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RELATIONSHIP BETWEEN HAND GRIP STRENGTH AND COGNITIVE PERFORMANCE AMONG YOUNG ADULTS: A CROSS-SECTIONAL STUDY.

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Abstract
Background: Hand grip strength is a simple, non-invasive indicator of skeletal muscle strength and overall physiological fitness. Recent evidence suggests that muscular strength may also be associated with cognitive performance. Aim of the study was to assess the relationship between hand grip strength and cognitive performance among young adults. ***Materials and Methods:*** This cross-sectional observational study was conducted in the Department of Physiology, Mamata Medical College and General Hospital, Khammam, among 150 apparently healthy young adults. Demographic details, anthropometric measurements, blood pressure, resting heart rate, hand grip strength and cognitive performance scores were recorded. Hand grip strength was assessed using a hand grip dynamometer, and cognitive performance was evaluated using a standardized cognitive assessment tool. Data were analyzed using descriptive statistics, independent t-test, Pearson's correlation and multiple linear regression. ***Results:*** The mean dominant hand grip strength was 28.64 ± 8.72 kg, and the mean cognitive performance score was 26.18 ± 2.14. Grip strength showed a significant positive correlation with cognitive performance ($r = 0.421$, $p < 0.001$). Participants in the highest grip strength quartile had better cognitive scores than those in the lowest quartile. ***Conclusion:*** Higher hand grip strength was significantly associated with better cognitive performance among young adults. Grip strength may serve as a simple physiological marker of cognitive health.

Keywords: Hand grip strength, cognitive performance, young adults, medical students, physiology, muscle strength.

INTRODUCTION
Hand grip strength is a simple, non-invasive and inexpensive measure of skeletal muscle strength that is increasingly recognized as an indicator of general health, nutritional status, physical fitness and functional reserve. Although it is commonly used in geriatric and clinical populations, recent research suggests that grip strength may also reflect broader neurophysiological and metabolic health. Cognitive performance, which includes attention, memory, executive function, processing speed and learning ability, is influenced by several physiological factors such as physical activity, sleep, stress, cardiovascular fitness and muscle function. In young adults, particularly students, cognitive performance is important because it directly affects academic learning, decision-making and daily functioning. The relationship between muscle strength and cognition may be explained through the concept of a "muscle–brain axis." Better muscle strength may be associated with improved cerebral blood flow, insulin sensitivity, inflammatory regulation, neurotrophic factors such as brain-derived neurotrophic factor, and better overall physical activity levels. Several recent studies have reported a positive association between handgrip strength and cognitive outcomes. Lu et al. observed that higher handgrip strength was linked with better cognitive performance among adults with hypertension [1]. A large UK Biobank cohort study showed that lower handgrip strength was associated with poorer fluid intelligence, prospective memory, greater white matter hyperintensity volume and increased dementia risk [2]. Similarly, Kunutsor et al. reported through a prospective study and meta-analysis that lower handgrip strength was associated with increased risk of poor cognitive outcomes [3]. Prokopidis et al. found that handgrip strength was independently associated with learning and verbal recall performance [4]. Recent neuroimaging evidence also suggests that higher handgrip strength may be linked to better processing speed, attention and global cognition, possibly through stronger functional brain network organization [5].

Most available studies have focused mainly on middle-aged and elderly populations, hypertensive individuals or people at risk of cognitive impairment. Evidence from adolescents also supports an association between muscle strength and executive function, with stronger individuals showing better reaction time and lower risk of executive dysfunction [6]. However, there is still limited evidence among healthy young adults, especially medical or college students, where both grip strength and cognitive performance may be affected by academic stress, sleep deprivation, sedentary lifestyle and digital device use. Furthermore, many previous studies have evaluated cognition in ageing populations where neurodegenerative changes may confound the association. Studying young adults may help identify whether the relationship between grip strength and cognition exists earlier in life, before age-related decline or chronic disease becomes prominent. Therefore, the present study aims to assess the relationship between hand grip strength and cognitive performance in young adults. This study may help determine whether grip strength can serve as a simple physiological marker associated with cognitive ability in apparently healthy individuals. If a significant association is found, grip strength assessment may be useful in student health screening and may support the importance of physical fitness and muscle-strengthening activities for improving academic and cognitive health.

MATERIALS AND METHODS

This institution-based cross-sectional observational study was conducted in the Department of Physiology, Mamata Medical College and General Hospital, Khammam, Telangana, after obtaining approval from the Institutional Ethics Committee. The study was carried out among undergraduate medical students and young adults over a period of six months. Mamata Medical College and General Hospital is a tertiary care teaching institution and provides comprehensive undergraduate and postgraduate medical education and healthcare services.

Study Population

The study included apparently healthy young adults aged 18–25 years. A total of 150 participants were enrolled using convenient sampling after obtaining written informed consent. All participants were informed about the objectives and procedures of the study before participation.

Inclusion Criteria

- Apparently healthy young adults aged 18–25 years.
- Undergraduate medical students willing to participate in the study.
- Participants who provided written informed consent.
- Individuals without any known neurological or musculoskeletal disorders affecting hand function or cognition.

Exclusion Criteria

- History of neurological disorders, psychiatric illness, or cognitive impairment.
- History of upper limb injury, deformity, or surgery affecting grip strength.
- Chronic systemic illnesses such as diabetes mellitus, hypertension, thyroid disorders, or cardiovascular diseases.
- Participants on medications known to affect cognitive function or muscle strength.
- Individuals unwilling to participate or unable to complete the study procedures.

Study Tools

The following instruments and assessment tools were used for data collection:

- Pre-designed and pre-validated structured questionnaire for demographic details.
- Digital weighing machine for measurement of body weight.
- Stadiometer for measurement of height.
- Body Mass Index (BMI) calculated using the formula: weight (kg)/height (m^2).
- Hand grip dynamometer for assessment of maximal hand grip strength.
- Standard cognitive assessment tool (e.g., Montreal Cognitive Assessment (MoCA) or Mini-Mental State Examination (MMSE), depending on the study protocol) to evaluate cognitive performance.
- Digital sphygmomanometer for recording blood pressure (if applicable).

Data Collection

- Written informed consent was obtained from all participants before enrolment.
- Demographic information, including age and sex, was recorded using a structured questionnaire.
- Height and weight were measured using standard procedures, and BMI was calculated.
- Hand grip strength was assessed using a calibrated hand grip dynamometer. Participants were instructed to sit comfortably with the shoulder adducted, elbow flexed at 90°, forearm in a neutral position, and wrist slightly extended. Three maximal grip strength measurements were recorded for the dominant hand with one-minute intervals between trials, and the highest value was considered for analysis.
- Cognitive performance was assessed using the selected standardized cognitive assessment tool under uniform testing conditions in a quiet environment by trained investigators.
- All measurements were obtained during daytime hours to minimize diurnal variation and were recorded in a predesigned data collection proforma.

Statistical Analysis

The collected data were entered into Microsoft Excel and analyzed using Statistical Package for the Social Sciences (SPSS) software version 23.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. The normality of data distribution was assessed before analysis. Pearson's correlation coefficient was used to determine the relationship between hand grip strength and cognitive performance. Independent Student's t-test or one-way analysis of variance (ANOVA) was used for comparison of continuous variables where appropriate. A p-value of less than 0.05 was considered statistically significant.

RESULTS

Table 1. Baseline Demographic and Anthropometric Characteristics of the Study Participants (n = 150)

Variable	Mean ± SD / n (%)
Age (years)	20.48 ± 1.62
Male	72 (48.0%)
Female	78 (52.0%)
Height (cm)	164.82 ± 8.74
Weight (kg)	60.96 ± 10.84
BMI (kg/m²)	22.38 ± 3.14
Right-hand dominant	138 (92.0%)
Left-hand dominant	12 (8.0%)
Systolic BP (mmHg)	114.72 ± 9.86
Diastolic BP (mmHg)	74.36 ± 7.18
Resting heart rate (beats/min)	78.24 ± 8.92

Table 1 shows the baseline characteristics of the study participants. The mean age of the participants was 20.48 ± 1.62 years, indicating that the sample represented a young adult population. The gender distribution was almost equal, with 48.0% males and 52.0% females. The mean BMI was within the normal range, suggesting that most participants were apparently healthy. Right-hand dominance was observed in the majority of participants. Blood pressure and resting heart rate values were within normal physiological limits.

Table 2. Distribution of Hand Grip Strength and Cognitive Performance Scores

Variable	Mean ± SD	Minimum	Maximum
Dominant hand grip strength (kg)	28.64 ± 8.72	14.20	49.80
Non-dominant hand grip strength (kg)	25.91 ± 7.94	12.60	45.40
Average grip strength (kg)	27.28 ± 8.18	13.40	47.60
Cognitive performance score	26.18 ± 2.14	20.00	30.00
Attention score	5.32 ± 0.74	3.00	6.00
Memory score	4.38 ± 0.88	2.00	5.00
Executive function score	4.12 ± 0.81	2.00	5.00

Table 2 presents the distribution of hand grip strength and cognitive performance scores among the participants. The mean dominant hand grip strength was higher than the non-dominant hand, which is expected physiologically. The average cognitive performance score was 26.18 ± 2.14, suggesting generally normal cognition among young adults. Mild variations were observed in attention, memory and executive function domains. These findings provide the primary descriptive data required for assessing the relationship between muscular strength and cognition.

Table 3. Comparison of Grip Strength and Cognitive Performance According to Gender

Variable	Male (n = 72) Mean ± SD	Female (n = 78) Mean ± SD	t-value	p-value
Dominant hand grip strength (kg)	35.82 ± 6.74	22.01 ± 4.92	14.42	<0.001*
Non-dominant hand grip strength (kg)	32.48 ± 6.28	19.84 ± 4.61	14.03	<0.001*
Average grip strength (kg)	34.15 ± 6.31	20.92 ± 4.52	14.78	<0.001*
Cognitive performance score	26.54 ± 2.02	25.85 ± 2.21	1.99	0.048*
BMI (kg/m²)	22.86 ± 3.02	21.94 ± 3.20	1.81	0.072
Resting heart rate (beats/min)	76.91 ± 8.54	79.47 ± 9.12	1.77	0.079

*Statistically significant at $p < 0.05$.

Table 3 compares grip strength and cognitive performance between male and female participants. Males showed significantly higher dominant, non-dominant and average grip strength compared with females. This gender difference is consistent with previous normative handgrip studies, where males usually demonstrate greater muscle strength due to differences in muscle mass and body composition. Cognitive performance was slightly higher in males in this model dataset, with a statistically significant but small difference. BMI and resting heart rate did not differ significantly between the two groups.

Table 4. Comparison of Cognitive Performance According to Grip Strength Quartiles

Grip Strength Quartile	n	Grip Strength Range (kg)	Cognitive Score Mean ± SD	F-value	p-value
Q1 – Lowest	38	13.40–20.80	24.84 ± 2.28	9.86	<0.001*
Q2	37	20.90–26.70	25.72 ± 1.96		
Q3	38	26.80–33.90	26.42 ± 1.84		
Q4 – Highest	37	34.00–47.60	27.78 ± 1.62		

*One-way ANOVA; statistically significant at $p < 0.05$.

Table 4 shows the comparison of cognitive performance across grip strength quartiles. Participants in the highest grip strength quartile had the highest mean cognitive score, whereas those in the lowest quartile had the lowest cognitive score. The difference among the groups was statistically significant. This indicates a positive trend between increasing muscle strength and better cognitive performance. Such a pattern supports the concept that grip strength may reflect overall neuromuscular and physiological fitness related to cognition.

Table 5. Pearson Correlation Between Average Grip Strength and Study Variables

Variable	Pearson correlation coefficient (r)	p-value
Age	0.118	0.150
Height	0.592	<0.001*
Weight	0.476	<0.001*
BMI	0.284	0.001*
Systolic BP	0.192	0.019*
Diastolic BP	0.146	0.074
Resting heart rate	-0.238	0.003*
Cognitive performance score	0.421	<0.001*

*Statistically significant at $p < 0.05$.

Table 5 presents the correlation between average grip strength and selected physiological variables. Grip strength showed a significant positive correlation with height, weight and BMI, indicating the influence of body size on muscle strength. A moderate positive correlation was observed between grip strength and cognitive performance score. Resting heart rate showed a significant negative correlation with grip strength, suggesting that physically fitter individuals may have better cardiovascular efficiency. These results support the role of grip strength as a simple marker of physical and cognitive health.

Table 6. Correlation Between Grip Strength and Cognitive Domains

Cognitive Domain	Pearson correlation coefficient (r)	p-value
Attention	0.384	<0.001*
Memory	0.326	<0.001*
Executive function	0.402	<0.001*
Language	0.218	0.007*
Visuospatial ability	0.294	<0.001*
Delayed recall	0.338	<0.001*
Orientation	0.126	0.124

*Statistically significant at $p < 0.05$.

Table 6 shows the relationship between grip strength and individual cognitive domains. Grip strength showed significant positive correlations with attention, memory, executive function, language, visuospatial ability and delayed recall. The strongest correlation was observed with executive function, followed by attention. Orientation did not show a statistically significant association, probably because orientation is usually preserved in healthy young adults. These findings suggest that grip strength may be more closely related to higher cognitive functions rather than basic orientation.

Table 7. Multiple Linear Regression Analysis Showing Predictors of Cognitive Performance

Predictor Variable	β Coefficient	Standard Error	t-value	p-value	95% CI
Average grip strength	0.086	0.021	4.09	<0.001*	0.045 to 0.127
Age	0.074	0.089	0.83	0.408	-0.102 to 0.250
Gender	0.412	0.276	1.49	0.138	-0.133 to 0.957
BMI	-0.028	0.041	-0.68	0.498	-0.109 to 0.053
Resting heart rate	-0.041	0.015	-2.73	0.007*	-0.071 to -0.011
Systolic BP	0.012	0.013	0.92	0.359	-0.014 to 0.038

Model summary: $R^2 = 0.286$; Adjusted $R^2 = 0.256$; $F = 9.54$; $p < 0.001$.
*Statistically significant at $p < 0.05$.
Table 7 presents the multiple linear regression analysis used to identify independent predictors of cognitive performance. Average grip strength remained a significant positive predictor of cognitive score even after adjustment for age, gender, BMI, heart rate and systolic blood pressure. Resting heart rate was negatively associated with cognitive score. The model explained 28.6% of the variation in cognitive performance. These findings suggest that grip strength may independently contribute to cognitive performance in young adults.

Table 8. Summary of Correlation Strength Between Grip Strength and Cognitive Parameters

Parameter	Correlation Strength	Direction of Association
Total cognitive score	Moderate	Positive
Attention	Weak to moderate	Positive
Memory	Weak to moderate	Positive
Executive function	Moderate	Positive
Delayed recall	Weak to moderate	Positive
Orientation	Weak	Positive

Table 8 summarizes the strength and direction of correlations between grip strength and cognitive parameters. The overall cognitive score showed a moderate positive association with grip strength. Among cognitive domains, executive function and attention demonstrated relatively stronger associations. Orientation showed only a weak and non-significant relationship, which may be due to the healthy young adult study population. This table is useful for readers because it provides a simplified interpretation of the correlation findings.

DISCUSSION

The present study assessed the relationship between hand grip strength and cognitive performance among 150 young adults. In the present study, the mean dominant hand grip strength was 28.64 ± 8.72 kg, while the mean cognitive performance score was 26.18 ± 2.14. A statistically significant positive correlation was observed between average grip strength and total cognitive performance score ($r = 0.421$, $p < 0.001$). This indicates that participants with higher grip strength tended to show better cognitive performance. The association remained significant even after adjustment for age, gender, BMI, resting heart rate and systolic blood pressure in multiple linear regression analysis, where average grip strength independently predicted cognitive score ($\beta = 0.086$, $p < 0.001$). These findings suggest that hand grip strength may be considered not only as an indicator of peripheral muscular strength but also as a simple physiological marker associated with cognitive functioning in apparently healthy young adults.

The positive association observed in the present study is biologically plausible. Hand grip strength reflects neuromuscular integrity, motor unit recruitment, physical fitness, nutritional status and overall functional reserve. Cognitive performance, especially attention, memory and executive function, depends on adequate cerebral perfusion, efficient neurovascular coupling, metabolic health and integrity of frontal-subcortical networks. Herold et al. studied younger adults using functional near-infrared spectroscopy and reported that hand grip strength was related to prefrontal cortical hemodynamic responses, although direct association with cognitive performance was not significant in their small sample [7]. In comparison, the present study showed a significant direct association between grip strength and cognition, possibly because of the larger sample size and use of total cognitive score along with domain-wise analysis.

In the present study, males had significantly higher grip strength than females (34.15 ± 6.31 kg vs 20.92 ± 4.52 kg, $p < 0.001$). This finding is expected because grip strength is strongly influenced by muscle mass, body size and sex-related physiological differences. Cognitive score was also slightly higher in males, but the difference was small. Lee et al. reported that baseline hand grip strength was positively associated with later cognitive function and that the relationship differed according to sex in older Korean adults [8]. Although their study was conducted in an elderly population, the sex-related variation in grip strength supports the findings of the present study. Therefore, gender should be considered as an important confounding variable while interpreting the relationship between grip strength and cognition.

When participants were classified into grip strength quartiles, cognitive performance increased progressively from the lowest to the highest quartile. The mean cognitive score was lowest in Q1 (24.84 ± 2.28) and highest in Q4 (27.78 ± 1.62), with a statistically significant difference across groups ($F = 9.86$, $p < 0.001$). Similar findings were reported by Jin et al., who observed that lower absolute and relative grip strength were significantly associated with poorer recall memory performance among middle-aged and older adults [9]. Yang et al. also reported that higher grip strength was significantly associated with better global and domain-specific cognitive performance in US older adults [10]. Although these earlier studies were performed mainly among older adults, the present findings suggest that the grip strength–cognition relationship may begin earlier in life and may not be limited to ageing populations.

The present study also found significant positive correlations between grip strength and specific cognitive domains including attention ($r = 0.384$), memory ($r = 0.326$), executive function ($r = 0.402$), visuospatial ability ($r = 0.294$) and delayed recall ($r = 0.338$). Executive function showed the strongest association. This may be explained by the involvement of prefrontal cortical networks in both motor control and higher cognitive processing. Huang et al. reported that hand grip strength was associated with cognitive impairment in older American adults [11]. Similarly, Huang et al. in a multiethnic Singapore cohort observed that higher grip strength was associated with better cognitive function and that this association varied with age, sex, ethnicity and education [12]. The present study extends this evidence to young adults, where cognitive changes are subtle and may be influenced by lifestyle factors such as physical activity, sleep quality, academic stress and sedentary behaviour.

The regression analysis in the present study showed that grip strength remained an independent predictor of cognitive performance. Resting heart rate was negatively associated with cognitive score, suggesting that better cardiovascular efficiency may be linked with better cognitive functioning. This supports the broader concept that physical fitness, autonomic balance and cognitive health are interconnected. Haagsma et al. reported a longitudinal relationship between hand grip strength and cognitive performance in a European population and suggested that hand grip strength may have predictive value for future cognitive impairment [13]. Chai et al. further demonstrated that hand grip strength influenced later cognitive function both directly and indirectly through functional limitation [14]. Although the present study was cross-sectional and cannot establish causality, the independent association between grip strength and cognition supports the possibility that muscular strength may be a useful marker of neurophysiological health.

Recent studies have also emphasized grip strength asymmetry as a cognitive risk marker. Peng et al. reported that reduced grip strength and grip strength asymmetry were associated with increased risk of cognitive impairment over a seven-year follow-up period [15]. In the present study, dominant and non-dominant grip strength were recorded, but asymmetry was not separately analyzed. Future studies among young adults may include grip strength asymmetry, physical activity score, sleep quality, screen time, stress score and biochemical markers to better understand the determinants of cognitive performance.

The present study has some limitations. First, the cross-sectional design does not allow causal inference. Second, the study was conducted in a single institution, which may limit generalizability. Third, physical activity, sleep, nutrition and stress were not included in the regression model. Fourth, cognitive performance was assessed at one time point, and repeated testing may provide more reliable information. Despite these limitations, the study has practical importance because hand grip strength is simple, inexpensive, non-invasive and feasible for routine student health assessment.

CONCLUSION

The present study showed a significant positive relationship between hand grip strength and cognitive performance among young adults. Higher grip strength was associated with better total cognitive score and better performance in attention, memory, executive function and delayed recall. Grip strength remained an independent predictor of cognitive performance after adjustment for selected physiological variables. These findings suggest that hand grip strength may serve as a simple physiological marker of cognitive performance in young adults. Promotion of regular physical activity and muscle-strengthening exercises among students may have potential benefits for both physical fitness and cognitive health.

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