



Exploring the link between grit and excessive daytime sleepiness: a study in a population sample

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Abstract

Purpose Excessive daytime sleepiness (EDS) is a common condition with implications for individual health and public safety. While factors such as snoring and depression are known contributors to EDS, the role of grit in EDS remains unexplored. This study aimed to investigate the association between EDS in a representative sample of Korean adults, with a specific focus on the two components of grit: perseverance of effort (PE) and consistency of interest (CI).

Methods A nationwide cross-sectional survey was conducted through door-to-door interviews using structured questionnaires between September and December 2018 in Korea. EDS was assessed using the Epworth Sleepiness Scale, while grit was measured using the Short Grit Scale, comprising PE and CI subscales. Multivariable logistic regression analyses were performed to explore the association between grit and EDS, adjusting for covariates.

Results A total of 2,356 participants (49.3% male; aged 19–92 years) were enrolled in the study. The prevalence of EDS was 15.2%. Participants with EDS had significantly lower overall grit scores, driven by lower CI subscale scores. After adjusting for confounders, higher grit scores were significantly associated with EDS (OR 0.35, 95% CIs 0.26–0.45, $p < 0.001$). This association persisted in subgroup analyses, including those with depression and habitual snoring. In contrast, no significant association was observed between the PE subscales and EDS.

Conclusion Our findings suggest that intrinsic motivation, as reflected by the CI subscale of grit, is inversely associated with EDS. Therefore, exploring interventions that include nurturing grit could be a potential approach to addressing EDS.

Keywords Grit · Personality traits · Excessive daytime sleepiness · Cross-sectional study

Introduction

Excessive daytime sleepiness (EDS) is a common complaint in sleep clinics as well as in general population, with prevalence rates ranging from 8.7 to 41.5%, depending on the study population [1–3]. Subjective sleepiness is not only linked to individual health concerns but also to impaired sustained attention and increased public safety risks [2, 4]. Therefore, identifying the causes of EDS and addressing them is crucial.

Several factors are known to contribute to EDS, including sleep-related conditions such as sleep apnea and insufficient sleep, as well as physical and mental health problems [2]. Previous studies suggest that lifestyle factors and comorbidities can be just as influential in contributing to

EDS as sleep-related issues. For instance, one study found that depression and obesity had a greater impact on EDS than sleep duration [1]. Another study demonstrated that greater physical activity and lower levels of education were associated with higher rates of EDS [3]. Personality traits also appear to influence EDS, with lower conscientiousness, lower agreeableness, and higher neuroticism linked to greater daytime sleepiness among American university students [5].

Grit, a personality trait characterized by perseverance of effort (PE) and consistency of interest (CI), has been associated with various positive health outcomes, including better mental well-being, greater resilience, successful aging and improved self-regulation [6, 7]. These traits suggest that individuals with higher levels of grit may be better equipped

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to manage stress, maintain healthy routines, and prioritize restorative behaviors, all of which are essential for adequate sleep and daytime functioning. Moreover, grit is closely related to intrinsic motivation [8], which can help individuals remain awake and alert [9]. Despite these connections, the potential link between grit and EDS remains underexplored. Investigating this relationship is important because EDS is not only influenced by sleep duration and quality but also by psychological factors, such as motivation and self-discipline, both of which are core components of grit [10, 11]. Understanding whether individuals with higher grit experience less daytime sleepiness could provide insight into new behavioral interventions for managing EDS, especially in populations at risk of poor sleep hygiene or chronic fatigue. Therefore, exploring the relationship between grit and EDS may contribute to a more holistic understanding of how personality traits influence sleep-related outcomes.

Thus, the present study aims to investigate the association between self-reported daytime sleepiness and grit in a general adult population in South Korea. We hypothesized that individuals with higher levels of grit would be less likely to report EDS, independent of other covariates. Additionally, we explored whether the two components of grit—PE and CI—contribute differently to EDS.

Materials and methods

Study population and survey process

The Korean Sleep Headache Study, a nationwide survey examining sleep and headache in a representative sample of adults, was conducted between September and December 2018. The study employed a two-stage random cluster sampling method to reflect the regional distribution across Korea, excluding Jeju-do, as described previously [12]. In the first stage, 15 administrative districts (do) were selected as primary sampling units. In the second stage, basic administrative units (si, gun, and gu) were chosen using probability proportional to cluster size. The sample included 75 si (small to medium-sized cities), 82 gun (rural areas), and 69 gu (metropolitan areas).

A target sample size was assigned to each administrative unit, with the overall sample size calculated to achieve an estimated sampling error of $\pm 1.8\%$ with 95% confidence intervals (CIs). Trained and experienced interviewers conducted door-to-door surveys using structured, interviewer-administered questionnaires. All participants provided written informed consent during the interviews. The study design was approved by the institutional review board of Seoul National University Bundang Hospital (B-1808-484-303).

Excessive daytime sleepiness (EDS)

Daytime sleepiness was assessed using the Epworth Sleepiness Scale (ESS), a self-reported measure consisting of eight items, with total scores ranging from 0 to 24. A validated Korean version of ESS was used in this study [13]. Internal consistency, as measured by Cronbach's alpha, was 0.79 in our sample. Participants with ESS scores greater than 10 were classified as having EDS [14].

Grit

Grit was assessed using the Short Grit scale (Grit-S) [15]. This self-reported scale consists of eight items rated on a 5-point Likert scale and is divided into two domains. The PE subscale includes items 2, 4, 7, and 8, which describe the tendency toward sustained effort over time. The CI subscale includes items 1, 3, 5, and 6, which measure the tendency toward sustained interests over time and are reverse scored. The overall Grit-S score was calculated by averaging all eight items, yielding a score ranging from 1 ('Not at all gritty') to 5 ('Extremely gritty'). Subscale scores for PE and CI were also calculated by averaging the items within each respective domain. In our sample, the scale demonstrated good internal consistency, with a Cronbach's alpha of 0.77 for the overall grit scale, and 0.76 and 0.73 for the PE and CI subscales, respectively.

Covariates

All participants completed a questionnaire that included socio-demographic information such as education level (completed high school or less), income level (< 3 million KRW or ≥ 3 million KRW), alcohol consumption (current, former or never), smoking status (current, former or never), physical activity (< 3 times/week or ≥ 3 times/week), self-reported height and weight for calculating body mass index (BMI, kg/m^2). Obesity is defined as having a BMI greater than 25, based on guideline in Korea [16].

Sleep-related features were assessed using questionnaires and included sleep duration, snoring, and sleep quality. Habitual snoring was defined as snoring more than three times a week. Participants reported their typical sleep duration by answering the question: 'How many hours of sleep did you usually get per night over the past month? Please provide separate responses for weekdays and weekends.' To calculate the average sleep duration, a weighted mean was used, combining weekday and weekend sleep with the following formula: $(5 \times \text{weekday sleep} + 2 \times \text{weekend sleep}) / 7$. Sleep quality was derived from the Korean version of the Pittsburgh Sleep Quality Index [17]. Poor sleep quality was defined as the score > 5 .

Depression and anxiety were evaluated using the Patient Health Questionnaire-9 (the score ≥ 10) and the Generalized Anxiety Disorder-7 (the score ≥ 10) [18, 19]. The presence of hypertension and diabetes mellitus were also recorded.

Statistical analysis

Continuous variables were reported as means with standard deviations (SD), while categorical variables were presented as counts with percentages. Baseline characteristics were compared between groups with and without EDS using Student's *t*-test for continuous variables and the chi-square

test for categorical variables. For all significant results with *t*-tests, we also computed effect sizes with Cohen's *d*.

To examine the association with EDS and grit, multi-variable logistic regression analysis was performed with EDS as the dependent variable. Odds ratios (OR) with 95% CIs were calculated. Models were adjusted for socio-demographics (age, sex, BMI, education, income, alcohol consumption and smoking status), sleep-related variables (duration, quality, and snoring) and comorbidities (depression, anxiety, hypertension, and diabetes mellitus). Grit was used as a continuous variable. Additionally, subgroup analyses were conducted for participants with depression and snoring. Furthermore, to assess whether age modified the association between grit and EDS, stratified multivariable logistic regression analyses across three age groups: ≤ 40 years, 41–60 years, and > 60 years. These age categories were chosen based on observed shifts in EDS prevalence within the sample.

A two-tailed *p*-value < 0.05 was considered statistically significant. All statistical analyses were conducted using R (version 4.3.0), and R Studio (version 2023.12.0).

Results

A total of 2,501 individuals aged 29 to 92 years (49.5% male), participated in the survey. After excluding 53 participants with missing data and 92 shift workers, the final analysis included 2,356 individuals, with a mean age of the participants was 48.0 years (SD 16.3) and 49.3% males.

Baseline characteristics by EDS

Baseline demographic and clinical characteristics were compared between participants with and without EDS (Table 1). Among the 2,356 participants, 15.2% reported EDS and were classified into the EDS group, with a mean (SD) ESS score of 13.4 (2.7). The EDS group had significantly lower grit scores than the non-EDS group (mean [SD], 3.10 [0.39] vs. 3.30 [0.42], $p < 0.001$) with a modest effect size (Cohen's $d = 0.49$). This difference was primarily observed in the CI subscale of grit, but not in the PE subscale.

Participants with EDS were older and included a higher proportion of females than the non-EDS group. Significant differences were also noted in education, income levels and lifestyle variables, except for smoking status.

All sleep-related parameters and comorbidities significantly differed between the two groups. The EDS group reported shorter sleep duration, poorer sleep quality, and more frequent habitual snoring compared to the non-EDS group. Additionally, the prevalence of comorbidities was higher in the EDS group.

Table 1 Characteristics of the population stratified by EDS status

	EDS (<i>N</i> =357)	Non-EDS (<i>N</i> =1999)	<i>p</i>	Cohen's <i>d</i>
ESS	13.4 $\pm$ 2.7	5.4 $\pm$ 2.8	< 0.001	2.82
Grit-S Overall	3.10 $\pm$ 0.39	3.30 $\pm$ 0.42	< 0.001	0.49
Grit-S CI	3.37 $\pm$ 0.70	3.71 $\pm$ 0.67	0.001	0.50
Grit-S PE	2.83 $\pm$ 0.65	2.90 $\pm$ 0.78	0.073	0.09
Sociodemographic				
Age, years	54.9 $\pm$ 17.0	46.7 $\pm$ 15.9	< 0.001	
Sex (Female)	208 (58.3%)	986 (49.3%)	0.002	
Education (≥ 12 years)	243 (68.1%)	1736 (86.8%)	< 0.001	
Income ($\geq 3,000,000$ KRW)	230 (64.4%)	1560 (78.0%)	< 0.001	
Lifestyle				
Alcohol (current)	242 (67.8%)	1501 (75.1%)	0.005	
Smoking (current)	76 (21.3%)	498 (24.9%)	0.161	
Regular exercise (≥ 3 /week)	97 (27.2%)	404 (20.2%)	0.004	
BMI, kg/m ²	23.5 $\pm$ 2.8	23.0 $\pm$ 2.7	0.002	0.18
Obesity (BMI ≥ 25)	92 (25.8%)	423 (21.2%)	0.061	
Sleep				
Sleep duration, hours	7.0 $\pm$ 1.4	7.2 $\pm$ 1.1	0.069	
PSQI	5.0 $\pm$ 3.0	3.6 $\pm$ 2.2	< 0.001	0.60
Poor sleep quality (PSQI > 5)	126 (35.3%)	332 (16.6%)	< 0.001	
Habitual snoring	107 (30.0%)	369 (18.5%)	< 0.001	
Comorbidities				
Anxiety	14 (3.9%)	20 (1.0%)	< 0.001	
Depression	75 (21.0%)	124 (6.2%)	< 0.001	
Hypertension	110 (30.8%)	291 (14.6%)	< 0.001	
Diabetes mellitus	60 (16.8%)	145 (7.3%)	< 0.001	

EDS, Excessive Daytime Sleepiness; **ESS**, Epworth Sleepiness Scale; **CI**, Consistency of Interest; **PE**, Perseverance of Effort; **KRW**, Korean Won as a currency unit; **BMI**, Body mass index; **PSQI**, Pittsburgh Sleep Quality Index

Table 2 Multivariable logistic regression analysis for EDS

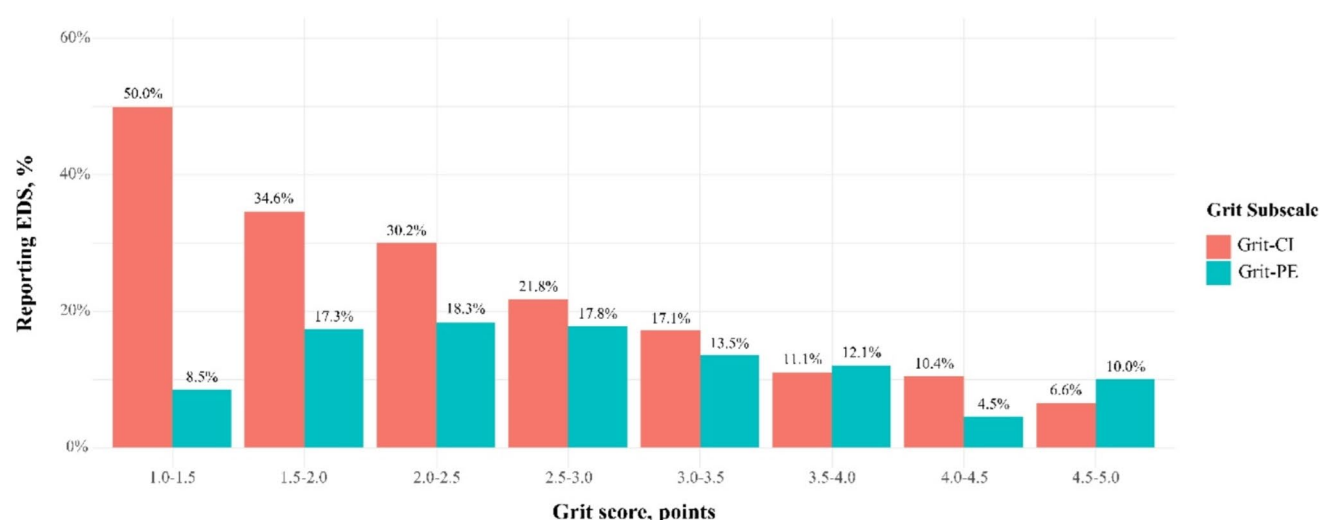
	Model I			Model II			Model III		
	OR	95% CIs	<i>p</i>	OR	95% CIs	<i>p</i>	OR	95% CIs	<i>p</i>
Grit	0.35	0.26–0.48	<0.001	0.56	0.46–0.67	<0.001	0.89	0.76–1.04	0.149
BMI (kg/m²)	1.03	0.99–1.08	0.166	1.03	0.99–1.08	0.175	1.03	0.98–1.08	0.222
Sleep duration (hours)	1.03	0.93–1.14	0.632	1.05	0.95–1.17	0.360	1.03	0.93–1.14	0.622
Poor sleep quality (yes)	1.83	1.37–2.45	<0.001	1.84	1.37–2.45	<0.001	2.03	1.52–2.69	<0.001
Habitual snoring (yes)	1.72	1.29–2.29	<0.001	1.64	1.23–2.18	0.001	1.70	1.28–2.25	<0.001
Depression (yes)	2.40	1.67–3.41	<0.001	2.61	1.83–3.71	<0.001	2.86	2.01–4.05	<0.001
Anxiety (yes)	2.03	0.89–4.53	0.084	1.51	0.67–3.36	0.314	2.02	0.89–4.48	0.087
R²	0.13			0.13			0.11		

OR, odds ratio; 95% CIs, 95% confidence interval; BMI, Body mass index

Adjusted for age, sex, education level, income level, alcohol consumption, regular exercise, hypertension, and diabetes mellitus

Grit was used as a continuous variable

In **Model I**, the overall Grit-S score was used; in **Model II**, the Grit-S CI (Consistency of Interest) subscale score was used; and in **Model III**, the Grit-S PE (Perseverance of Effort) subscale score was used

**Fig. 1** The prevalence of EDS according to Grit Score

Association between grit and EDS

Multivariable logistic regression analyses were performed to examine the relationship between grit and EDS (Table 2). After adjusting for confounders, higher grit scores were significantly associated with a lower likelihood of EDS (OR 0.35, 95% CIs 0.26–0.45, $p < 0.001$). This association was primarily driven by the CI subscale (OR 0.56, 95% CIs 0.46–0.67, $p < 0.001$), while no significant association was observed for the PE subscale (OR 0.89, 95% CIs 0.76–1.04, $p = 0.149$). Also habitual snoring and depression were independently associated with an increased likelihood of EDS, regardless of the grit subscale.

Further analysis showed that participants with higher CI scores had a lower proportion of EDS (Fig. 1). However, no significant trend was observed across varying levels of the PE subscale.

Association between grit and EDS in subgroups

Subgroup analyses, adjusted for relevant covariates, were conducted for specific groups (Table 3). In participants with depression, higher grit scores were significantly associated with a lower likelihood of EDS (OR 0.35, 95% CIs 0.13–0.93, $p = 0.039$). Similarly, in participants with habitual snoring, higher grit remained significantly associated with a reduced likelihood of EDS (OR 0.54, 95% CIs 0.29–0.97, $p = 0.042$). Interestingly, BMI was significantly associated with EDS only in the habitual snoring group. No significant association between sleep duration and EDS was noted in either subgroup.

Stratified analyses by age groups were also performed, adjusting for the same covariates (Table 4). Higher grit scores were consistently associated with a lower likelihood of EDS across all age strata: OR 0.29 (95% CIs 0.14–0.55) in individuals ≤ 40 years, OR 0.91 (95% CIs 0.86–0.95) in

Table 3 Multivariable logistic regression analysis for EDS in subgroups

	Model I			Model II		
	OR	95% CIs	<i>p</i>	OR	95% CIs	<i>p</i>
Grit	0.35	0.13–0.93	0.039	0.54	0.29–0.97	0.042
BMI (kg/m²)	1.00	0.88–1.12	0.939	1.13	1.03–1.23	0.006
Sleep duration (hours)	0.92	0.70–1.21	0.566	0.94	0.77–1.14	0.523
Poor sleep quality (yes)	2.10	0.99–4.43	0.052	2.16	1.24–3.74	0.006
Habitual snoring (yes)	2.55	1.03–6.54	0.046			
Depression (yes)				3.81	1.56–9.50	0.003
Anxiety (yes)	1.22	0.40–3.64	0.722	2.43	0.47–14.34	0.298
R²	0.19			0.18		

OR, odds ratio; **95% CIs**, 95% confidence interval; **BMI**, body mass index

Adjusted for age, sex, education level, income level, alcohol consumption, regular exercise, hypertension, and diabetes mellitus

Grit was used as a continuous variable and as the overall Grit-S score

In **Model I**, analyses were performed in participants with depression; and in **Model II**, analyses were performed in participants with habitual snoring

Table 4 Multivariable logistic regression analysis for EDS, stratified by age group

	Model I			Model II			Model III		
	OR	95% CIs	<i>p</i>	OR	95% CIs	<i>p</i>	OR	95% CIs	<i>p</i>
Grit	0.29	0.14–0.55	<0.001	0.91	0.86–0.95	<0.001	0.36	0.21–0.60	<0.001
BMI (kg/m²)	1.01	0.92–1.11	0.780	1.01	1.00–1.02	0.205	1.03	0.95–1.11	0.538
Sleep duration (hours)	1.16	0.92–1.48	0.215	1.00	0.98–1.03	0.771	0.97	0.83–1.13	0.705
Poor sleep quality (yes)	1.62	0.85–3.01	0.132	1.09	1.03–1.16	0.005	1.93	1.19–3.11	0.007
Habitual snoring (yes)	2.27	1.20–4.15	0.009	1.02	0.96–1.07	0.554	2.27	1.41–3.66	0.001
Depression (yes)	2.32	1.06–4.77	0.027	1.18	1.08–1.28	<0.001	2.64	1.46–4.81	0.001
Anxiety (yes)	2.63	0.73–8.58	0.120	1.11	0.90–1.35	0.329	2.95	0.30–65.73	0.386
R²	0.07			0.08			0.16		

OR, odds ratio; **95% CIs**, 95% confidence interval; **BMI**, body mass index

Adjusted for age, sex, education level, income level, alcohol consumption, regular exercise, hypertension, and diabetes mellitus

Grit was used as a continuous variable and as the overall Grit-S score

In **Model I**, analyses were performed in participants younger than 40 years; in **Model II**, analyses were performed in those aged 41–60 years, and in **Model III**, analyses were performed in participants older than 60 years

those aged 41–60 years, and OR 0.36 (95% CIs 0.21–0.60) in those > 60 years (all $p < 0.001$).

Discussion

In this nationwide survey of Korean adults, we found that EDS was prevalent, affecting 15.4% of participants. Importantly, we observed an inverse association between grit and EDS, particularly with the CI subscale, even after adjusting for potential confounders. In subgroup analyses, grit remained significantly associated with EDS in participants with habitual snoring and depression.

The prevalence of EDS in our study (15.4%), was slightly higher than those reported in previous studies from Korea (12.2%), the United States (12.7%), and Switzerland (11.3%) [3, 20, 21]. This higher rate aligns with the observed upward trend in EDS prevalence over time. Consistent with prior research, our findings also showed that older age and

female sex were associated with a higher prevalence of EDS [22].

Our study reveals an inverse relationship between grit and excessive daytime sleepiness (EDS), primarily driven by the consistency of interest (CI) subscale. This association may be explained by the role of intrinsic motivation in maintaining wakefulness. Previous research has shown that motivation plays a critical role in staying awake, as demonstrated in maintenance of wakefulness tests [10, 11, 23, 24]. Gritty individuals, who exhibit higher intrinsic motivation and resilience in pursuing long-term goals, may be less prone to experiencing daytime sleepiness [25].

Interestingly, only the CI subscale, which reflects passion and intrinsic motivation, was associated with EDS, while the PE subscale was not. This aligns with emerging evidence suggesting that CI and PE measure distinct traits [26, 27]. While previous studies have found PE to be a better predictor of academic success than CI [28, 29], our results suggest that the predictive power of grit components may vary depending on the outcome of interest [30, 31]. Since CI

reflects passion and sustained interest, whereas PE reflects effort and self-regulation over time [32], our findings suggest that motivation, rather than effort alone, plays a key role in mitigating daytime sleepiness.

Neurobiological studies provide additional insight into the relationship between grit and EDS. The gray matter volume of putamen, a brain region involved in motivation, has been positively associated with grit [33, 34]. Similarly, the medial prefrontal cortex, which is linked to increased daytime sleepiness, shows neuronal activity correlated with grit [35, 36]. Moreover, recent research revealed that functional connectivity in the brain's motivation pathway, specifically involving precuneus, was associated with CI [37]. These intricate neural interactions suggest that gritty individuals may have a neurological basis for better managing daytime sleepiness.

Our study also found a significant association between sleep quality and EDS, but not with sleep duration, consistent with previous research [3, 21]. Since the required amount of sleep can vary among individuals [38], perceived sleep sufficiency appears to be more relevant to EDS than absolute sleep duration [3]. This underscores the importance of assessing and managing perceived sleep sufficiency in individuals reporting EDS. Interestingly, a higher proportion of individuals in the EDS group reported engaging in regular physical activity. While this may seem counter-intuitive, one possible explanation is that individuals with EDS might adopt exercise as a compensatory strategy. Alternatively, higher physical activity levels may increase sleep need, and insufficient recovery sleep could contribute to perceived sleepiness. This aligns with prior findings in a Korean adult cohort [3].

In line with previous studies, depression had the strongest association with EDS among all variables [39, 40]. Furthermore, our subgroup analysis showed that snoring remained significantly associated with EDS in participants with depression, indicating an interplay between psychological health and sleep disturbances. Obstructive sleep apnea (OSA) is an independent risk factor for EDS [21]. Habitual snoring, a known indicator of OSA, was significantly associated with EDS in our study [2, 41]. Notably, BMI was not associated with EDS in the general population and among individuals with depression, but it became a significant factor in participants with habitual snoring. This reflects the combination of habitual snoring and elevated BMI may increase the risk of OSA, which in turn could contribute to EDS. These findings highlight the need to assess OSA in those who report both snoring and EDS as part of a comprehensive intervention strategy. Although our sample was representative of the general adult population in Korea, we acknowledge that the potential for age-related differences in EDS. To address this, we conducted stratified analyses by

age group, which demonstrated that the association between grit and EDS remained consistent across both younger and older age groups.

Managing EDS may benefit from a multifactorial approach. While grit is often viewed as a personality trait, some studies suggest that it can be developed over time. For example, a prospective longitudinal study among Korean students found that structured educational environments helped foster grit and improve academic performance [42]. Addressing underlying factors such as depression may also help alleviate daytime sleepiness [43]. Furthermore, continuous positive airway pressure therapy has emerged as an effective treatment not only for OSA but also for daytime symptoms such as sleepiness and depression [44, 45]. These findings emphasize the importance of a comprehensive evaluation and management of risk factors to effectively address EDS.

This study is one of the first to explore the association between grit and EDS in a large general adult population. A key strength of our analysis was the inclusion of various sleep-related and lifestyle factors, which helped to minimize potential confounding effects. However, the cross-sectional design limits the ability to establish causal relationships. Additionally, we relied on self-reported measures for daytime sleepiness and sleep duration, which may introduce bias. Although the ESS is a validated tool and self-reported sleep patterns have been shown to correlate with actigraphy-derived patterns [46, 47], the use of objective measures would provide more detailed insights into sleep-related factors. Third, while our models demonstrated statistically significant associations between grit and EDS, the R^2 values (ranging from 0.11 to 0.19) indicate modest explanatory power. This suggests that additional unmeasured factors, such as physiological sleep disorders, environmental stressors, or chronotype, may also contribute to EDS. The multifactorial nature of EDS has been highlighted in prior research [1, 3, 21, 22, 48–50]. Lastly, although ESS is widely used to assess EDS, it may exhibit variability across different populations, particularly among patients with untreated OSA. Nonetheless, the categorical use of ESS is consistent with standard research practices, and prior studies, including one reporting its test–retest reliability in untreated OSA, help mitigate this concern [51, 52].

Our study indicates that EDS is common among Korean adults and is inversely associated with grit, particularly the CI subscale. These findings suggest that intrinsic motivation may play a role in managing daytime sleepiness. While further research is needed, our results point to grit as a possible area for interventions aimed at improving wakefulness and reducing EDS.

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development of the Grit Scale. The Grit Scale has been a crucial instrument in our study, enabling us to explore the association between grit and EDS in the Korean population.

Author contributions **Conceptualization:** Dana Oh, Chang-Ho Yun; **Methodology:** Jae Rim Kim, Hyo Jin Park, Sang Min Paik, Sun-Ku Han, Woo-Jin Lee; **Formal analysis:** Jae Rim Kim; **Investigation:** Dana Oh, Jee-Eun Yoon, Woo-Jin Lee; **Visualization:** Jae Rim Kim, Hyo Jin Park, Sang Min Paik, Sun-Ku Han; **Data curation:** Jee-Eun Yoon; **Writing - original draft preparation:** Jae Rim Kim, Dana Oh; **Writing - review and editing:** Jae Rim Kim, Chang-Ho Yun; **Supervision:** Chang-Ho Yun; **Project administration:** Daeyoung Kim, Kwang Ik Yang, Min Kyung Chu, Chang-Ho Yun; **Funding acquisition:** Daeyoung Kim, Chang-Ho Yun.

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Data availability The data that support the findings of this study are available on request from the corresponding author, C.-H. Yun. The data are not publicly available due to the privacy or ethical restrictions.

Declarations

Ethics approval This study protocol was approved by the institutional review board/ethics committee of Seoul National University Bundang Hospital (B-1808-484-303). The study was conducted in accordance with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Consent for publication Not applicable.

Consent to participate Written informed consent was obtained from all participants before enrollment in the study.

Competing of interest C.-H. Yun is a member of the advisory board for Ybrain, Inc. and ARPI, Inc. and a founder and CEO of zBrain, Inc., Republic of Korea. All other authors report no conflicts of interest.

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