changes but not specific to any disease, and studies conducted in the United States highlight its use in the National Health and Nutrition Examination Survey (NHANES) for adults aged 60 and older (Jang et al., 2024). Its sensitivity, however, means scores may reflect many influences beyond cognitive decline itself. The most important of these are demographic characteristics. Older adults perform worse on the DSST, and this decline persists after education and health status are considered (Salthouse, 1992), although this evidence compared age groups at a single point in time. In 5,125 adults aged 18 to 99, women outperformed men on processing speed tasks including digit symbol, but this advantage was small and less certain after age 65 (Siedlecki et al., 2019). Higher education is associated with better cognitive performance across several domains, including reasoning (Guerra-Carrillo et al., 2017), and lower socioeconomic status with lower scores (Paulson & Marchant, 2009). Researchers therefore adjust for age, gender and education to ensure that observed habits are linked to cognition rather than to demographic characteristics (Wang, 2004). Unlike demographics, lifestyle factors can be changed, and there is a growing body of literature on their role in cognitive ageing (Gow et al., 2012), with approximately 30–50% of dementia cases attributed to modifiable risk factors (Brück et al., 2025). Empirical studies suggest that physical activity benefits memory and executive function in older adults(Chen et al., 2026) and is associated with markers of synaptic integrity (Casaletto et al., 2022). In contrast, Sabia et al. (2017) followed 10,308 British civil servants for 27 years and found no association with later cognitive decline, suggesting that earlier protective findings may reflect reverse causation, as activity declined years before dementia diagnosis. This difference may arise because single-time-point studies cannot tell whether activity protects cognition or declining cognition reduces activity, although Sabia et al. 's sample may not represent the wider population. Smoking is consistently linked to lower processing speed (Jaarsma et al., 2023). According to recent findings from 39,852 older adults, both short (<6 hours) and long (≥9 hours) sleep were associated with higher risk of cognitive decline (Liu, 2025), a U-shaped pattern confirmed by a meta-analysis of 49 cohort studies (Yang et al., 2024). Sleep problems are also linked to a 1.68 times higher risk of cognitive impairment (Bubu et al., 2017), although this meta-analysis of observational studies cannot establish the cause. Studies conducted in the United States link the sarcopenic-obesity phenotype to the lowest DSST scores (Booranasuksakul et al., 2024), but this evidence is cross-sectional. Across these factors, each has largely been studied separately. Researchers have long debated whether moderate drinking protects cognition. Zhang et al. (2025) found light drinking associated with better cognitive function, yet several studies suggest this reflects who drinks rather than alcohol itself. Cooper et al. (2009) found the alcohol–cognition relationship diminished significantly after controlling for premorbid intelligence and physical health. Consistent with this, in the Lothian Birth

Cohort 1936 in Scotland, most associations were removed or substantially weakened after adjusting for childhood intelligence and social class (Corley et al., 2011), although this single cohort limits generalisability, and Ritchie et al. (2014) reported similar findings. Differences in which background factors were controlled may explain why some studies still report benefits, suggesting that other lifestyle associations may similarly weaken after adjustment. This points to a broader problem: habits are unevenly distributed across social groups. Studies conducted in Europe highlight that among 96,990 adults aged 50 and older, higher education was linked to both better cognition and greater physical activity (Cheval et al., 2023), and low socioeconomic status is associated with higher risk of cognitive impairment (Feng et al., 2024). Habits also cluster, as alcohol use and poor diet are more common among overweight individuals (Rodrigues et al., 2023). Yet Rodrigues et al. (2023) did not test whether these associations were independent of demographics, and Zhou et al. (2025) did not identify which lifestyle factors contribute most to cognitive decline. Many such studies are also cross-sectional, showing association but not direction. Taken together, processing speed is an early marker of cognitive decline shaped strongly by demographics, and several lifestyle factors have been linked to cognition. However, this evidence has three limitations.First, most studies examine lifestyle factors one at a time, so it is unclear how much each contributes when others are considered. Second, evidence that lifestyle associations weaken after adjustment comes largely from alcohol studies (Cooper et al., 2009; Corley et al., 2011; Ritchie et al., 2014) using broad cognitive measures rather than processing speed. Third, although demographic factors shape both lifestyle and cognition (Cheval et al., 2023), few studies directly compare how each habit's association changes before and after these factors are considered. As a result, it remains unclear which lifestyle associations with processing speed are independent of age, gender and education, and which reflect demographic differences between people.

Methodology

1. Research Design

This study employed a quantitative, cross-sectional, correlational design to test for relationships between lifestyle variables and cognitive processing speed among U.S. adults aged 60 and older, and to assess these relationships after controlling for age, gender and education. The data analyzed were from the National Health and Nutrition Examination Survey (NHANES) 2011–2014. For this reason, regression models were used to study the relationships between age, gender, education and cognitive performance, as some of the lifestyle factors might vary between the demographic groups. Unadjusted association between each lifestyle factor and the DSST score was evaluated by simple linear regression. The seven lifestyle factors were combined and analyzed in multiple linear regression. A hierarchical linear regression was then used to see if lifestyle associations survived after the demographic variables and to what extent. Standardised coefficients (β) were used to compare models. The statistical assumptions of the regression were evaluated using variance inflation factors (VIF), Durbin–Watson statistic, Q–Q plots and residual plots. The data were cleaned, modelled and tested using JASP (Version 0.98.1)

2. Sampling

The target population was U.S. adults 60 years and older. The data were obtained from the National Health and Nutrition Examination Survey (NHANES) 2011–2014, which uses a multistage probability design incorporating stratified and cluster sampling (CDC, 2014). The participants were then selected using purposive (criterion-based) sampling, with the inclusion criteria being age ≥ 60 years, completion of

the Digit Symbol Substitution Test (DSST) and complete data on all variables. Non-drinkers or inactive participants were excluded because they did not report drinking quantity or amount of activity, as NHANES does not ask about these items of the non-drinking or non-activity individuals. A total of 124 older adults (mean age 67.2 years, with 41.1% women) who consumed alcohol and engaged in vigorous and moderate recreational activity were finally selected. Records with missing or invalid responses were excluded. Since only drinkers and active participants were selected, no zero values for alcohol or physical activity were present.

3. Procedures

NHANES participants completed an in-home interview and were tested at a mobile examination centre. The appropriate NHANES 2011–2014 data files for this study were downloaded, merged by participant ID in Microsoft Excel. Participants who reported zero alcohol consumption or zero recreational physical activity were excluded because the detailed quantity or frequency measures used in this analysis were not available for non-drinkers or inactive participants. Records with missing or invalid responses on the study variables were also excluded, leaving 124 participants. Valid zero responses were retained where zero represented a value for the relevant variable; NHANES refusal and "don't know" codes (e.g., 7/9, 77/99 and 777/999) were treated as invalid responses. The cleaned dataset was then entered into JASP (Version 0.98.1) for regression analysis.

4. Data Screening and Model Diagnostics

4.1. Data Screening

Data Screening All variables were pretested for missing and implausible responses before estimation. The criterion of zero alcohol consumption and zero recreational activity led to exclusion; all other zero values were not removed if they were valid answers to the respective question. The mean DSST score was 59.68 (SD = 14.26), mean age was 67.20 years (SD = 5.68), and mean BMI was 26.95 kg/m² (SD = 4.59).

4.2. Multicollinearity

Variance Inflation Factors (VIF) and Tolerance were computed to determine if the predictors were inflated too much to be estimated separately. Since all the VIF values (ranged from 1.03 to 1.40) were within the acceptable limits of VIF < 5 and the tolerance values for all the variables were above 0.71, there was no concern for multicollinearity.

4.3. Independence of Residuals

Residuals were tested for independence using the Durbin-Watson statistic. The value for the final model was 2.02 ($p = .840$), which is close to the ideal value of 2 and suggests no substantial autocorrelation between residuals

4.4. Normality and Homoscedasticity

The Q-Q plot of the standardised residuals displayed points that were fairly close to the reference line, suggesting that the residuals were approximately normally distributed. The scatter of residuals around the predicted values in the plot was random with no systematic pattern or funnel shape indicating assumption of homoscedasticity (equal variance). Overall, the diagnostic plots and statistics suggested that the

assumptions were reasonably satisfied; therefore, linear regression was considered appropriate for the analysis.

5. Data Analysis

The analyses were conducted using JASP (Version 0.98.1) with DSST score as the dependent variable. Descriptive statistics summarized the sample, and simple linear regression was used to look at the unadjusted association between each lifestyle factor and the score for the DSST. After that, all seven lifestyle factors were entered into a multiple linear regression (Model 0) to determine if each factor was independently associated, which allowed for the evaluation of their combined contribution. A hierarchical regression was conducted by adding age, gender and education (Model 1); the difference in R^2 indicated the amount of variance that was added by demographics, and the comparison of the standardised coefficients (β) across models indicated whether lifestyle associations remained robust after adjusting for demographics. Statistical significance was set at $p < .05$.

6. Ethical Considerations

The procedures of the NHANES were reviewed by the National Center for Health Statistics Research Ethics Review Board and all participants gave written informed consent. The publicly available NHANES data are anonymised; therefore, no additional ethical approval was required for this secondary analysis

7. Limitations of the Methodology

The sample size was comparatively small and only included adults who indicated they drank alcohol and engaged in some recreational physical activity. Because NHANES did not have the level of detail needed for quantity and frequency measures in this study, non-drinkers and inactive adults were not included. Some records were also discarded because of missing or invalid responses and the results may not apply to all U.S. adults 60 years of age and older. The survey weights from the NHANES were not used, which further restricted the representativeness. Reported measurements of physical activity and lifestyle may reflect reporting bias and only include recreational physical activity. Because of the cross-sectional design, cause-and-effect inferences cannot be made.

Analysis and Results

1. Individual Associations Between Lifestyle Factors and Processing Speed

Simple linear regression was done for each lifestyle factor individually (Table 2, first two columns). The DSST performance was significantly associated with two factors. Higher levels of moderate recreational activity were correlated with lower DSST scores ($\beta = -.23$, $F(1, 122) = 6.77$, $p = .010$) that accounted for 5.3% of variance; for each additional 10 minutes of moderate activity per day, DSST scores were lowered by approximately 0.5 points. There was also a significant negative correlation between alcohol consumption and scores ($\beta = -.22$, $F(1, 122) = 5.95$, $p = .016$), accounting for 4.6% of the variance, with each additional drink per drinking day corresponding to a score about 2.3 points lower. There was a positive association with vigorous recreational activity, though this was not significant ($\beta = .15$, $p = .095$, $R^2 = .023$). BMI ($\beta = -.13$, $p = .149$), troubled sleep history($\beta = -.08$, $p = .351$), smoking status ($\beta = -.05$, $p = .554$) and sleep duration ($\beta = .01$, $p = .890$) were not significantly associated with DSST, each explaining less than 2% of the variance.

Table 2. Lifestyle associations across models

Lifestyle factor	**Alone R^2**	**Alone β (p)**	**Lifestyle model (M_0) β (p)**	**Lifestyle + demographics (M_1) β (p)**
Moderate activity	.053	−.23 (.010)	−.18 (.055)	−.12 (.140)
Alcohol consumption	.046	−.22 (.016)	−.17 (.069)	−.08 (.377)
Vigorous activity	.023	0.15 (.095)	.14 (.121)	.07 (.360)
BMI	.017	−0.13 (.149)	−.06 (.498)	−.05 (.512)
Sleep disorder history	.007	−.08 (.351)	−.06 (.530)	−.05 (.590)
Smoking status	.003	−.05 (.554)	−.06 (.498)	−.06 (.458)
Sleep duration	.000	.01 (.890)	−.01 (.887)	.00 (.978)
Model R^2			.114 (p = .045)	.365 (p < .001)
R^2 change				.251 (p < .001)

The two lifestyle factors that were significantly associated with DSST scores in the separate, unadjusted analyses were alcohol consumption and moderate recreational physical activity. This negative relationship between alcohol consumption and the DSST score is inconsistent with some studies reporting positive relationships between lighter levels of drinking and the DSST score (Zhang et al., 2025). This finding is, however, only applicable to drinkers of the analytic sample and does not reflect the differences between drinkers and non-drinkers. The negative relationship with moderate activity was surprising as physical activity has been shown to be linked to brain health (Casaletto et al., 2022). The cross-sectional design does not allow these explanations to be distinguished: it may be a result of differences in age or retirement status, of reverse causation, or self-report error (Sabia et al., 2017). This association was not statistically significant when the lifestyle factors were added together, and was additionally diminished after demographic adjustment. The non-significant results of the BMI, sleep and smoking measures may also be due to the measures used. BMI was not distinguished by fat mass and muscle mass; although U-shaped association was suggested, sleep duration was modelled as linear; and the smoking measure included current and former smokers.

2. Combined Association of Lifestyle Factors (Model 0)

The seven lifestyle factors were entered together (Model 0) accounting significantly for 11.4% of the variance in DSST scores, $F(7, 116) = 2.14$, $p = .045$ (adjusted $R^2 = .061$). In this model, none of the factors were significant (Table 2, M_0 column; Table 3). The associations with moderate activity ($\beta = -.18$, $p = .055$) and alcohol consumption ($\beta = -.17$, $p = .069$) were somewhat weaker when all seven factors were included in the same model, and were just above the significance level.

In Model 0, the lifestyle factors collectively explained 11.4% of the variance in DSST scores, $F(7, 116) = 2.14$, $p = .045$ (adjusted $R = .061$). When multiple lifestyle factors were examined together, however, none of the seven factors was a statistically significant predictor (Table 2 and Table 3). The coefficients for moderate activity ($\beta = -.18$, $p = .055$) and alcohol consumption ($\beta = -.17$, $p = .069$) were also reduced from their respective unadjusted models and were not significant at the $p < .05$ level. The difference

between R^2 (.114) and adjusted R^2 (.061) also suggests the model's contribution to the explanation of the data should be interpreted cautiously due to the number of predictors and sample size

Table 3. Regression coefficients for lifestyle and demographic predictors of DSST scores

Predictor	**M_0 B (SE)**	**M_0 β**	**M_0 p**	**M_1 B (SE)**	**M_1 β**	**M_1 p**
Sleep duration	−0.18 (1.24)	−.01	.887	−0.03 (1.07)	.00	.978
Sleep disorder history	−2.04 (3.24)	−.06	.530	−1.50 (2.78)	−.05	.590
Vigorous activity	1.29 (0.83)	.14	.121	0.66 (0.72)	.07	.360
Moderate activity	−0.040 (0.021)	−.18	.055	−0.027 (0.018)	−.12	.140
Alcohol consumption	−1.79 (0.97)	−.17	.069	−0.84 (0.94)	−.08	.377
Smoking status	−1.79 (2.64)	−.06	.498	−1.69 (2.26)	−.06	.458
BMI	−0.19 (0.28)	−.06	.498	−0.16 (0.24)	−.05	.512
Age	–	-	-	−0.83 (0.20)	−.33	< .001
Gender (female)	-	-	-	6.46 (2.34)	.22	.007
Education level	-	-	-	5.22 (1.32)	.32	< .001

3. Adjustment for Demographic Characteristics (Model 1)

Adding age, gender and education to the seven lifestyle factors (Model 1) increased the variance explained to 36.5%, $F(10, 113) = 6.50$, $p < .001$ (adjusted $R^2 = .309$). An additional 25.1% of variance ($R = .251$, $p < .001$; Table 4) was explained by the demographic block. In the adjusted model, age ($B = −0.83$, $SE = 0.20$, $\beta = −.33$, $p < .001$), gender (female; $B = 6.46$, $SE = 2.34$, $\beta = .22$, $p = .007$) and education level ($B = 5.22$, $SE = 1.32$, $\beta = .32$, $p < .001$) were statistically significant predictors. The number of additional years of age was found to be associated with a decrease of about 0.8 DSST points per year, and an increase of about 5.2 points per education level; in this sample, women had about 6.5 more points compared to men. None of the lifestyle factors was statistically significant in Model 1 (all $p \geq .140$). Demographic adjustment of the unadjusted associations for alcohol consumption and moderate activity did not maintain the associations. Given the cross-sectional design, these estimates describe associations and cannot establish causal relationships.

Table 4. Model summary statistics for Model 0 and Model 1

Model	**Predictors**	**R^2**	**Adjusted R^2**	**F**	**df**	**p**	**ΔR^2**	**p (ΔR^2)**
M_0	Lifestyle factors (7)	.114	.061	2.14	7, 116	.045	.114	.045
M_1	Lifestyle factors + demographics (10)	.365	.309	6.50	10, 113	< .001	.251	< .001

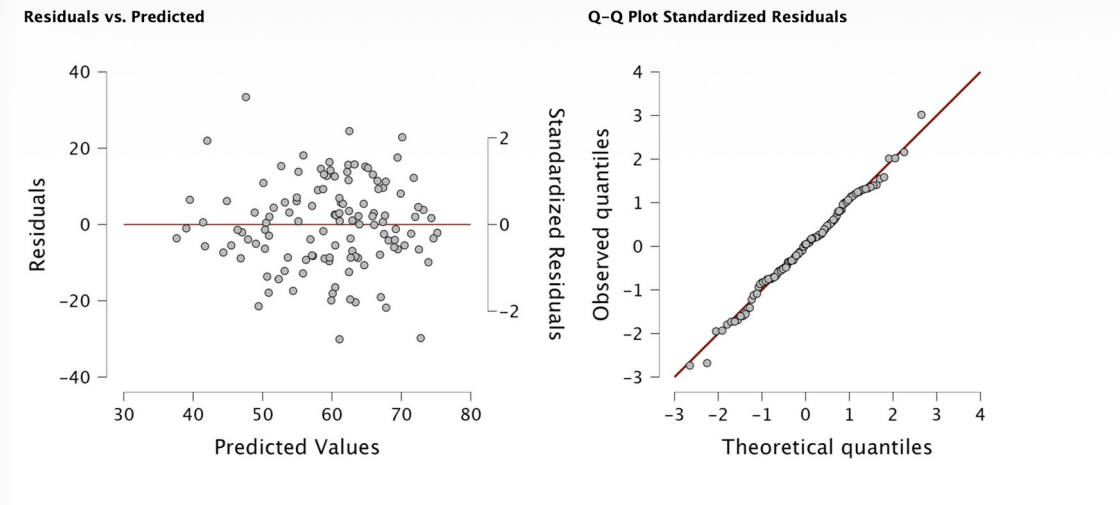
Overall, the lifestyle associations largely reflected those who practised the habits and not the habits themselves. This is similar to confounding, in which a third variable is correlated with both the habit and the outcome (Pourhoseingholi et al., 2012). The alcohol reduction was similar to earlier findings that alcohol–cognition associations had been reduced or eliminated when accounting for general intelligence,

health and social class (Cooper et al., 2009; Corley et al., 2011; Ritchie et al., 2014). This study builds on the work in two ways. First, the same pattern was observed for physical activity, in line with evidence of links between education, physical activity and cognitive functioning (Cheval et al., 2023). Second, it was for processing speed, not for the general cognitive scales that were previously used. Demographic results are consistent with previous studies. Age is directly linked to the well-documented deceleration of processing speed as a result of aging (Salthouse, 1992; Matsui et al., 2025). Education is known to be related to DSST performance (Brody et al., 2019) and still was after adjustment. The participants had a relatively high mean education level (4.38). This female advantage is similar to that of Siedlecki et al. (2019), except that they found this advantage to be smaller and less certain after the age of 65, which makes its significance in this sample notable. Overall, the findings indicate that lifestyle factors were associated with processing speed individually and as a whole, but these associations disappeared after adjustment; age, gender and education were independent predictors

4. Model Diagnostics

The assumptions of linear regression were met for the final model. There was no multicollinearity problem as the variance inflation factors ranged from 1.03 to 1.40 and tolerance values were 0.71 or higher. The Durbin-Watson statistic of 2.02 (p = .840) indicated independent residuals. The Q-Q plot displayed standardised residuals that were approximately normally distributed along the reference line and the plotted residuals against the predicted values showed a random scatter around zero without a funnel shape, thus supporting homoscedasticity (Figure 1).

Figure 1. Residuals versus predicted values (left) and Q-Q plot of standardised residuals (right) for Model 1



The results of these diagnostics support the conclusions drawn from Model 1. The low variance inflation factors are especially relevant with regard to the research question. They demonstrate that the reduced lifestyle associations were not due to demographic and lifestyle variables being so correlated that they would not allow independent assessment of the associations. Rather, the coefficients were not distorted by multicollinearity, and the lifestyle associations were actually smaller after controlling for demographics. The overall pattern of the residuals was the expected one, and the standardised residual for one participant exceeded ±3(the largest was close to 3), so the results are unlikely to be driven by a few unusual cases.

Limitations

The cross-sectional design does not allow conclusions to be drawn about whether lifestyle behaviours influence cognitive processing speed or whether differences in cognitive functioning influence lifestyle behaviours. There is limited generalizability due to the relatively small and restricted sample size (n = 124), exclusion of non-drinkers and inactive adults, and the absence of NHANES survey weights. The lifestyle factors are self-reported, and thus could be subject to reporting bias. Last, sleep duration was linearized, which may have resulted in the loss of a possible U-shaped relationship with processing speed; further investigations are needed to explore non-linear sleep–processing relationships .

Conclusion

The purpose of this study was to determine if there were associations between lifestyle factors and cognitive processing speed in adults aged 60 and older in NHANES 2011-2014 before and after adjusting for age, gender, and education. More alcohol use was significantly associated with lower DSST performance scores ($\beta = -.22$) and more moderate recreational activity ($\beta = -.23$); sleep duration, trouble sleeping, and vigorous activity were not. BMI and smoking were not significantly associated with DSST performance scores. The seven lifestyle factors together explained 11.4% of the variance in processing speed, but no one factor was significant if the other factors were included. Significant lifestyle associations were eliminated after the age, gender and education variables were included, and their associations, after these variables were added to the model, decreased by about half to two-thirds. Another 25.1% of the variance was explained by the demographic factors; older age related to slower processing speed, and higher education and female gender related to faster processing speed. The observed lifestyle–processing speed relationships may reflect differences between individuals who engage in these habits rather than the effects of the habits themselves, and they are similar to previously reported results that found alcohol–cognition associations are diminished when controlling for background characteristics. Demographic factors must thus be taken into account in lifestyle and cognition studies and in prevention strategies because the associations could be stronger than they actually are without taking these factors into account. Additionally, future research should incorporate more nationally representative samples of adults not only including non-drinkers, but also non-active adults and follow up with participants over time to determine if lifestyle modification impacts the rate of cognitive decline.

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