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# Cardiovascular Risk Burden Assessed by China-PAR Score and Its Link to Cognitive Performance in Older Adults: A Cross-Sectional Study

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## Abstract

# Background

Cardiovascular risk burden has been linked to cognitive impairment, yet evidence on the association between cardiovascular risk estimated using models developed specifically for the Chinese population and multidomain cognitive performance remains limited. This study examined the association between the China-PAR score and cognitive function in community-dwelling older adults.

# Methods

Using cluster random sampling, 733 adults aged below 85 years from Tianjin, China, were included in this cross-sectional study. Ten-year atherosclerotic cardiovascular disease risk was estimated using the China-PAR model. Cognitive function was assessed using the Wechsler Adult Intelligence Scale–Revised in China (WAIS-RC), including FIQ, VIQ, PIQ, and 11 subtests. Multiple linear regression models evaluated associations between the China-PAR score and cognitive performance, adjusting for years of education, body mass index, and APOE $\varepsilon 4$ carrier status.

# Results

Higher China-PAR scores were consistently associated with lower FIQ, VIQ, and PIQ. In the fully adjusted model, the higher China-PAR score was associated with lower FIQ, VIQ, and PIQ: FIQ, − 0.153 (− 0.226 to − 0.081), $p < 0.001$; VIQ, − 0.110 (− 0.174 to − 0.047), $p = 0.001$; PIQ, − 0.185 (− 0.270 to − 0.099), $p < 0.001$. Significant negative associations were also observed for Information, Comprehension, Arithmetic, Vocabulary, Digit Symbol, Picture Completion, Block Design, Picture Arrangement, and Object Assembly, but not for Similarities or Digit Span.

# Conclusions

Higher China-PAR scores were associated with lower global and domain-specific cognitive performance in community-dwelling older adults. Prospective studies are needed to confirm these findings, establish causality, and clarify the underlying biological mechanisms and pathways.

## Background

With the rapid aging of the global population, dementia has become a major public health challenge. Alzheimer's disease and related dementias seriously affect the quality of life and independence of older adults and impose substantial medical, social, and economic burdens on families and health-care systems [1, 2]. Therefore, early identification of high-risk populations and potentially modifiable factors is essential for delaying cognitive decline and reducing the future burden of dementia.

Cardiovascular health is closely related to brain health. Traditional cardiovascular risk factors, including hypertension, diabetes, dyslipidemia, smoking, and obesity, may contribute to cardiovascular and cerebrovascular diseases through endothelial dysfunction, atherosclerosis, vascular remodeling, and chronic inflammation. Cardiovascular and cerebrovascular diseases and vascular brain injury have been associated with cognitive impairment and dementia [3]. These findings support the concept of heart–brain interaction and suggest that cardiovascular risk factors may act as upstream determinants of cognitive function. Evaluating their cumulative burden may therefore help clarify their relationship with cognition in older adults.

Cardiovascular risk assessment models integrate multiple vascular risk factors to estimate an individual's overall cardiovascular risk [4]. Compared with individual risk factors, comprehensive scores better reflect cumulative vascular risk exposure. Commonly used models include the Framingham Risk Score, which incorporates age, blood pressure, cholesterol, smoking, and diabetes [5]; the American College of Cardiology/American Heart Association (ACC/AHA) Pooled Cohort Equations, which estimate 10-year atherosclerotic cardiovascular disease risk [6]; and SCORE2, which predicts fatal and non-fatal cardiovascular events in European populations [7]. However, their applicability to Chinese populations may be limited by differences in genetic background, disease patterns, lifestyle, and cardiometabolic characteristics.

The Prediction for ASCVD Risk in China (China-PAR) model was developed specifically to estimate 10-year atherosclerotic cardiovascular disease risk in Chinese adults [8]. It incorporates age, sex, blood pressure, lipid levels, smoking, diabetes, waist circumference, geographic region, urban–rural residence, antihypertensive treatment, and family history of cardiovascular disease. In this study, the estimated 10-year risk generated by the model was used as the China-PAR score to represent each participant's cumulative cardiovascular risk burden.

Although cardiovascular risk models are widely used for cardiovascular disease prevention, their application to cognitive health among Chinese older adults remains insufficiently explored. Evidence regarding the association between the China-PAR score and cognitive function in community-dwelling older adults is particularly limited. Therefore, this cross-sectional study investigated this association, with global and domain-specific cognitive function assessed using the Wechsler Adult Intelligence Scale–Revised in China (WAIS-RC). The findings may provide preliminary evidence that the China-PAR score could help identify community-dwelling older adults with lower concurrent cognitive performance.

## Methods

# Study Population

This cross-sectional study was conducted among community-dwelling older adults in Wangdingdi Street, Nankai District, Tianjin, China. A cluster random sampling method was used to recruit study participants. First, six communities within Wangdingdi Street were selected as sampling clusters. Then, eligible older

adults living in the selected communities were invited to participate in the survey and health assessment according to the inclusion and exclusion criteria.

## Sample Size Estimation

The sample size was estimated based on the primary multiple linear regression analysis using G*Power 3.1 [9]. A fixed-model multiple regression analysis was specified to test the increase in $R^2$ attributable to the China-PAR score after adjustment for covariates. The full model included four predictors: the China-PAR score, years of education, body mass index, and APOE ε4 carrier status. Assuming a small effect size of $f^2 = 0.02$, an $\alpha$ level of 0.05, and a statistical power of 80%, the minimum required sample size was 395 participants. After allowing for a possible non-response or incomplete-data rate of 15%, at least 465 participants were required.

## Inclusion and Exclusion Criteria

Inclusion criteria:

(1) Individuals aged below 85 years; (2) Individuals who had resided in the community for at least 2 years.

Exclusion criteria:

(1) Individuals with impaired consciousness; (2) Individuals with severe visual or hearing impairment; (3) Individuals with mental disorders; (4) Individuals with neurological diseases.

Finally, a total of 733 older adults aged below 85 years were included in this study, exceeding the minimum required sample size. Before the investigation, all participants were informed of the study purpose, procedures, and potential risks. The study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of Tianjin Medical University (approval number: TMUhMEC2016031). Written informed consent was obtained from all participants or their legally authorized representatives before participation.

## Questionnaire Survey

Trained investigators administered a structured questionnaire previously developed and used by our research group [10, 11] to collect sociodemographic characteristics, including name, sex, age, ethnicity, years of education, current residence, employment status, and occupational history, as well as medical history, smoking, and family history. Medical history was based on diagnoses made by physicians at tertiary Grade A hospitals. Smoking was self-reported; participants currently smoking cigarettes were classified as current smokers, and all others as non-current smokers.

## Physical Examination

Trained investigators performed physical examinations using standardized procedures. Waist circumference was measured twice at the midpoint between the lower rib margin and iliac crest at the end of normal expiration, and the mean was recorded to the nearest 0.1 cm.

Blood pressure was measured with a calibrated upper-arm electronic sphygmomanometer after at least 5 minutes of seated rest. Two measurements were taken at 1–2-minute intervals. When they differed by > 5 mmHg, a third was obtained, and the mean of the latter two was used.

# China-PAR Score

The China-PAR model was used to estimate the 10-year risk of atherosclerotic cardiovascular disease (ASCVD) based on age, sex, systolic blood pressure, total cholesterol, high-density lipoprotein cholesterol, antihypertensive treatment, diabetes, smoking, waist circumference, geographic region, urban–rural residence, and family history of ASCVD.

Continuous variables were natural-log transformed when required, categorical variables were coded according to the China-PAR algorithm, and sex-specific equations were applied. The model was expressed as: $risk\ score = \Sigma\ (\beta_{\ i} \bullet\ \ \mathrm{X}_i) + \Sigma\ (\gamma_{\ j} \bullet\ Interaction\ term_j)$, where *βi* represents the regression coefficient of each variable, *Xi* is the corresponding risk factor, and *γj·Interaction termj* denotes interaction terms. The 10-year risk was calculated as: 10-year ASCVD risk = 1-$S_0(10)^{exp}$(risk score), where $S_0(10)$ represents the baseline survival probability at 10 years.

Variables obtained from questionnaires, physical examinations, and serum biochemical tests were entered into the China-PAR assessment system. According to the calculated risk value, participants were classified into three risk categories: low risk (< 5.0%), moderate risk (5.0%–9.9%), and high risk (≥ 9.9%) [8].

## Cognitive Function Assessment

Cognitive function was assessed using the Wechsler Adult Intelligence Scale–Revised in China (WAIS-RC), which comprises 11 subtests. The verbal scale includes information, comprehension, arithmetic, similarities, digit span, and vocabulary, assessing abilities such as general knowledge, long-term and short-term memory, attention, comprehension, judgment, mental calculation, and logical reasoning. The performance scale includes digit symbol, picture completion, block design, picture arrangement, and object assembly, assessing learning ability, perceptual discrimination, visual recognition and memory, spatial processing, visuomotor coordination, causal reasoning, social planning, abstract thinking, and visual integration.

Systematically trained and experienced neurologists assessed each participant individually according to standardized administration and scoring procedures. General participant information, testing time, and testing location were recorded throughout the assessment process. Raw scores were converted to standardized scores using the WAIS-RC manual. The six verbal and five performance subtest scores were summed to obtain verbal and performance scale scores, respectively, while all 11 scores were summed to

obtain the total scale score. Full-scale IQ (FIQ), verbal IQ (VIQ), and performance IQ (PIQ) were then determined using the age-specific conversion table.

Scores for all VIQ and PIQ subtests were retained for analysis. Participants were also categorized by FIQ interquartile ranges: Q1 (81–103), Q2 (104–109), Q3 (110–115), and Q4 (116–133).

## Laboratory Measurements

# Serum Biochemical Indicators

Morning fasting venous blood (5 mL) was collected into coagulation-promoting tubes, left for 30 minutes, and centrifuged at 3000 rpm for 10 minutes. Serum was separated and stored at − 80°C until batch testing. Serum total cholesterol (TC) and high-density lipoprotein cholesterol (HDL-C) were measured using enzymatic colorimetric assay kits supplied by Zhongsheng Beikong Biotechnology Company and an automated biochemical analyzer (OLYMOUS AU640).

**APOE ε4 Detection**

Genomic DNA was extracted from peripheral blood leukocytes using a commercial kit according to the manufacturer's instructions. DNA concentration and purity were assessed with a NanoDrop 2000 spectrophotometer at 260 and 280 nm.

APOE genotyping was performed to determine the presence of the APOE ε4 allele. The APOE ε2, ε3, and ε4 alleles are defined by two single nucleotide polymorphisms, rs429358 and rs7412, which correspond to amino acid variations at positions 112 and 158 of the apolipoprotein E protein [12, 13]. APOE genotyping was performed using allele-specific polymerase chain reaction (AS-PCR). PCR reagents and reaction mixtures were prepared according to the laboratory protocol, and amplification was performed using a LightCycler 480 II real-time PCR system (Roche, Switzerland). To verify successful amplification, 4 μL of the PCR product was mixed with 1 μL of loading buffer and separated by electrophoresis on a 2% agarose gel at 150 V for 15 min. The gel was subsequently visualized using a Bio-Rad ChemiDoc XRS+ imaging system, and APOE genotypes were determined according to the allele-specific amplification patterns. The APOE genotypes were classified as ε2/ε2, ε2/ε3, ε2/ε4, ε3/ε3, ε3/ε4, or ε4/ε4.

Participants with at least one ε4 allele (ε2/ε4, ε3/ε4, or ε4/ε4) were classified as APOE ε4 carriers; those with ε2/ε2, ε2/ε3, or ε3/ε3 were classified as non-carriers. APOE ε4 carrier status was included as a covariate in multivariable regression models.

# Statistical Analysis

Analyses were performed using SPSS 25.0. Participants were divided into FIQ quartiles. Normally distributed continuous variables were expressed as mean ± standard deviation and compared using one-way analysis of variance, followed by the homogeneity of variance was satisfied. Non-normally distributed variables, variables with heterogeneous variances, and ordinal variables were compared using the

Kruskal–Wallis test. Categorical variables were expressed as counts (percentages) and compared using the $\chi^2$ test or Fisher's exact test. A two-sided $P < 0.05$ indicated statistical significance.

Multiple linear regression models examined associations of the China-PAR score with FIQ, VIQ, and PIQ. Years of education, body mass index, and APOE $\varepsilon 4$ status were progressively included as covariates. Additional models examined associations between the China-PAR score and the 11 WAIS-RC subtests. Results were reported as regression coefficients ($\beta$), 95% confidence intervals (95% CI), and P values and were visualized using forest plots.

## Results

# General Characteristics of Participants

A total of 733 community-dwelling older adults aged below 85 years were included in this cross-sectional study. Among them, 572 participants were female, accounting for 78.04% of the total sample. The mean age of the participants was 76.43 ± 6.70 years, and the mean years of education was 14.57 ± 3.39 years. The mean China-PAR score was 21.28 ± 8.52, indicating the overall cardiovascular risk burden of the study population.

The general characteristics of participants in different FIQ groups are shown in Table 1. There were statistically significant differences in age, years of education, systolic blood pressure, diastolic blood pressure, HDL-C, hypertension, and China-PAR score among the four FIQ groups ($p < 0.05$). Specifically, participants with higher FIQ tended to be younger, have more years of education, higher HDL-C levels, and lower China-PAR scores. No statistically significant differences were observed in sex, BMI, waist circumference, total cholesterol, APOE $\varepsilon 4$, smoking or diabetes among the groups($p > 0.05$).

Table 1
The general characteristics of participants in different FIQ groups

| **Age (years)** | **Q1 (81–103) n = 208** | **Q2 (104–109) n = 186** | **Q3 (110–115) n = 174** | **Q4 (116–133) n = 165** | **Statistics(*F*/ $\chi^2$)** | ***p* value** |
|---|---|---|---|---|---|---|
| | **78.01 ± 6.09** | **76.76 ± 6.11** | **76.47 ± 6.99** | **74.02 ± 7.10** | **11.594*** | **<0.001** |
| Sex (Female) | 156(75.00) | 144(77.42) | 133(76.44) | 139(84.24) | 5.128# | 0.163 |
| Education (years) | 12.66 ± 3.73 | 14.62 ± 2.85 | 15.39 ± 2.83 | 16.05 ± 2.93 | 41.796* | <0.001 |
| BMI(kg/m$^2$) | 27.83 ± 5.15 | 28.30 ± 5.82 | 27.91 ± 5.17 | 27.72 ± 5.52 | 0.389* | 0.761 |
| Waist circumference(cm) | 95.13 ± 11.25 | 94.75 ± 11.15 | 96.64 ± 11.43 | 94.49 ± 11.54 | 1.246* | 0.292 |
| SBP (mmHg) | 135.58 ± 16.93 | 134.33 ± 19.46 | 132.62 ± 16.87 | 130.27 ± 16.08 | 3.151* | 0.024 |
| DBP (mmHg) | 72.74 ± 12.13 | 70.74 ± 17.92 | 73.68 ± 11.03 | 74.96 ± 11.23 | 3.097* | 0.026 |
| TC (mmol/L) | 5.07 ± 0.99 | 5.02 ± 0.97 | 5.16 ± 0.95 | 5.22 ± 1.07 | 1.446* | 0.228 |
| HDL-C (mmol/L) | 1.46 ± 0.40 | 1.55 ± 0.44 | 1.66 ± 0.48 | 1.62 ± 0.52 | 7.119* | <0.001 |
| APOE $\varepsilon$4, n (%) | 50(24.04) | 33(17.74) | 34(19.54) | 42(25.45) | 4.232# | 0.237 |
| Smoking, n (%) | 88(42.31) | 83(44.62) | 76(43.68) | 71(43.03) | 0.229# | 0.973 |
| Hypertension, n (%) | 127(61.06) | 100(53.76) | 93(53.45) | 72(43.64) | 11.233# | 0.011 |
| Diabetes, n (%) | 31(14.90) | 17(9.14) | 16(9.20) | 11(6.67) | 7.671# | 0.053 |
| China-PAR score (%) | 23.29 ± 8.75 | 21.56 ± 8.56 | 20.79 ± 8.14 | 18.90 ± 7.96 | 8.689* | <0.001 |

Note: Continuous variables are presented as mean ± standard deviation, and categorical variables are presented as n (%). For continuous variables, the statistic represents the *F* value; for categorical variables, the statistic represents the $\chi^2$ value. $p < 0.05$ was considered statistically significant. **F* value; #$\chi^2$ value.

# Association between China-PAR score and cognitive function

Multiple linear regression models were used to examine the associations between China-PAR score and cognitive function indicators, including FIQ, VIQ, PIQ. The results showed that China-PAR score was negatively associated with FIQ, VIQ, and PIQ across different models. In the unadjusted model, higher

China-PAR score was significantly associated with lower FIQ, VIQ, and PIQ scores: FIQ, − 0.206 (− 0.285 to − 0.127), $p < 0.001$; VIQ, − 0.160 (− 0.231 to − 0.090), $p < 0.001$; PIQ, − 0.234 (− 0.325 to − 0.144), $p < 0.001$. After adjustment for years of education in Model 2, the negative associations between China-PAR score and these cognitive indicators remained statistically significant: FIQ, − 0.148 (− 0.220 to − 0.075), $p < 0.001$; VIQ, − 0.108 (− 0.172 to − 0.044), $p = 0.001$; PIQ, − 0.176 (− 0.260 to − 0.091), $p < 0.001$. In Model 3, after further adjustment for BMI and APOE $\varepsilon 4$ status, higher China-PAR score remained significantly and negatively associated with lower FIQ, VIQ, and PIQ: FIQ, − 0.153 (− 0.226 to − 0.081), $p < 0.001$; VIQ, − 0.110 (− 0.174 to − 0.047), $p = 0.001$; PIQ, − 0.185 (− 0.270 to − 0.099), $p < 0.001$. These findings indicate that higher China-PAR scores were consistently associated with lower cognitive performance, and the associations remained stable after stepwise adjustment for potential confounding factors.

# Subtest analysis

To further analyze the relationship between China-PAR score and different dimensions of cognitive function, multiple linear regression models were constructed using China-PAR score as the independent variable and the 11 subtest scores of the WAIS-RC as dependent variables. The regression coefficients, 95% confidence intervals, and *p* values for each subtest are presented in Table 2.

In the verbal subtests, the China-PAR score was significantly associated with Information, − 0.037 (− 0.059 to − 0.015), $p = 0.001$; Comprehension, − 0.030 (− 0.056 to − 0.004), $p = 0.024$; Arithmetic, − 0.014 (− 0.023 to − 0.006), $p = 0.001$; and Vocabulary, − 0.029 (− 0.048 to − 0.010), $p = 0.003$. No statistically significant associations were observed for Similarities, − 0.018 (− 0.037 to 0.000), $p = 0.052$, or Digit Span, − 0.010 (− 0.025 to 0.004), $p = 0.165$.

In the performance subtests, the China-PAR score was significantly associated with Digit Symbol, − 0.024 (− 0.038 to − 0.009), $p = 0.001$; Picture Completion, − 0.027 (− 0.052 to − 0.002), $p = 0.035$; Block Design, − 0.036 (− 0.054 to − 0.017), $p < 0.001$; Picture Arrangement, − 0.057 (− 0.081 to − 0.033), $p < 0.001$; and Object Assembly, − 0.044 (− 0.066 to − 0.022), $p < 0.001$.

Table 2
Associations Between the China-PAR Score and WAIS-RC Subtest Scores

| WAIS-RC subtest | *β* (95% CI) | *p* value |
|---|---|---|
| Information | −0.037 (− 0.059, − 0.015) | 0.001* |
| Comprehension | −0.030 (− 0.056, − 0.004) | 0.024* |
| Arithmetic | −0.014 (− 0.023, − 0.006) | 0.001* |
| Similarities | −0.018 (− 0.037, 0.000) | 0.052 |
| Digit Span | −0.010 (− 0.025, 0.004) | 0.165 |
| Vocabulary | −0.029 (− 0.048, − 0.010) | 0.003* |
| Digit Symbol | −0.024 (− 0.038, − 0.009) | 0.001* |
| Picture Completion | −0.027 (− 0.052, − 0.002) | 0.035* |
| Block Design | −0.036 (− 0.054, − 0.017) | < 0.001* |
| Picture Arrangement | −0.057 (− 0.081, − 0.033) | < 0.001* |
| Object Assembly | −0.044 (− 0.066, − 0.022) | < 0.001* |

Note: All models were adjusted for years of education, BMI, and APOE *ε*4 status. *$P < 0.05$ was considered statistically significant.

## Discussion

In this cross-sectional study of 733 community-dwelling older adults aged below 85 years in Tianjin, higher China-PAR scores were significantly associated with lower FIQ, VIQ, and PIQ scores after adjustment for years of education, BMI, and APOE *ε*4 status. Subtest analyses showed significant negative associations with Information, Comprehension, Arithmetic, Vocabulary, Digit Symbol, Picture Completion, Block Design, Picture Arrangement, and Object Assembly. These findings suggest that greater cardiovascular risk burden is associated with lower global cognition and multiple verbal and performance-based cognitive domains.

# Association between China-PAR Score and Cognitive Function

Higher China-PAR scores were negatively associated with FIQ, VIQ, and PIQ across all regression models. These associations remained significant in the fully adjusted model, indicating that the inverse relationship between cumulative cardiovascular risk burden and cognitive function was not fully explained by education, adiposity, or APOE *ε*4-related genetic susceptibility.

The China-PAR model was developed for the Chinese population and integrates major cardiovascular risk factors, including age, blood pressure, lipid levels, smoking, diabetes, waist circumference, antihypertensive treatment, geographic region, urban–rural residence, and family history of cardiovascular disease [8]. Compared with individual risk factors, the China-PAR score may better reflect cumulative vascular risk exposure. Previous systematic reviews have linked cardiovascular risk models with cognitive decline and dementia, supporting the relevance of integrated cardiovascular risk assessment to cognitive health [14]. Consistently, hypertension, diabetes, dyslipidemia, and smoking have been associated with cognitive impairment and dementia [15, 16].

Several mechanisms may underlie the observed association. Cardiovascular risk factors may contribute to cognitive impairment through chronic cerebral hypoperfusion, endothelial dysfunction, blood–brain barrier disruption, oxidative stress, neuroinflammation, and cerebral small vessel disease [16–18]. The latter can cause white matter hyperintensities, lacunar infarcts, cerebral microbleeds, and frontal-subcortical circuit disruption, which are associated with poorer executive function, slower processing speed, and global cognitive decline [18–20]. Therefore, the observed negative associations with FIQ, VIQ, and PIQ are biologically plausible.

Notably, the association was numerically greater for PIQ than for VIQ in the fully adjusted model ($\beta$ = −0.185 vs. $\beta$ = −0.110), although the difference between the coefficients was not formally tested. PIQ depends largely on processing speed, visuospatial organization, perceptual reasoning, and visuomotor integration, which rely on frontal–parietal networks and long-range white matter connections that may be particularly vulnerable to vascular injury. In contrast, verbal abilities such as accumulated knowledge and vocabulary represent crystallized cognitive functions that may be relatively preserved through education and cognitive reserve. This interpretation is consistent with the significant associations observed across all performance subtests, whereas Similarities and Digit Span were not statistically significant. Further longitudinal studies are needed to confirm whether cardiovascular risk preferentially affects performance-based cognitive domains.

The robustness of these associations in Model 3 suggests that the China-PAR score may help identify community-dwelling older adults with lower concurrent cognitive performance. Subtest analyses were therefore conducted to determine which cognitive domains were most closely associated with cardiovascular risk burden.

# Further Analysis of the Association Between China-PAR Score and WAIS-RC Subtests

The associations between China-PAR scores and the 11 WAIS-RC subtests were further examined. Among the verbal subtests, Information and Vocabulary reflect accumulated knowledge, semantic memory, and crystallized verbal ability, whereas Comprehension reflects verbal understanding, social judgment, and experience-based reasoning. Arithmetic requires attention, working memory, and mental calculation. These abilities are not limited to a single brain region, but are generally related to distributed language,

semantic, and executive networks involving the temporal cortex, inferior frontal regions, and frontoparietal systems [21]. The significant associations suggest that higher cardiovascular risk may be related to semantic processing, verbal reasoning, and attentional control.

Among the performance subtests, Digit Symbol is commonly regarded as a sensitive indicator of processing speed, visual attention, psychomotor speed, and executive efficiency. Previous studies have shown that the Digit Symbol Substitution Test is sensitive to impairments in processing speed, working memory, and executive function [22]. In addition, processing speed and attention-related performance in older adults are closely associated with frontoparietal connectivity and broader brain network integrity [23, 24]. The negative association with Digit Symbol may therefore reflect lower processing speed and attention-related performance among older adults with higher cardiovascular risk. This finding is consistent with evidence that vascular brain injury and cerebral small vessel disease often affect information processing speed and executive function at an early stage [19, 20].

Picture Completion, Block Design, Picture Arrangement, and Object Assembly mainly assess visual perception, visuospatial construction, perceptual organization, nonverbal reasoning, and visual-motor integration. Block Design, in particular, is closely related to visuospatial processing, perceptual organization, and nonverbal cognitive reserve [25, 26]. These abilities depend on coordinated activity across parietal, occipital, temporal, and frontal regions. Picture Completion and Object Assembly require visual recognition and integration, whereas Picture Arrangement involves sequential and social-causal reasoning. Cardiovascular risk may affect these processes through vascular brain injury, reduced cerebral perfusion, and white matter damage, which can disrupt long-range neural connections supporting visuospatial and executive processing [18–20].

The non-significant associations for Similarities and Digit Span suggest that the relationship between China-PAR score and cognition is not uniform across domains. Similarities mainly reflects abstract verbal reasoning, whereas Digit Span reflects short-term attention and working memory. These domains may be less sensitive to cardiovascular risk burden in this sample, or their associations may be affected by education, test variability, or cognitive reserve. The findings therefore suggest stronger associations with processing speed, visuospatial organization, perceptual reasoning, and complex verbal knowledge than with short-term memory span.

Overall, the subtest analysis extends the findings based on total IQ scores and suggests that cardiovascular risk is associated with multiple cognitive domains, particularly processing speed, executive efficiency, and visuospatial-perceptual organization. Future longitudinal studies combining neuropsychological assessment and brain imaging are needed to determine whether higher China-PAR scores predict domain-specific cognitive decline and whether cerebral small vessel disease or other vascular brain changes mediate these associations.

# Strengths and Limitations

This study has several strengths. First, it included 733 community-dwelling older adults, providing a relatively sufficient sample. Second, the China-PAR model was used to assess cardiovascular risk. This model is based on large-scale cohort studies in the Chinese population and has good applicability and predictive value in China [8]. In addition, the WAIS-RC was used to systematically assess multiple cognitive dimensions, and regression analyses of the overall scores and individual subtests were performed to examine their associations with the China-PAR score. This is one of the few studies examining the association between a population-specific cardiovascular risk burden and multi-domain cognitive function in Chinese community-dwelling older adults.

Several limitations should also be acknowledged. First, the cross-sectional design precluded determination of temporal sequence and causal relationships. Second, although participants were recruited from several communities, all were located in one area of Tianjin, which may limit generalizability to other regions and populations. In addition, women accounted for 78.0% of the study sample, which may reflect differential response rates during community-based recruitment and may have introduced selection bias. This sex imbalance may limit the generalizability of the findings to older men, and future studies should recruit more male participants to verify whether the observed associations are consistent across sexes. Third, despite adjustment for education, BMI, and APOE $\varepsilon 4$ status, residual confounding from factors such as physical activity, diet, and socioeconomic status cannot be excluded. Future multicenter longitudinal studies with larger, more diverse samples, repeated cognitive assessments, and brain imaging are needed to confirm the temporal relationship and clarify the underlying vascular and neurological mechanisms.

## Conclusions

This study found that higher China-PAR scores were significantly associated with lower FIQ, VIQ, and PIQ among community-dwelling older adults. At the subtest level, higher scores were associated with lower performance in Information, Comprehension, Arithmetic, Vocabulary, Digit Symbol, Picture Completion, Block Design, Picture Arrangement, and Object Assembly. The China-PAR score may help identify individuals with lower concurrent cognitive performance in this population. Prospective studies are needed to establish causality, while mechanistic studies should clarify the underlying biological mechanisms and pathways.

## Abbreviations

ACC/AHA
American College of Cardiology/American Heart Association
APOE
Apolipoprotein E
ASCVD
Atherosclerotic cardiovascular disease
BMI
Body mass index
China

PAR—Prediction for ASCVD Risk in China
DBP
Diastolic blood pressure
FIQ
Full—scale intelligence quotient
HDL
C—High—density lipoprotein cholesterol
PIQ
Performance intelligence quotient
SBP
Systolic blood pressure
TC
Total cholesterol
VIQ
Verbal intelligence quotient
WAIS
RC—Wechsler Adult Intelligence Scale—Revised in China

# Declarations

### Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of Tianjin Medical University (approval number: TMUhMEC2016031). Written informed consent was obtained from all participants or their legally authorized representatives before participation.

### Consent for publication

Not applicable.

### Availability of data and materials

De-identified data supporting the findings of this study are available as supplementary files accompanying this article. All directly identifying information has been removed to protect the privacy of the participants. Additional information regarding the dataset may be obtained from the corresponding author upon reasonable request, subject to institutional and ethical restrictions.

### Competing interests

The authors declare that they have no competing interests.

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**Clinical trial number**

Not applicable.

**Authors' contributions**

YQ contributed to investigation and writing – original draft. WZ contributed to methodology, investigation, and formal analysis. SG contributed to methodology and investigation. HC contributed to conceptualization, supervision, and project administration. XH contributed to methodology. SZ contributed to data curation and investigation. JY contributed to methodology and investigation. FM contributed to supervision, funding acquisition, and project administration. All authors read and approved the final manuscript.

# References

1. GBD 2019 Dementia Forecasting Collaborators. Estimation of the global prevalence of dementia in 2019 and forecasted prevalence in 2050: an analysis for the Global Burden of Disease Study 2019. *Lancet Public Health*. 2022;7(2):e105-e125. doi:10.1016/S2468-2667(21)00249-8
2. Livingston G, Huntley J, Liu KY, et al. Dementia prevention, intervention, and care: 2024 report of the Lancet standing Commission. *Lancet*. 2024;404(10452):572-628. doi:10.1016/S0140-6736(24)01296-0
3. Wang Y, Liu M, Chen Y, et al. Trade-offs among brain structural network characteristics across the cognitive decline process in cerebral small vessel disease. *Front Aging Neurosci*. 2024;16:1465181. Published 2024 Nov 28. doi:10.3389/fnagi.2024.1465181
4. van Daalen KR, Zhang D, Kaptoge S, Paige E, Di Angelantonio E, Pennells L. Risk estimation for the primary prevention of cardiovascular disease: considerations for appropriate risk prediction model selection. *Lancet Glob Health*. 2024;12(8):e1343-e1358. doi:10.1016/S2214-109X(24)00210-9
5. Elias MF, Sullivan LM, D'Agostino RB, et al. Framingham stroke risk profile and lowered cognitive performance. *Stroke*. 2004;35(2):404-409. doi:10.1161/01.STR.0000103141.82869.77
6. Goff DC Jr, Lloyd-Jones DM, Bennett G, et al. 2013 ACC/AHA guideline on the assessment of cardiovascular risk: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *Circulation*. 2014;129(25 Suppl 2):S49-S73. doi:10.1161/01.cir.0000437741.48606.98
7. SCORE2 working group and ESC Cardiovascular risk collaboration. SCORE2 risk prediction algorithms: new models to estimate 10-year risk of cardiovascular disease in Europe. Eur Heart J. 2021;42(25):2439-2454. doi:10.1093/eurheartj/ehab309
8. Yang X, Li J, Hu D, et al. Predicting the 10-Year Risks of Atherosclerotic Cardiovascular Disease in Chinese Population: The China-PAR Project (Prediction for ASCVD Risk in China). *Circulation*.

2016;134(19):1430-1440. doi:10.1161/CIRCULATIONAHA.116.022367

9. Faul F, Erdfelder E, Buchner A, Lang AG. Statistical power analyses using G*Power 3.1: tests for correlation and regression analyses. *Behav Res Methods*. 2009;41(4):1149-1160. doi:10.3758/BRM.41.4.1149
10. Wu X, Wang H, Chen C, et al. The association between cardiovascular risk burden and cognitive function amongst the old: a 9-year longitudinal cohort study. Eur J Neurol. 2021;28(9):2907-2912. doi:10.1111/ene.14947
11. Li T, Chen C, Yuan J, et al. The Association between Vitamin D Deficiency and Changes in Cognitive Functions in Chinese Older Adults: A Prospective Cohort Study. Curr Alzheimer Res. 2023;20(7):506-514. doi:10.2174/0115672050266769231025060359
12. Hixson JE, Vernier DT. Restriction isotyping of human apolipoprotein E by gene amplification and cleavage with Hhal. *J Lipid Res*. 1990;31(3):545-548.
13. Zhong L, Xie YZ, Cao TT, et al. A rapid and cost-effective method for genotyping apolipoprotein E gene polymorphism. *Mol Neurodegener*. 2016;11:2. Published 2016 Jan 12. doi:10.1186/s13024-016-0069-4
14. Jia R, Wang Q, Huang H, Yang Y, Chung YF, Liang T. Cardiovascular disease risk models and dementia or cognitive decline: a systematic review. *Front Aging Neurosci*. 2023;15:1257367. Published 2023 Oct 12. doi:10.3389/fnagi.2023.1257367
15. Mahinrad S, Sorond F, Gorelick PB. The Role of Vascular Risk Factors in Cognitive Impairment and Dementia and Prospects for Prevention. *Clin Geriatr Med*. 2023;39(1):123-134. doi:10.1016/j.cger.2022.07.007
16. Iadecola C, Gottesman RF. Neurovascular and Cognitive Dysfunction in Hypertension. *Circ Res*. 2019;124(7):1025-1044. doi:10.1161/CIRCRESAHA.118.313260
17. Santisteban MM, Iadecola C, Carnevale D. Hypertension, Neurovascular Dysfunction, and Cognitive Impairment. *Hypertension*. 2023;80(1):22-34. doi:10.1161/HYPERTENSIONAHA.122.18085
18. Wardlaw JM, Smith C, Dichgans M. Small vessel disease: mechanisms and clinical implications. *Lancet Neurol*. 2019;18(7):684-696. doi:10.1016/S1474-4422(19)30079-1
19. Zanon Zotin MC, Sveikata L, Viswanathan A, Yilmaz P. Cerebral small vessel disease and vascular cognitive impairment: from diagnosis to management. *Curr Opin Neurol*. 2021;34(2):246-257. doi:10.1097/WCO.0000000000000913
20. Hamilton OKL, Backhouse EV, Janssen E, et al. Cognitive impairment in sporadic cerebral small vessel disease: A systematic review and meta-analysis. *Alzheimers Dement*. 2021;17(4):665-685. doi:10.1002/alz.12221
21. Gore KR, Woollams AM, Bruehl S, Halai AD, Lambon Ralph MA. Direct Neural Evidence for the Contrastive Roles of the Complementary Learning Systems in Adult Acquisition of Native Vocabulary. *Cereb Cortex*. 2022;32(16):3392-3405. doi:10.1093/cercor/bhab422
22. Jaeger J. Digit Symbol Substitution Test: The Case for Sensitivity Over Specificity in Neuropsychological Testing. *J Clin Psychopharmacol*. 2018;38(5):513-519.

doi:10.1097/JCP.0000000000000941

23. Pahl J, Prokopiou PC, Bueichekú E, et al. Locus coeruleus integrity and left frontoparietal connectivity provide resilience against attentional decline in preclinical alzheimer's disease. *Alzheimers Res Ther*. 2024;16(1):119. Published 2024 May 31. doi:10.1186/s13195-024-01485-w
24. Rosano C, Perera S, Inzitari M, Newman AB, Longstreth WT, Studenski S. Digit Symbol Substitution test and future clinical and subclinical disorders of cognition, mobility and mood in older adults. *Age Ageing*. 2016;45(5):688-695. doi:10.1093/ageing/afw116
25. Joung H, Yi D, Byun MS, et al. Functional Neural Correlates of the WAIS-IV Block Design Test in Older Adult with Mild Cognitive Impairment and Alzheimer's Disease. *Neuroscience*. 2021;463:197-203. doi:10.1016/j.neuroscience.2021.04.001
26. Corujo-Bolaños G, Yánez-Pérez R, Cedrés N, Ferreira D, Molina Y, Barroso J. The block design subtest of the Wechsler adult intelligence scale as a possible non-verbal proxy of cognitive reserve. *Front Aging Neurosci*. 2023;15:1099596. Published 2023 Mar 2. doi:10.3389/fnagi.2023.1099596

# Figures

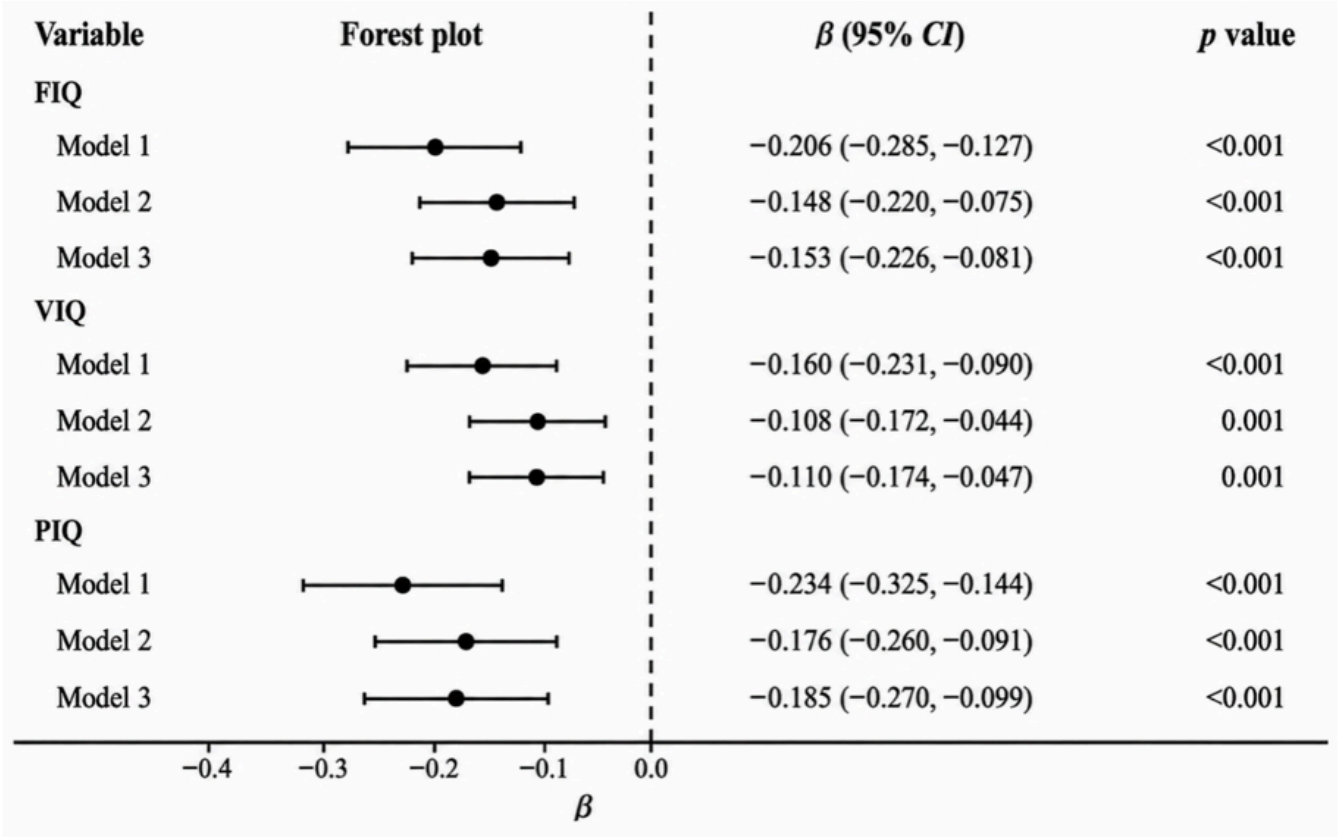


**Figure 1**

**Forest plot of the associations between China-PAR score and FIQ, VIQ, and PIQ**

Note: Model 1 was unadjusted; Model 2 was adjusted for years of education; and Model 3 was adjusted for years of education, BMI, and APOE $\varepsilon 4$ status.

## Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- data.xlsx
- VIQPIQFIQdata.xlsx
- WAISRC11tests.xlsx