Cognitive but not physical advantages in Japanese SuperAgers:
Evidence from urban and rural cohorts

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日本のスーパー高齢者における認知と身体機能
—都市部と農村部の比較から—

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要約

スーパーエイジャー（SA：エピソード記憶が非常に良好な高齢者）に関する既存研究は、主として脳画像所見に焦点を当てており、その行動特性に関する検討は十分ではない。本研究の目的は、日本の高齢者 SA が記憶以外の認知領域でも優れたパフォーマンスを示すか、および同年齢の高齢者と比べて基本的身体機能に差異がみられるかを明らかにすることであった。データは八雲研究および東山研究から得た。75 歳以上の地域在住高齢者を、ウェクスラー論理記憶検査の成績に基づいて、SA 群（n = 87）または対照群（n = 71）に分類した。参加者は、4 つの認知機能検査（記憶および非記憶課題）と 4 つの身体機能評価（例：握力、歩行速度）を受けた。その結果、SA 群は文字流暢性を除き、記憶（エピソード記憶）および非記憶領域（情報処理速度、意味流暢性、実行機能）を含むほぼすべての認知課題で対照群より有意に高い成績を示した。一方、歩行速度、筋力、バランス機能などの身体機能指標では、群間に有意差は認められなかった。これらの知見は、SA 群がエピソード記憶に加えて複数の認知領域においても優位性を有することを示している。また、身体機能については、認知機能が平均的な同年齢者と大きな差がないことも明らかになった。したがって、高齢者の健康増進戦略においては、認知機能の低下予防のみならず、認知機能と身体機能の双方に着目する必要があると示唆される。

Key words
super-agers, Yakumo Study, Higashiyama Study, cognitive function, physical function

1. Introduction

A central feature of successful aging is the preservation of cognitive and physical functions into advanced age. SuperAgers (SAs), as defined by the Northwestern SuperAging (NW-SA) project, represent a distinctive aging phenotype characterized by exceptional cognitive preservation. Harrison et al. (2012) reported that individuals over the age of 80 years with superior episodic memory showed greater cortical thickness in the left anterior mid-cingulate cortex (aMCC) compared to age-matched peers, and no signs of atrophy relative to middle-aged adults (aged 50-65). Subsequent neuroimaging studies have consistently demonstrated distinct structural brain features in SAs.

Several studies—excluding Gardiner et al. (2021)—have reported that SAs, also referred to as “Super-Normal,” “High-Performing Older Adults,” or “Optimal Memory Performers,” exhibit larger hippocampal volumes, fewer neurofibrillary changes, reduced amyloid plaque accumulation in the anterior cingulate cortex, and increased neuronal size in key brain regions (e.g., Yang et al., 2016; Baran & Lin, 2018; Gefen et al., 2015; 2018; Nassif et al., 2022). Using multimodal MRI, Harrison et al. (2018) also identified greater cortical thickness in regions associated with memory, including the anterior cingulate and prefrontal cortices.

However, structural brain measures alone cannot fully explain the behavioral and cognitive performance of older adults. Cognitive reserve, brain reserve, and brain maintenance mechanisms may allow individuals to maintain performance despite underlying neuropathology (Clare et al., 2017; Stern et al., 2020).

Although the number of studies on SAs has increased, their behavioral and cognitive profiles remain incompletely understood. Harrison et al. (2012) found minimal differences between SAs and typical older adults on non-memory tasks, with only a slight advantage in the Trail Making Test-B. Similarly, Karpouzian-Rogers et al. (2023) reported better performance in episodic memory among SAs, but no significant differences in processing speed, working memory, or executive function. Cook-Maher et al. (2022) observed superior memory and attention in SAs but not in verbal ability or visuospatial function. Garo-Pascual et al. (2023), in a larger Spanish cohort, reported broader cognitive and physical advantages in SAs. However, the scope of their test battery was limited.

Previous research on SAs faces several critical limitations. First, most studies have used small sample sizes. Second, behavioral assessments often focus narrowly on cognitive outcomes, with little integration of physical or motor function measures. Finally, most studies have focused on Western, predominantly White populations, limiting the generalizability of findings across cultures. Cultural differences in psychological processes (Farah, 2017; Kitayama & Salvator, 2024) may influence aging trajectories, making it essential to examine SAs in non-Western contexts.

Understanding whether SAs exhibit superior physical as well as cognitive function is important for public health strategies aimed at healthy aging. This is particularly relevant given the popular belief—promoted in media and commercial programs—that “brain training (cognitive training)” alone can maintain both mind and body health in old age. However, the scientific basis for such claims remains inconclusive. For example, Nouchi & Kawashima (2014) found that cognitive training improved certain functions such as executive control and processing speed, which are closely related to daily functioning, but did not affect all cognitive domains. A meta-review by Chiu et al. (2017) concluded that cognitive training had moderate effects on executive and general cognition and small but positive effects on memory and visuospatial attention. In contrast, Gates et al. (2019), in a randomized controlled trial with adults aged 65 and older, found no significant improvements in overall cognition or subdomains (e.g., memory, executive function, processing speed) after computer-based cognitive training. They also reported no effects on the quality of life, activities of daily living, or adverse outcomes. These mixed findings indicate that cognitive training alone may not be sufficient for comprehensive health benefits in older adults. Nevertheless, brain training has become a widespread industry targeting seniors. Many older individuals realize to perceive brain training as adequate, often neglecting physical exercise, which is strongly endorsed by health professionals. This discrepancy may be due to differences in motivation—cognitive training is often more accessible, requires less preparation, and can feel more stimulating or enjoyable.

These backgrounds produced to the present study that primary aim to examine the behavioral characteristics of Japanese SAs using data from both the Yakumo (rural region) and Higashiyama (urban region) studies. Specifically, we sought to evaluate the cognitive and physical functions of SAs residing in rural and urban settings, that may differ in psychological self-awareness, exercise habits, and level of involvement in the local community. To examine possible regional differences was also the purpose of this study. This study represents the first comprehensive investigation into the psychosocial and cognitive profiles of SAs within a Japanese population.

A secondary aim was to explore whether preserved cognitive function in very old age is associated with preserved physical function. Clarifying this relationship may help determine whether interventions targeting only cognitive domains are sufficient to mitigate age-related decline, or whether parallel promotion of both cognitive and physical training is needed in public health strategies for older adults.

2. Method

2.1 Participants

Participants were drawn from the databases of the Yakumo Study and the Higashiyama Study. Participants were classified as SAs (criteria described later) if they met the following criteria: age ≥ 75 years, Mini-Mental State Examination (MMSE) score ≥ 24, and a score ≥ 14 on the Wechsler Logical Memory Test (WLMT). Those with WLMT scores below 14 were categorized as Controls. The cutoff score of 14 was based on the average score of 13.6 for 50-year-olds (Hatta et al., 2005). Our criteria for SAs differ from the original NW-SA definition. We adopted the age threshold of 75 years to align with Japan’s legal definition of older adulthood and to secure an adequate sample size for meaningful statistical analyses. Several previous studies have used similar age criteria (Powell et al., 2024). Additionally, the WLMT was used instead of the RAVLT because it is a culturally validated and widely used episodic memory measure in Japan. Although this divergence may limit direct comparison with NW-SA studies, our selection still reflects individuals with superior memory function relative to age norms.

In the Yakumo Study, from 2010 to 2019, 3,406 participants underwent the Nagoya University Cognitive Assessment Battery (NU-CAB), with 551 individuals aged 75 or older. Among those, 55 met the SA criteria and 32 served as Controls after excluding overlapping years. In the Higashiyama Study, 71 individuals aged 75 or older were included. After screening by criteria, 32 participants were classified as SAs and 39 as Controls. As the cognitive score patterns did not significantly differ between the studies as described later, the data were combined, yielding a final sample of 87 SAs and 71 Controls. Demographic characteristics are presented in Table 1.

2.2 Study background

The Yakumo Study, an ongoing cohort initiated in 1981, involves collaboration between Yakumo Town and Nagoya University. It targets rural community-dwellers with diverse backgrounds in agriculture, fishing, forestry, and clerical work. Participants were included if they voluntarily completed both cognitive and physical function assessments. The Higashiyama Study, launched in 2023 by Kyoto Women's University in cooperation with the Higashiyama Ward in Kyoto, focused on urban residents aged 65 and older. Participants completed cognitive and physical assessments and a nutrition survey. The study population represents an urban demographic from a densely populated commercial district.

2.3 Cognitive and physical measures

Cognitive Measures: Cognitive function was assessed using the Nagoya University Cognitive Assessment Battery (NU-CAB), a standardized battery developed for population-based research (Hatta, 2004). The battery included the following tests:

- Mini-Mental State Examination (MMSE):
  Assessed global cognitive functioning.
- Digit Cancelation Test (D-CAT):
  Comprised of two versions (D-CAT1 and D-CAT3), this paper-and-pencil task evaluated information processing speed, selective and sustained attention, working memory, and executive function.
- Wechsler Logical Memory Test (WLMT):
  Measured episodic memory through the immediate recall of a short narrative.
- Letter Fluency Test (LFT) and Semantic Fluency Test (SFT):
  Evaluated verbal fluency and lexical access.
- Money Road Map Test (RMT):
  Assessed visuospatial function and orientation.
- Stroop Test:
  Measured executive function through interference control.

Due to time constraints, the RMT and Stroop Test were not administered in the Higashiyama cohort.

The D-CAT is a paper-and-pencil type screening test for attention and executive function that follows Sohlberg and Matter's attention model (Sohberg & Matters, 1987). The D-CAT sheet comprised 12 rows of 50 digits. Each row contained 5 sets of numbers 0-9 arranged randomly. In the D-CAT, participants were instructed to search for the target number and delete each number with a slash mark as quickly and accurately as possible. There were two conditions in the D-CAT, the target was a single digit (D-CAT1) and the target was three digits (D-CAT3); the former addressed mainly information processing speed and focusing, while the latter addressed information processing speed, focusing, and executive function assessment (particularly the updating component amongst inhibition, shifting and updating that consisted of the executive function (Miyake & Fredman, 2012). Reliability and validity were previously reported (Hatta et al., 2012). WLMT scoring was based on the number of correctly recalled segments (maximum: 25), and only immediate recall performance was used due to its strong correlation with delayed recall (r = 0.92; Hatta et al., 2005).

Physical Measures: Physical functioning was evaluated through tests common to both studies:

- 10-Meter Walk Test (10 m-WK):
  Assessed gait speed under "comfortable" and "maximum effort" conditions. Time was recorded for the central 6 me-

Table 1: Demographic characteristics of the SA and control groups

	Mean age yrs. old and *SD*	Mean years of education and *SD*	Percentage of women
SAs *N* = 87	79.48 (7.27)	11.23 (5.92)	52.9 %
Controls *N* = 71	82.42 (12.69)	10.46 (5.84)	67.6 %

ters, following the guidelines of the Academy of Neurologic Physical Therapy.

- Muscle Strength (Grip and Back Strength):
  Grip strength was measured twice on each hand, and the average was calculated. Back strength was assessed via a standing isometric pull using a dynamometer.
- Balance Function (Stabilometry):
  Participants stood still for 60 seconds on a stabilometer with their eyes open. Two indices were extracted: total trajectory length and area of sway.

These assessments were conducted by orthopedic teams, and the stabilometer data served as indices of static postural control, particularly relevant in detecting early balance deficits in older adults.

3. Results

The cognitive and physical function scores were standardized to facilitate appropriate statistical analyses. To preliminarily assess whether regional (i.e., cultural) differences influenced patterns of cognitive and physical performance scores between the Higashiyama (urban) and Yakumo (rural) cohorts, a two-way analysis of variance (ANOVA) was conducted. This analysis included cognitive and physical performance measures, with region (urban vs. rural) as a between-subjects factor. The ANOVA revealed no significant interaction effects ($F_{1, 8} = 0.73$), indicating that regional differences did not influence performance patterns. Therefore, the SAs from both regions were combined into a single SA group for subsequent analyses.

To compare the cognitive and physical performance between the SAs and Control groups, ANCOVAs were conducted firstly for each item using years of education as a covariate. The covariate had negligible effects and no significant interactions. Follow-up ANOVAs revealed that the SA group performed significantly better than the control group on D-CAT1 ($F_{1, 155} = 3.92$, $p < .05$), D-CAT3 ($F_{1, 155} = 12.18$, $p < .01$), WLMT ($F_{1, 155} = 338.98$, $p < .001$), and SFT ($F_{1, 155} = 21.41$, $p < .001$). No significant group difference was observed for the LFT ($F_{1, 155} = 1.78$, $p = .18$).

In contrast, none of the physical function measures showed significant group differences: 10m walk test ($F_{1, 155} = 2.27$, $p = .13$), Muscle strength ($F_{1, 155} = 0.01$, $p = .91$), sway trajectory Length ($F_{1, 155} = 1.28$, $p = .26$), or sway trajectory Area ($F_{1, 155} = 6.61$, $p = .06$).

In summary, the SAs demonstrated significantly superior cognitive performance compared to the controls (except LFT), but no significant differences were observed in physical function.

4. Discussion

In the NW-SA study, SAs are defined as individuals aged 80 years or older whose episodic memory performance is comparable to that of people in their 50s-60s, and who are not suspected of having mild cognitive impairment (MCI).

Table 2: Mean performances and standardized scores and *SD*s of the cognitive and physical items for the SA and control groups

	Controls		SAs		*t* and *p* scores, respectively
	Performance	Z-score	Performance	Z-score	
	Mean (*SD*)	Mean (*SD*)	Mean (*SD*)	Mean (*SD*)	
D-CAT1	20.41 (6.27)	–0.41 (1.06)	22.69 (10.43)	0.18 (0.90)	$F = 3.52, p < 0.05$
D-CAT3	34.70 (10.11)	–0.28 (1.01)	40.15 (9.23)	0.26 (0.92)	$F = 12.18, p < 0.01$
WLMT	13.31 (3.34)	–0.89 (0.61)	17.43 (2.75)	0.78 (0.49)	$F = 338.98, p < 0.00$
LFT	7.52 (7.39)	–0.16 (1.02)	8.02 (3.41)	0.14 (0.96)	$F = 1.76, p < 0.18$
SFT	10.44 (7.32)	–0.38 (0.93)	11.72 (3.49)	0.36 (0.93)	$F = 21.41, p < 0.00$
10 m-Walk	13.21 (17.26)	0.078 (1.0)	11.96 (8.66)	–0.06 (0.91)	$F = 2.27, p < 0.13$
Muscle strength	62.73 (55.60)	0.03 (1.14)	41.13 (31.85)	–0.02 (0.86)	$F = 0.01, p < 0.91$
Length	125.02 (324.77)	0.07 (1.00)	91.32 (123.33)	–0.06 (0.99)	$F = 1.28, p < 0.26$
Area	138.92 (446.58)	0.14 (1.04)	90.13 (138.26)	–0.13 (0.94)	$F = 3.61\ p < 0.06$

Notes: Length and area refer to the center of gravity trajectory length and center of gravity trajectory area. The degree of freedom of the *F*-test is 1/155.

Inspired by the NW-SA study, the present research aims to examine the behavioral characteristics of SAs rather than their brain imaging findings. Unlike neuroimaging studies, which can examine such characteristics with only 12-15 participants, behavioral studies require a considerably larger sample size for statistical analysis. Therefore, this study targeted individuals aged 75 years or older who demonstrated episodic memory performance comparable to that of people in their 50s and who were not suspected of having dementia. Although it might be more accurate to refer to these participants as "pseudo-SuperAgers" to reflect the studys' aim more precisely, we chose to refer to them simply as SAs for the sake of clarity and consistency.

This study investigated the behavioral characteristics of Japanese SAs and Control participants, expanding upon the recent findings by Garo-Pascual et al. (2023). Prior research, including that by Harrison et al. (2012) and Karpouzian-Rogers et al. (2023), has suggested that SAs exhibit superiority primarily in memory-related functions, with no clear advantage in other cognitive domains. These behavioral findings appear inconsistent with neuroanatomical evidence emphasizing the role of the anterior midcingulate cortex (aMCC), which is involved not only in episodic memory but also in spatial attention, cognitive control, and motivational regulation (Touroutoglou et al., 2023).

Garo-Pascual et al. (2023) addressed this discrepancy by studying a larger sample (64 SAs and 55 controls), showing that the SAs outperformed the controls not only in cognitive tasks but also in physical tasks. However, their assessment of physical function was based on only two items—Timed Up and Go (TUG) and finger tapping—administered to just seven participants (three SAs and four controls), as noted in their appendix.

In contrast, our study systematically evaluated five cognitive and four physical functions in a well-powered sample. Consistent with previous findings (Garo-Pascual et al., 2023), we observed superior cognitive performance among SAs across several domains, including verbal memory and semantic fluency, although the results for LFT did not reach statistical significance. Because the selection criterion for SAs was episodic memory, it may have been more compatible with SFT, which has a higher imagery evocativeness, and may have produced results that differed from those of LFT. The WLMT is more faithful to Talving's definition of episodic memory than the RAVLT (Rey Auditory-Verbal Learning Test), the episodic memory test used in the NW-SA study. The LFT involves a search using a mental dictionary starting with the initial letter (phonological search), whereas the SFT involves a search for object names based on the instructions of category names such as animals and fruits, so the search for object names is thought to be mediated by imagery. According to Tulving's definition, the episodic memory task and semantic fluency task are considered to have high affinity in terms of the possibility of imagery.

Not coincident with Garo-Pascual et al. (2023), we found no group differences between the SAs and controls in any physical function measure, although their employed physical items were not fully systematically evaluated.

Given the aMCC's involvement in both cognitive and physical motor functions, we hypothesized that SAs might also demonstrate enhanced physical performance, particularly in tasks requiring automatic motor coordination. However, our findings indicate that, within the parameters of this study, superior cognitive aging does not necessarily co-occur with measurable superiority in basic physical functions. Indeed, many studies propose that physical fitness, especially resistance training, can enhance cognitive function in older adults. However, our null findings may reflect several factors: (1) the SAs in our sample may have maintained cognitive function through mechanisms unrelated to physical fitness (e.g., cognitive reserve or social engagement); (2) basic physical measures (e.g., grip strength, gait speed) may not fully capture higher-order motor functions; and (3) physical activity levels were not directly measured in this study.

Our results further extend that those SAs exhibit broader cognitive advantages beyond memory, consistent with the aMCC's role in integrating multiple cognitive domains. Rather than viewing SAs as merely possessing expanded memory capacity, it may be more appropriate to conceptualize them as individuals with advanced cognitive systems capable of flexible and efficient processing across multiple domains.

Mesulam (2000) identified three principal variables influencing brain aging: time, genetic and constitutional factors, and stochastic life events. While the first two have been extensively studied, the role of environmental exposures and life experiences remains less understood. We performed a two-way ANOVA to examine potential interactions between region (urban vs. rural) and cognitive/physical function scores, but found no significant effects. While this suggests a limited regional influence on objective test performance, our previous analysis using the same sample indicated that subjective aging perceptions do differ by region (Hatta et al., 2025).

These results indicate that among older Japanese adults, regional or cultural effects may have a greater impact on subjective perceptions than on objective cognitive or physical functions. Longitudinal studies, such as those based on the Yakumo database, are needed to further explore midlife factors, including more comprehensive psychosocial and cultural measures. (e.g., socioeconomic status, sleep, nutrition, physical activity, and alcohol/smoking habits) that influence healthy aging trajectories.

In summary, this study made beyond confirming prior findings on cognitive superiority in SAs. First, it is the first study to systematically examine SAs in a Japanese population, addressing the cross-cultural generalizability of the SA phenotype. Second, unlike most previous studies focusing solely on memory, we evaluated both the memory and non-memory domains and found broader cognitive advantages. Third, by including physical function assessments and comparing urban/rural cohorts, we highlight the partial dissociation between cognitive and physical aging. These findings highlight the importance of promoting both cognitive and physical health from midlife. Public health efforts should incorporate strategies for enhancing not only cognitive stimulation (brain training) but also physical activity to support holistic aging.

5. Limitations

This study has several limitations. First, we did not actually use brain imaging to confirm whether the aMCC was larger in the SA group than in the Control group. This is because previous studies on the anatomical characteristics of the SA related to the aMCC have been robust. Second, as this is a common assumption in neuropsychological research, we did not confirm the correspondence between the test items thought to reflect cognitive function and actual neural activity. Third, it should be noted that the tests used as episodic memory testswere not the same (RAVLT: NW-SA study and WLMT: present study), which may have led to differences in the results of the two studies. Fourth, due to time constraints in the Higashiyama Study protocol, Stroop and Road Map Test were not administered in that cohort. To maintain analytic comparability, we focused our main group comparisons on cognitive tasks common to both cohorts. Although this is a limitation, the included tests (e.g., WLMT, D-CAT, verbal fluency tasks) cover key cognitive domains and offer sufficient scope to evaluate cognitive performance differences. Fifth, in our previous study, we examined developmental changes for the immediate and delayed recall conditions in the word recall test and the WLMT from the age of 40 to 80 years or older. Results showed that performances in the immediate recall condition was superior, recall performance decreased with age, and there were gender differences but no interaction between age and recall conditions. Finally, in order to increase the number of participants, our used criteria migh include a possibility that some participants suspected having MCI.

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