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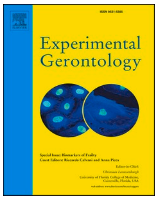

What predicts memory complaints of older individuals living in the Sardinian Blue Zone? An exploratory interdisciplinary approach

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ABSTRACT

Memory complaints indicate the self-reported experience of memory failures or difficulties in daily life. While different measures of functional and psychological health seem to be associated with memory complaints in later life, the concurrent impact of perceived physical health, memory self-efficacy, and objectively measured motor and sleep parameters remains under-examined. This study addressed this gap by recruiting 118 community dwellers (M_{age} = 81.7 years, SD = 8.1 years) from the Sardinian Blue Zone, an area characterized by exceptional longevity. Participants completed assessments for memory self-efficacy, memory complaints, perceived physical health and cognitive efficiency. Additionally, objective measures of physical activity (PA)—measured as the number of daily steps and time spent in sedentary behavior—and sleep efficiency were collected via wrist-worn activity trackers for 7 consecutive days. Hierarchical logistic regression revealed a significant final model ($\chi^2(1) = 31.101$, $p < .001$), with excellent calibration (Hosmer and Lemeshow test, $\chi^2(1) = 7.484$ $p = .485$). Better Perceived physical health (OR = 0.64, 95% CI [0.48, 0.84], $p = .001$) and memory self-efficacy (OR = 0.80, 95% CI [0.67, 0.96], $p = .014$), reduced sedentary behavior (OR < 0.001, $p = .018$), and higher daily steps (OR = 1.00, $p = .016$) predicted fewer memory complaints, explaining 23.5% to 39.9% of the variance based on GDS-item10 score. In conclusion, objective data on mobility and sedentary behavior and subjective health-related evaluations converge to predict subjective memory complaints among older adults who are aging successfully.

1. Introduction

Memory complaints refer to the subjective perception that one's memory is declining, either compared to previous functioning or relative to expectations, and may occur with or without objective evidence of cognitive impairment (Yu et al., 2025). While not considered a disorder per se, memory complaints are highly prevalent in late adulthood, affecting approximately 25–50% of older individuals (Jonker et al., 2000). Cross-sectional studies have yielded mixed findings regarding the relationship between subjective memory complaints and objective memory decline (e.g., Carrasco et al., 2017; Jonker et al., 1996; Jungwirth et al., 2004); however, longitudinal evidence is more consistent. Notably, older adults reporting memory complaints without objective deficits have a twofold increased risk of developing dementia, with 24.4% progressing to mild cognitive impairment and 10.9% to dementia over four years, compared with 4.6% of non-complainers (Mitchell et al., 2014).

Memory complaints are also linked to emotional and psychological outcomes. Older individuals with such complaints are more prone to depressive symptoms (Ji et al., 2023; Kim and Kim, 2024), lower psychological well-being, and reduced optimism, even in the absence of objective cognitive deficits (Cutler and Brăgaru, 2017; Fastame, 2022). Lower self-efficacy amplifies this effect, with O'Shea et al. (2016) reporting higher depressive symptoms in memory complainers with reduced belief in their ability to overcome challenges. Consistently, memory self-efficacy—the belief in one's capacity to successfully encode, recall, and manage everyday memory demands—predicts subjective memory complaints in adulthood (Aben et al., 2011).

Several demographic, lifestyle, and health factors also modulate memory complaints. Higher educational attainment, social engagement, and participation in socio-cultural activities are protective factors, whereas female sex, older age, hypertension, diabetes, and physical inactivity increase susceptibility (Carrasco et al., 2017; Yu et al., 2025). Physical activity (PA), in particular, has been associated with fewer subjective memory complaints, with leisure and structured exercise mitigating age-related working memory decline (Guo et al., 2025; Yu

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et al., 2024). Overall, regardless of marital status, income, education, and gender, PA— whether in the form of gym exercise, aquatic activities, yoga, or Pilates— prevents the risk of dementia, improves cardiovascular health, sleep, and quality of life (e.g., reinforcing social engagement and functional autonomy), and increases life expectancy (Parra-Rizo et al., 2024). Moreover, the combination of subjective cognitive complaints and reduced motor function, especially slower gait speed, predicts Motoric Cognitive Risk syndrome, a pre-dementia condition linked to falls, disability, and mortality (Verghese et al., 2013).

Despite this, direct evidence linking objectively measured PA to memory complaints remains limited, as most studies rely on cognitive tests rather than self-reported concerns, and subjective perception may not correspond to objective performance (Fastame, 2022). Objective, ecologically valid measures of sedentary behavior and PA, such as accelerometry, can provide continuous, real-world data, overcoming recall biases common in older adults (Heesch et al., 2018). Accelerometry also enables reliable assessment of sleep duration and quality (Birrer et al., 2024), important given that poor sleep—characterized by short or long duration, prolonged latency, or fragmentation—is associated with greater memory complaints and declines across multiple cognitive domains (Gamaldo et al., 2019; Siddarth et al., 2021; Xie et al., 2024).

Given the aging global population—expected to reach 1.4 billion individuals over 60 by 2030, with 426 million octogenarians by 2050—and the World Health Organization's emphasis on healthy aging (WHO, 2024), identifying predictors of memory complaints is critical. One promising avenue is the study of older adults aging exceptionally well, such as those living in Blue Zones, geographical regions characterized by longevity and simple lifestyles (Poulain and Herm, 2025). Beyond the Sardinian and Okinawan Blue Zones, recent validation includes the Martinique Blue Zone (Poulain and Herm, 2025). Residents of Blue Zones generally exhibit low depressive symptoms, preserved functional health, higher psychological well-being, and active lifestyles, both subjectively and objectively measured through PA and mobility indicators (Fastame et al., 2021, 2025; Legrand et al., 2021; Pau et al., 2025). Higher activity levels correlate with better cognitive function, engagement in socio-cultural activities, and fewer memory complaints (Fastame and Penna, 2014).

Despite these insights, the relationship between sleep patterns and metacognitive profiles in individuals aging well remains unexplored, reflecting a broader scarcity of objective sleep and memory complaint data in older populations (Siddarth et al., 2021). Furthermore, no studies have concurrently examined mobility, PA, sleep, perceived physical health, and memory self-efficacy as predictors of memory complaints, particularly in Blue Zone residents. Studying older adults who age successfully offers a unique opportunity to identify protective and predictive factors for memory complaints. These individuals often maintain high cognitive functioning, emotional well-being, and physical health despite advanced age, providing a natural model to examine how lifestyle, sleep, mobility, and self-efficacy interact to influence subjective memory perception. Insights gained from this population can help distinguish modifiable behavioral and psychological factors from age-related decline, informing strategies to prevent or mitigate memory complaints in the broader aging population.

Based on these considerations, the present study aimed to disentangle the interplay of memory self-efficacy, perceived physical health, motor activity, and sleep in predicting memory complaints among older adults living in the Sardinian Blue Zone. Given its exploratory nature, we hypothesized that memory complaints would be predicted by sleep efficiency (Siddarth et al., 2021), memory self-efficacy (Aben et al., 2011), perceived physical health (Carrasco et al., 2017), daily mobility (Chen et al., 2020), and sedentary behavior (Han et al., 2023).

2. Methods

2.1. Participants

One hundred and eighteen community-dwellers, 54 males and 64 females ($M_{age} = 81.7$ years, SD = 8.1 years), were enrolled in several villages of the Sardinian Blue Zone. Such a sample size was primarily determined by feasibility considerations related to the unique characteristics of Blue Zone population. Indeed, these regions are defined by exceptional longevity and a relatively high proportion of very old individuals in small geographical areas characterized by their modest size (i.e., on average 1000–3000 inhabitants), which inherently limits the pool of eligible participants. Recruitment was therefore constrained by the geographic dispersion, health status, willingness of older adults to participate in research as well as the following inclusion criteria: 1) living independently in their own homes; 2) being descendants from families living in the Sardinian Blue Zone for at least two previous generations; 3) being born and resident for their whole life (e.g., no emigration experiences) in the Sardinian Blue Zone; 4) free from severe cognitive decline, as indicated by a Mini-Mental State Examination (MMSE; Folstein et al., 1975) score of $\geq$20, which was used to assess global cognitive functioning and determine eligibility; 5) not reporting any neurologic or musculoskeletal condition that might negatively impact walking. All the respondents took part voluntarily in the study and did not receive any reward for their participation. Five participants were excluded because of suspected cognitive impairment. Table 1 summarizes the characteristics of the participants who met the inclusion criteria to take part in the study.

2.2. Materials

A socio-demographic interview (Fastame, 2021) was used to collect information about the socio-demographic characteristics and lifestyle of the respondents.

The MMSE (Folstein et al., 1975) was used to examine the global cognitive functioning of the participants. This screening pencil-and-

Table 1
Socio-demographic characteristics and lifestyle habits of the participants recruited for the current study. M refers to the mean score, whereas SD indicates standard deviation scores. MMSE reflects the Mini-Mental State Examination score.

		χ^2	df	p
N	118			
Gender		0.847	1	.357
Males	54			
Females	64			
Age range (years)	65–101			
Age (years)	M = 81.7 (SD = 8.1)			
MMSE (corrected)	M = 25.9 (SD = 2.1)			
MMSE (range)	20–30			
Marital status		0.847	1	.357
Single or widowed	54			
Married	64			
Reading		1.220	1	.269
Yes	53			
No	65			
Medicine intake		81.390	1	<.001
Yes	108			
No	10			
Tobacco consumption		95.220	1	<.001
Yes	6			
No	112			
Alcohol consumption		14.949	1	<.001
Yes	38			
No	80			
Leisure activities		51.559	1	<.001
Yes	98			
No	20			

paper test serves to evaluate distinctive cognitive functions (e.g., short and long-term memory, comprehension, spatio-temporal orientation). As suggested by Magni et al. (1996), scores were adjusted for formal schooling (i.e., years of education) and chronological age (maximum score = 30). To be eligible for study participation, a cut-off score of >19 was applied, indicating the lack of severe signs of cognitive decline.

The Perceived Physical Health index (Fastame et al., 2017), which includes one item, was used to evaluate how the respondent rated his/her physical health on a Likert scale ranging from 0 (worst health) to 10 (excellent health).

Item 10 of the Geriatric Depressive Scale (i.e., GDS-item10, Yesavage and Sheikh, 1986) was used to self-assess one's own metamemory efficiency. The GDS is a well-established and widely used tool designed for the screening of depressive symptoms in late adulthood. For the aims of the study, participants were asked to express their agreement in judging their feelings regarding possible memory difficulties relative to the previous week through a “YES/NO” answer modality (i.e., “Do you feel you have more problems with memory than most?”).

The cognitive self-consciousness subscale of the Metacognitions Questionnaire (i.e., MQC-30-cognitive confidence) developed by Wells and Cartwright-Hatton (2004) and validated for the Italian population by Quattropani et al. (2014) was administered as a metamemory measure to evaluate the beliefs of our participants regarding the efficiency of their memory. The subscale encompasses 6 items assessing how much one trusts his/her capacity to remember on a Likert scale ranging from 1 (total disagreement) to 4 (total agreement). The total score was calculated by summing the answers provided for each item (maximum total score = 24), suggesting that higher scores indicated a scarce confidence in one's memory efficiency.

Patterns of PA and sleep were objectively assessed using a clinically validated accelerometer (Actigraph GT3X, Ametris, USA, formerly Actigraph Co.) previously employed in similar studies on older adults (Webster et al., 2021; Ghazi et al., 2025; Pau et al., 2025). Participants were asked to wear the device on their non-dominant wrists 24 h/day for 7 consecutive days and to perform their usual daily activities, removing it only for personal hygiene or other water-based activities. A certain day was considered valid (and thus included in the results) only if the wear time was at least 16 h. The device was set to collect three-axial accelerations in 60-s epochs at 30 Hz frequency, which were subsequently processed using the dedicated software provided by the manufacturer (Actilife v6.13.6 Ametris., USA). In particular, the following metrics were considered:

- number of daily steps;
- percentage of time spent in sedentary behavior (defined as any waking behavior characterized by an energy expenditure of ≤1.5 metabolic equivalents (METs) while in a sitting, reclining, or lying posture) calculated using the cut points for accelerometric counts proposed by Migueles et al. (2021);
- sleep efficiency (%), calculated as the ratio between Total Sleep Time (that is, minutes scored as sleep) and Time in Bed, which represents the time from “lights off” (sleep opportunity start) to final awakening (getting out of bed). Sleep and wake periods were automatically detected by the Actilife software according to the Cole-Kripke algorithm (Cole et al., 1992).

2.3. Procedure

This study was conducted in accordance with the Helsinki Declaration (1964) and its subsequent amendments and was approved by the institutional Ethics Committee. Each volunteer provided a written informed consent before participation and then was tested in a quiet room of his/her home.

First, the MMSE test was administered to exclude the occurrence of cognitive decline. Then the socio-demographic interview was used to collect information on the daily habits and demographic characteristics (e.g., age, years of education, marital status) of the participants, followed by the perceived physical index, the GDS item 10, and the positive beliefs subscale of the MQC-30. The presentation order of these measures was counterbalanced according to the Latin square procedure. To prevent fatigue-related effects, test items were read aloud by the examiner, who recorded the responses on the corresponding answer sheets. Each psychological session lasted approximately 40 min. At the end, participants were provided with the activity tracker and instructed about its correct use. After one week, the device was recovered by the examiner, and raw accelerometric data were downloaded and processed as previously described.

2.4. Statistical analyses

Descriptive statistical analyses were carried out to examine the characteristics of the participants, and a logistic binomial regression was carried out to explore the contribution of five variables to the memory complaints expressed by our participants. The data sets were analyzed using IBM SPSS Statistics version 24, with 5% as the significance level.

3. Results

The descriptive analyses documented that gender ($\chi^2 = 0.847$, df = 1, $p = .357$), marital status (i.e., married vs. single/widowed, $\chi^2 = 0.847$, df = 1, p = .357), and the habit to regularly read (i.e., yes vs. no, $\chi^2 = 1.22$, df = 1, $p = .269$) were equally distributed across the participants. In contrast, the engagement in leisure activities was not equally distributed (i.e., yes vs. no, $\chi^2 = 51.559$, df = 1, $p < .001$), reflecting the maintenance of an active lifestyle among our participants. Indeed, most of the sample (n = 98, 83% of the participants) stated that they were regularly engaged in hobbies (e.g., socio-cultural activities, sports). Moreover, the mean MMSE score of the sample was 25.9, SD = 2.1, suggesting that the cognitive efficiency of our participants was relatively preserved.

A hierarchical binary logistic regression analysis was performed to explore the predictors of the GDS-10 score. The model was built in four steps using the enter method to examine whether physical activity (i.e., number of daily steps, percentage of time spent in sedentary behavior), sleep efficiency, cognitive self-efficacy (i.e., MQC-30-positive score), and perceived physical health contributed to the model's predictive power. In the first block, the number of daily steps was entered as the predictor. The model was statistically significant, χ^2 (1) = 4.40, p = .036, explaining between 3.7% and 6.3% of the variance (Cox & Snell R^2 = 0.037, Nagelkerke R^2 = 0.063). The adequate fit to the data was supported by the Hosmer and Lemeshow test (χ^2 (8) = 5.664, p = .685). The number of daily steps was a significant predictor (B < 0.001, SE < 0.001, Wald = 4.063, p = .044, 95% CI [1.000, 1.000]). In the second block, the percentage of time spent in sedentary behavior was introduced to the model, and this addition significantly improved the model fit (χ^2 (1) = 5.155, p = .023). This model accounted for 7.9% and 13.4% of the variance (Cox & Snell R^2 = 0.079, Nagelkerke R^2 = 0.134). Both number of daily steps (B < 0.001, SE < 0.001, Wald = 7.995, p = .005, OR = 1.000, 95% CI [0.999, 1.000]) and percentage of time spent in sedentary behavior (B = −8.128, SE = 3.543, Wald = 5.264, p = .022, OR < 0.001, 95% CI [0.00, 0.306]) parameters significantly predicted the binary dependent responses given to the item 10 of the GDS. The Hosmer and Lemeshow test for this block [χ^2 (8) = 15.445, p = .051] suggested that the overall accuracy remained 83.6%, with 0% sensitivity for “yes” cases. Then the sleep efficiency value was added in the Block 3. The inclusion of this potential predictor did not result in a significant improvement of the model (χ^2 (1) = 1.256, p = .262), which accounted for approximately 8.9% and 15.1% of the variance (Cox & Snell R^2 = 0.089, Nagelkerke R^2 = 0.151). The adequate fit to the data was supported by the Hosmer and Lemeshow test (χ^2 (8) = 8.622, p = .375). Overall, number of daily steps (B < 0.001, SE < 0.001, Wald = 8.687, p = .003, OR < 0.001, 95% CI [0.999, 1.000]) and percentage of time spent in sedentary behavior (B = −9.099, SE 3.712, Wald = 6.007, p = .014, OR < 0.001, 95% CI [0.00, 0.162]) were significant predictors, whereas the sleep efficiency (B = −0.046, SE 0.234, Wald = 1.419, p = .234, OR < 0.001, 95% CI [0.885, 1.030]) was not a significant predictor in this model. Finally, perceived physical health and MQC-30-cognitive confidence scores were added in the fourth block. The addition of these two predictors showed the most substantial improvement of the model (χ^2 (2) = 20.290, $p < .001$), which explained between 23.5% and 39.9% of the variance (Cox & Snell $R^2 = 0.235$, Nagelkerke $R^2 = 0.399$) and showed an adequate fit according to the Hosmer and Lemeshow test (χ^2 (8) = 7.484, $p = .485$). Perceived physical health score (B = −0.452, SE = 0.140, Wald = 10.376, $p = .001$, OR = 0.637, 95% CI [0.484, 0.838]) was the strongest significant predictor, followed by the MQC-30-cognitive confidence index (B = −0.221, SE = 0.090, Wald = 6.026, p = .014, OR = 0.802, 95% CI [0.672, 0.956]), percentage of time spent in sedentary behavior (B = − 10.243, SE = 4.329, Wald = 5.599, p = .018, OR < 0.001, 95% CI [0.000, 0.172]) and number of daily steps (B < 0.001, SE < 0.001, Wald = 5.756, p = .016, OR = 1.000, 95% CI [0.999, 1.000]) measures. The final model's overall predictive accuracy increased to 86.2%, with 94.8% sensitivity for ‘no’ cases and 42.1% for the ‘yes’ ones.

4. Discussion

This study intended to explore the role played by memory self-efficacy, perceived physical health, objectively assessed mobility, and PA under free-living conditions and sleep patterns in predicting memory complaints of older individuals living in an area characterized by the extreme longevity of its inhabitants, the Sardinian Blue Zone. We assumed that examining the above-mentioned aspects in older people aging well who exhibit a generally active lifestyle (e.g., social engagement, relatively high percentages of time spent in moderate-to-vigorous PA, cognitively stimulating recreational activities) as it is documented in the literature (e.g., Fastame et al., 2021, 2025; Pau et al., 2025), could contribute to elucidating the role of objectively assessed functional measures (i.e., sleep efficiency, number of daily steps, percentage of time spent in sedentary behavior), perceived physical health, and cognitive self-confidence in predicting memory complaints (i.e., operationalized through GDS item 10), in a sample of Sardinian older adults. To date, this is the first investigation conducted in a longevity Blue Zone where the above functional and psychological parameters were concurrently evaluated in a sample of cognitively preserved older individuals.

Overall, the current findings highlight the relevance of PA levels, cognitive self-consciousness, and perceived physical health in shaping late-life subjective memory complaints, whereas sleep efficiency does not seem to contribute as a significant predictor. Indeed, the most relevant finding is that perceived physical health, cognitive self-consciousness, number of daily steps, and percentage of time spent in sedentary behavior accounted for 23.5–39.9% of the variance relative to the GDS-items10. Therefore, participants reporting better perceived health, trusting more in the efficiency of their mind, and those who exhibited a more active lifestyle (i.e., characterized by a higher number of daily steps and a lower percentage of time spent in sedentary behavior) were less likely to complain about their memory efficiency. Specifically, following previous evidence (Carrasco et al., 2017), better perceived physical health was associated with fewer memory complaints; whereas consistent with Aben et al. (2011), we found that those participants who reported better cognitive confidence also thought that their memory function was similar to that of the others.

With respect to everyday mobility—here operationalized as the number of daily steps—our findings are consistent with previous studies reporting a significant association between this measure and the rate of subjective cognitive decline (Chen et al., 2020). Although the precise mechanisms underlying this relationship remain to be fully elucidated, it is plausible that the beneficial effects of walking on brain function reflect multiple, partially overlapping pathways. In line with evidence from aerobic exercise, walking may promote increases in brain and gray matter volume (Colcombe et al., 2006; Erickson et al., 2014), as well as upregulation of brain-derived neurotrophic factor and enlargement of hippocampal volume (Firth et al., 2018). In addition, regular walking has been associated with improved cerebral blood flow and vascular function, which may enhance oxygen and nutrient delivery to brain tissue and support cognitive processes (Ainslie et al., 2008; Smith and Ainslie, 2017). Metabolic regulation may represent a further pathway, as higher levels of physical activity contribute to improved glucose homeostasis and reduced cardiometabolic risk, factors that are themselves linked to cognitive decline (Kivipelto et al., 2001; Blondell et al., 2014). Finally, greater daily mobility may also reflect more active lifestyles characterized by increased social engagement and environmental stimulation, both of which have been independently associated with better cognitive outcomes (Fratiglioni et al., 2004; James et al., 2011). Notably, higher daily step counts have been associated with greater hippocampal volume in older adults, suggesting a potential protective role against age-related hippocampal atrophy (Varma et al., 2015). More broadly, the relevance of daily step count as a simple, scalable, and interpretable metric is further supported by its associations with a wide range of health outcomes, including all-cause mortality, cardiovascular disease incidence and mortality, type 2 diabetes, cancer incidence and mortality, dementia, depressive symptoms, physical function, and risk of falls (Ding et al., 2025).

The regression analysis further highlights a significant association between sedentary behavior and the severity of subjective memory complaints, as assessed by GDS item 10. However, comparative evidence remains limited; to our knowledge, only Chen et al. (2021) have examined the relationship between different types of sedentary behavior and frequency of forgetting — a commonly used proxy for subjective everyday memory function. Their findings indicated a moderate association, partially mediated by sleep quality, suggesting that reducing sedentary time may represent a viable strategy for improving subjective memory performance. Importantly, the two objective accelerometer-derived metrics used in the present study—daily step count and percentage of time spent in sedentary behavior—capture complementary dimensions of habitual mobility and should not be considered interchangeable. Whereas step count primarily indexes total ambulatory activity and overall energy expenditure, sedentary time reflects prolonged low-energy waking behaviors characterized by distinct physiological and behavioral profiles. From a neurobiological perspective, higher step counts are more closely linked to activity-dependent mechanisms such as increased neurotrophic signaling, enhanced cerebral perfusion, and structural brain adaptations, while prolonged sedentary time has been associated with reduced cerebral blood flow, impaired metabolic regulation, and low-grade systemic inflammation. From a behavioral perspective, higher step counts are often linked to purposeful and socially embedded activities, such as daily routines and social interactions (Reyes-Molina et al., 2025; Althoff et al., 2017). Conversely, sedentary behavior is associated with cognitively passive contexts, reduced environmental stimulation, and disrupted sleep, which together relate to poorer cognitive outcomes (Falck et al., 2017; Zhang et al., 2025). Accordingly, these measures index partially independent pathways through which lifestyle may influence cognitive health, with physical activity promoting protective processes and sedentary behavior contributing to risk-related mechanisms. Consistent with this interpretation, emerging evidence suggests that high step counts do not fully offset the adverse cognitive correlates of excessive sedentary behavior, indicating that both metrics provide unique and complementary contributions when modeling cognitive outcomes in older adults (Voss et al., 2014; Falck et al., 2017).

In contrast, it was quite surprising to observe that sleep efficiency does not represent a significant predictor of subjective memory complaints. We hypothesize that this could reflect compensatory effects of high physical and social engagement. Indeed, individuals who are more physically active and socially connected often report better cognitive outcomes and subjective well-being, even in the presence of suboptimal sleep metrics, because active lifestyles support cognitive reserves and mood regulation that buffer against mild sleep-related cognitive changes (e.g., higher physical activity predicts better overall sleep parameters and mental health) . Social and leisure activities also stimulate cognitive and emotional processes that can counteract the subjective perception of memory decline despite less efficient sleep, by reinforcing daily structure and attention engagement (Skurvydas et al., 2025). Furthermore, self-efficacy and perceived health may moderate these relationships: stronger self-efficacy has been shown to mediate health behaviors and promote better perceived sleep quality and psychological resilience, which in turn can diminish the impact of sleep inefficiencies on memory complaints (Peng et al., 2023). Likewise, individuals with higher perceived health tend to report better cognitive function and may interpret sleep disturbances as less cognitively threatening, reducing subjective memory complaints even when objective measures like sleep efficiency are lower (Dostálová et al., 2021). These psychosocial and lifestyle factors can therefore serve as protective moderators or indirect mediators, attenuating direct links between sleep efficiency and self-reported memory difficulties.

In this context, it should be borne in mind that our participants led a very active lifestyle, as most of them (i.e., 83%) were regularly engaged in leisure activities conducted with others (e.g., sports, socio-cultural activities) or alone (e.g., bricolage). Therefore, extending previous evidence documenting the preserved perceived mental health and very limited depressive symptoms of the older people living in the Sardinian Blue Zone (e.g., Fastame et al., 2021; Ruiu et al., 2022), combined with a moderate-to-vigorous physical engagement (Pau et al., 2025), the current findings revealed the beneficial effects of active lifestyle, cognitive self-confidence, and perceived physical health in preserving the metacognitive dimension of depressive symptoms in late adulthood, as it is evaluated through the GDS (Yesavage and Sheikh, 1986).

4.1. Practical applications

From an applied perspective, the current outcomes suggest that the combined objective evaluation of motor and cognitive parameters, and subjective metacognitive, functional (i.e., perceived physical health), and mental health constructs should be encouraged to detect those individuals at risk of developing depression and/or cognitive decline. Moreover, the active participation of older individuals in physically, socially, and cognitively stimulating leisure activities should be promoted to promote different facets of healthy aging (e.g., psychological well-being, social well-being, cognitive confidence), and to compensate for the incipient age-related losses (Baltes and Baltes, 1990).

4.2. Limitations and future directions

Several limitations warrant consideration, including the cross-sectional design, which precludes causal inference. Moreover, the battery used in the study included a few psychological tools, and apart from the MMSE, cognitive efficiency was not sufficiently examined, as well as depressive symptoms (i.e., only the GDS item 10 was used), and psychological well-being were not evaluated. Therefore, in the future, researchers should consider administering a wider battery of psychological tests, including working and episodic memory, attention, psychological well-being, and metacognition measures.

With respect to the use of accelerometers daily step counts and percentage of time spent in sedentary behavior, it should be noted that the wrist-worn placement adopted in this study, although known to increase compliance to the measurement (especially when sleep monitoring is required), may overestimate number of steps due to arm swing or other upper limb spurious movements and may misclassify sedentary behavior because it cannot provide information about posture.

Moreover, the sample size was small, a limitation due to the inclusion criteria used to recruit the participants (e.g., older individuals who reported a previous migration experience could not be recruited) and to the density of the villages where the data were collected (i.e., < 700 vs. 2900 inhabitants). Bearing in mind the exploratory nature of this study, although the ratio of events per variable (EPV) was lower than the ideal threshold of 10 for the reasons just mentioned, the high Nagelkerke $R^2 = 0.399$ and the goodness-of-fit of the final model [Hosmer and Lemeshow Test ($\text{chi2}\ (8) = 7.484$, $p = .485$)] indicating that the predicted probabilities matched the observed frequencies, suggest that the model captured robust associations among memory complaints, and distinct motor and psychological parameters. However, future longitudinal studies with larger older samples (i.e., both community-dwellers and people living in nursing homes) are recommended to reduce the risk of coefficient bias.

5. Conclusions

In conclusion, the current investigation shed light on the importance of an active lifestyle evaluated in terms of motor parameters, subjective physical health, and metacognitive self-awareness in predicting memory complaints in late adulthood. The contribution of the above-mentioned motor and psychological constructs should be jointly considered to promote well-being in the last decades of life.

CRediT authorship contribution statement

Maria Chiara Fastame: Writing – original draft, Supervision, Methodology, Formal analysis, Conceptualization. **Benedetta Brandas:** Data curation. **Massimiliano Pau:** Writing – original draft, Conceptualization.

Informed consent statement

Written informed consent was given by all participants prior to participation.

Compliance with ethical standards

The study was conducted in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki Declaration and its later amendments. The protocol used in the current study was approved by the Ethics Committee of the research institution.

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Declaration of competing interest

The authors report there are no competing interests to declare.

Data availability

The data that has been used is confidential.

References

Aben, L., Ponds, R.W., Heijenbrok-Kal, M.H., Visser, M.M., Busschbach, J.J., Ribbers, G. M., 2011. Memory complaints in chronic stroke patients are predicted by memory self-efficacy rather than memory capacity. Cerebrovasc. Dis. 31 (6), 566–572. https://doi.org/10.1159/000324627.

Ainslie, P.N., Cotter, J.D., George, K.P., Lucas, S., Murrell, C., Shave, R., Thomas, K.N., Williams, M.J., Atkinson, G., 2008. Elevation in cerebral blood flow velocity with aerobic fitness throughout healthy human ageing. J. Physiol. 586 (16), 4005–4010. https://doi.org/10.1113/jphysiol.2008.158279.

Althoff, T., Jindal, P., Leskovec, J., 2017. Online actions with offline impact: how online social networks influence online and offline user behavior. In: Proceedings of the …

International Conference on Web Search & Data Mining. International Conference on Web Search & Data Mining, 2017, pp. 537–546. https://doi.org/10.1145/3018661.3018672.

Baltes, P.B., Baltes, M.M., 1990. Psychological perspectives on successful aging: the model of selective optimization with compensation. In: Baltes, P.B., Baltes, M.M. (Eds.), Successful Aging: Perspectives From the Behavioral Sciences. Cambridge University Press, pp. 1–34.

Birrer, V., Elgendi, M., Lambercy, O., Menon, C., 2024. Evaluating reliability in wearable devices for sleep staging. NPJ Digit. Med. 7 (1), 74. https://doi.org/10.1038/s41746-024-01016-9.

Blondell, S.J., Hammersley-Mather, R., Veerman, J.L., 2014. Does physical activity prevent cognitive decline and dementia?: a systematic review and meta-analysis of longitudinal studies. BMC Public Health 14, 510. https://doi.org/10.1186/1471-2458-14-510.

Carrasco, P.M., Montenegro-Pena, M., Lopez-Higes, R., Estrada, E., Crespo, D.P., Rubio, C.M., Azorín, D.G., 2017. Subjective memory complaints in healthy older adults: fewer complaints associated with depression and perceived health, more complaints also associated with lower memory performance. Arch. Gerontol. Geriatr. 70, 28–37. https://doi.org/10.1016/j.archger.2016.12.007.

Chen, S.T., Stevinson, C., Tian, T., Chen, L.J., Ku, P.W., 2020. Accelerometer-measured daily steps and subjective cognitive ability in older adults: a two-year follow-up study. Exp. Gerontol. 133, 110874. https://doi.org/10.1016/j.exger.2020.110874.

Chen, Y., Holahan, C., Castelli, D., 2021. Sedentary behavior, sleep quality, and subjective memory function in middle-aged adults. Innov. Aging 5 (Supplement_1), 951–952. https://doi.org/10.1093/geroni/igab046.3436.

Colcombe, S.J., Erickson, K.I., Scalf, P.E., Kim, J.S., Prakash, R., McAuley, E., Kramer, A. F., 2006. Aerobic exercise training increases brain volume in aging humans. J. Gerontol. A Biol. Sci. Med. Sci. 61 (11), 1166–1170. https://doi.org/10.1093/gerona/61.11.1166.

Cole, R.J., Kripke, D.F., Gruen, W., Mullaney, D.J., Gillin, J.C., 1992. Automatic sleep/wake identification from wrist activity. Sleep 15 (5), 461–469. https://doi.org/10.1093/sleep/15.5.461.

Cutler, S.J., Brăgaru, C., 2017. Do worries about cognitive functioning and concerns about developing Alzheimer's disease affect psychological well-being? J. Aging Health 29 (8), 1271–1287. https://doi.org/10.1177/0898264316674535.

Ding, D., Nguyen, B., Nau, T., Luo, M., Del Pozo Cruz, B., Dempsey, P.C., Owen, K., 2025. Daily steps and health outcomes in adults: a systematic review and dose-response meta-analysis. Lancet Public Health 10 (8), e668–e681. https://doi.org/10.1016/S2468-2667(25)00164-1.

Dostálová, R., Stillman, C., Erickson, K.I., Slepička, P., Mudrák, J., 2021. The relationship between physical activity, self-perceived health, and cognitive function in older adults. Brain Sci. 11 (4), 492. https://doi.org/10.3390/brainsci11040492.

Erickson, K.I., Leckie, R.L., Weinstein, A.M., 2014. Physical activity, fitness, and gray matter volume. Neurobiol. Aging 35 (Suppl. 2), S20–S28. https://doi.org/10.1016/j.neurobiolaging.2014.03.034.

Falck, R.S., Davis, J.C., Liu-Ambrose, T., 2017. What is the association between sedentary behaviour and cognitive function? A systematic review. Br. J. Sports Med. 51 (10), 800–811. https://doi.org/10.1136/bjsports-2015-095551.

Fastame, M.C., 2021. Life satisfaction in late adult span: the contribution of family relationships, health self-perception and physical activity. Aging Clin. Exp. Res. 33, 1693–1698. https://doi.org/10.1007/s40520-020-01658-1.

Fastame, M.C., 2022. Are subjective cognitive complaints associated with executive functions and mental health of older adults? Cogn. Process. 23 (3), 503–512. https://doi.org/10.1007/s10339-022-01089-y.

Fastame, M.C., Penna, M.P., 2014. Psychological well-being and metacognition in the fourth age: an explorative study in an Italian oldest old sample. Aging Ment. Health 18 (5), 648–652. https://doi.org/10.1080/13607863.2013.866635.

Fastame, M.C., Hitchcott, P.K., Penna, M.P., 2017. Does social desirability influence psychological well-being: perceived physical health and religiosity of Italian elders? A developmental approach. Aging Ment. Health 21, 348–353. https://doi.org/10.1080/13607863.2015.1074162.

Fastame, M.C., Mulas, I., Pau, M., 2021. Mental health and motor efficiency of older adults living in the Sardinia's Blue Zone: a follow-up study. Int. Psychogeriatr. 33 (12), 1277–1288. https://doi.org/10.1017/S1041610220001659.

Fastame, M.C., Brandas, B., Pau, M., 2025. Gardening and healthy aging in the Sardinian blue zone. Act. Adapt. Aging 1–20. https://doi.org/10.1080/01924788.2025.2586441.

Firth, J., Stubbs, B., Vancampfort, D., Schuch, F., Lagopoulos, J., Rosenbaum, S., Ward, P.B., 2018. Effect of aerobic exercise on hippocampal volume in humans: a systematic review and meta-analysis. NeuroImage 166, 230–238. https://doi.org/10.1016/j.neuroimage.2017.11.007.

Folstein, M.F., Folstein, S.E., McHugh, P.R., 1975. Mini-mental state. A practical method for grading the cognitive state of patients for the clinician. J. Psychiatr. Res. 12, 189–198. https://doi.org/10.1016/0022-3956(75)90026-6.

Fratiglioni, L., Paillard-Borg, S., Winblad, B., 2004. An active and socially integrated lifestyle in late life might protect against dementia. Lancet Neurol. 3 (6), 343–353. https://doi.org/10.1016/S1474-4422(04)00767-7.

Gamaldo, A.A., Wright, R.S., Aiken-Morgan, A.T., Allaire, J.C., Thorpe Jr., R.J., Whitfield, K.E., 2019. The association between subjective memory complaints and sleep within older African American adults. J. Gerontol. B Psychol. Sci. Soc. Sci. 74 (2), 202–211. https://doi.org/10.1093/geronb/gbx069.

Ghazi, S.N., Behrens, A., Berner, J., Sanmartin Berglund, J., Anderberg, P., 2025. Objective sleep monitoring at home in older adults: a scoping review. J. Sleep Res. 34 (4), e14436. https://doi.org/10.1111/jsr.14436.

Guo, W., Cheng, G., Li, W., Wang, B., 2025. Association between leisure activities and subjective memory complaints in older adults: a cross-sectional study. Geriatr. Nurs. 64, 103387. https://doi.org/10.1016/j.gerinurse.2025.103387.

Han, X., Song, L., Li, Y., Dong, Y., Liu, R., Han, Q., Wang, X., Mao, M., Cong, L., Tang, S., Hou, T., Zhang, Q., Liu, C., Han, X., Shi, L., Nyberg, L., Launer, L.J., Wang, Y., Du, Y., Qiu, C., 2023. Accelerometer-measured sedentary behavior patterns, brain structure, and cognitive function in dementia-free older adults: a population-based study. J. Alzheimers Dis. 96 (2), 657–668. https://doi.org/10.3233/JAD-230575.

Heesch, K.C., Hill, R.L., Aguilar-Farias, N., van Uffelen, J.G.Z., Pavey, T., 2018. Validity of objective methods for measuring sedentary behaviour in older adults: a systematic review. Int. J. Behav. Nutr, Phys. Act. 15 (1), 119. https://doi.org/10.1186/s12966-018-0749-2.

James, B.D., Wilson, R.S., Barnes, L.L., Bennett, D.A., 2011. Late-life social activity and cognitive decline in old age. J. Int. Neuropsychol. Soc. 17 (6), 998–1005. https://doi.org/10.1017/S1355617711000531.

Ji, Y., Feng, Y., Wu, S., Wu, Y., Wang, J., Zhao, X., Liu, Y., 2023. Longitudinal trajectories of depressive symptoms: the role of multimorbidity, mobility and subjective memory. BMC Geriatr. 23 (1), 22. https://doi.org/10.1186/s12877-023-03733-4.

Jonker, C., Launer, L.J., Hooijer, C., Lindeboom, J., 1996. Memory complaints and memory impairment in older individuals. J. Am. Geriatr. Soc. 44 (1), 44–49. https://doi.org/10.1111/j.1532-5415.1996.tb05636.x.

Jonker, C., Geerlings, M.I., Schmand, B., 2000. Are memory complaints predictive for dementia? A review of clinical and population-based studies. Int. J. Geriatr. Psychiatry 15 (11), 983–991. https://doi.org/10.1002/1099-1166(200011)15:11<983::AID-GPS238>3.0.CO;2-5.

Jungwirth, S., Fischer, P., Weissgram, S., Kirchmeyr, W., Bauer, P., Tragl, K.H., 2004. Subjective memory complaints and objective memory impairment in the Vienna-Transdanube aging community. J. Am. Geriatr. Soc. 52 (2), 263–268. https://doi.org/10.1111/j.1532-5415.2004.52066.x.

Kim, J.S., Kim, E., 2024. Subjective memory complaints and medication adherence among hypertensive Korean older adults with multimorbidity: mediating effect of depression and social support. BMC Public Health 24 (1), 585. https://doi.org/10.1186/s12889-024-18061-4.

Kivipelto, M., Helkala, E.L., Laakso, M.P., Hänninen, T., Hallikainen, M., Alhainen, K., Soininen, H., Tuomilehto, J., Nissinen, A., 2001. Midlife vascular risk factors and Alzheimer's disease in later life: longitudinal, population based study. BMJ (Clin. Res. Ed.) 322 (7300), 1447–1451. https://doi.org/10.1136/bmj.322.7300.1447.

Legrand, R., Nuemi, G., Poulain, M., Manckoundia, P., 2021. Description of lifestyle, including social life, diet and physical activity, of people $\geq$ 90 years living in Ikaria, a longevity blue zone. Int. J. Environ. Res. Public Health 18 (12), 6602. https://doi.org/10.3390/ijerph18126602.

Magni, E., Binetti, G., Bianchetti, A., Rozzini, R., Trabucchi, M., 1996. Mini-mental state examination: a normative study in Italian elderly population. Eur. J. Neurol. 3 (3), 198–202. https://doi.org/10.1111/j.1468-1331.1996.tb00423.x.

Migueles, J.H., Cadenas-Sanchez, C., Alcantara, J.M.A., Leal-Martín, J., Mañas, A., Ara, I., Glynn, N.W., Shiroma, E.J., 2021. Calibration and cross-validation of accelerometer cut-points to classify sedentary time and physical activity from hip and non-dominant and dominant wrists in older adults. Sensors 21 (10). https://doi.org/10.3390/s21103326 (Basel, Switzerland).

Mitchell, A.J., Beaumont, H., Ferguson, D., Yadegarfar, M., Stubbs, B., 2014. Risk of dementia and mild cognitive impairment in older people with subjective memory complaints: meta-analysis. Acta Psychiatr. Scand. 130 (6), 439–451. https://doi.org/10.1111/acps.12336.

O'Shea, D.M., Dotson, V.M., Fieo, R.A., Tsapanou, A., Zahodne, L., Stern, Y., 2016. Older adults with poor self-rated memory have less depressive symptoms and better memory performance when perceived self-efficacy is high. Int. J. Geriatr. Psychiatry 31 (7), 783–790. https://doi.org/10.1002/gps.4392Digital Object Identifier (DOI).

Parra-Rizo, M.A., Cigarroa, I., Olivera-Sánchez, S., Guillem-Saiz, J., Agustí-López, A.I., González-Moreno, J., Cantero-García, M., Cordero-Galindez, C.F., Yáñez-Yáñez, R. A., 2024. Perfil sociodemográfico de los adultos mayores físicamente activos según el tipo de actividades deportivas practicado: Gimnasia, actividades acuáticas, yoga, pilates y danza (Sociodemographic profile of physically active older adults according to the type of physical activities practiced: gymnastic exercises, aquatic activities, yoga, pilates and dance). Retos 56, 280–288. https://doi.org/10.47197/retos.v56.102223.

Pau, M., Brandas, B., Fastame, M.C., 2025. Women have the power: when motor efficiency makes the difference in older individuals of the Sardinian blue zone. Physiol. Behav. 291, 114811. https://doi.org/10.1016/j.physbeh.2025.114811.

Peng, J., Zhang, J., Wang, B., He, Y., Lin, Q., Fang, P., Wu, S., 2023. The relationship between sleep quality and occupational well-being in employees: the mediating role of occupational self-efficacy. Front. Psychol. 14, 1071232. https://doi.org/10.3389/fpsyg.2023.1071232.

Poulain, M., Herm, A., 2025. Blue zone, a demographic concept and beyond. Am. J. Lifestyle Med. 0 (0). https://doi.org/10.1177/1559827625134250.

Quattropani, M.C., Lenzo, V., Mucciardi, M., Toffle, M.E., 2014. Psychometric properties of the Italian version of the Short Form of the Metacognitions Questionnaire (MCQ-30). BPA Appl. Psychol. Bull. [Bollettino Di Psicologia Applicata] 62 (269), 29.

Reyes-Molina, D., Zapata-Lamana, R., Nazar, G., Cigarroa, I., Ruiz, J.R., Parrado, E., Losilla, J.M., Celis-Morales, C., 2025. Conceptual and evidence update on incidental physical activity: a scoping review of experimental and observational studies. Scand. J. Med. Sci. Sports 35 (1), e70015. https://doi.org/10.1111/sms.70015.

Ruiu, M., Carta, V., Deiana, C., Fastame, M.C., 2022. Is the Sardinian Blue Zone the New Shangri-La for mental health? Evidence on depressive symptoms and its correlates in late adult life span. Aging Clin. Exp. Res. 34 (6), 1315–1322. https://doi.org/10.1007/s40520-021-02068-7.

Siddarth, P., Thana-Udom, K., Ojha, R., Merrill, D., Dzierzewski, J.M., Miller, K., Small, G.W., Ercoli, L., 2021. Sleep quality, neurocognitive performance, and memory self-appraisal in middle-aged and older adults with memory complaints. Int. Psychogeriatr. 33 (7), 703–713. https://doi.org/10.1017/S1041610220003324.

Skurvydas, A., Predkeliene, A., Baranauskienė, N., Mockeviciene, D., Sarkauskiene, A., Valanciene, D., Lisinskiene, A., Dirvanskiene, R., Majauskiene, D., 2025. The relationships between stress, physical activity, mood, cognitive-emotional abilities, personality traits, and sleep. BMC Psychiatry 25 (1), 1118. https://doi.org/10.1186/s12888-025-07567-9.

Smith, K.J., Ainslie, P.N., 2017. Regulation of cerebral blood flow and metabolism during exercise. Exp. Physiol. 102 (11), 1356–1371. https://doi.org/10.1113/EP086249.

Varma, V.R., Chuang, Y.F., Harris, G.C., Tan, E.J., Carlson, M.C., 2015. Low-intensity daily walking activity is associated with hippocampal volume in older adults. Hippocampus 25 (5), 605–615. https://doi.org/10.1002/hipo.22397.

Verghese, J., Wang, C., Lipton, R.B., Holtzer, R., 2013. Motoric cognitive risk syndrome and the risk of dementia. J. Gerontol. A Biol. Sci. Med. Sci. 68 (4), 412–418. https://doi.org/10.1093/gerona/gls191.

Voss, M.W., Carr, L.J., Clark, R., Weng, T., 2014. Revenge of the "sit" II: does lifestyle impact neuronal and cognitive health through distinct mechanisms associated with sedentary behavior and physical activity? Ment. Health Phys. Act. 7 (1), 9–24. https://doi.org/10.1016/j.mhpa.2014.01.001.

Webster, K.E., Zhou, W., Gallagher, N.A., Smith, E.M.L., Gothe, N.P., Ploutz-Snyder, R., Colabianchi, N., Larson, J.L., 2021. Device-measured sedentary behavior in oldest old adults: a systematic review and meta-analysis. Prev. Med. Rep. 23, 101405. https://doi.org/10.1016/j.pmedr.2021.101405.

Wells, A., Cartwright-Hatton, S., 2004. A short form of the metacognitions questionnaire: properties of the MCQ-30. Behav. Res. Ther. 42 (4), 385–396. https://doi.org/10.1016/S0005-7967(03)00147-5.

World Health Organization, 2024. Ageing and health. From. https://www.who.int/news-room/fact-sheets/detail/ageing-and-health. (Accessed 20 February 2025).

Xie, X., Zheng, X., Mei, L., Hu, Y., Liu, J., Ma, G., Yang, Y., Dai, Q., Ma, M., 2024. Association between sleep duration and subjective memory complaints: a large-scale cross-sectional study based on NHANES. Prev. Med. Rep. 43, 102790. https://doi.org/10.1016/j.pmedr.2024.102790.

Yesavage, J.A., Sheikh, J.I., 1986. 9/Geriatric depression scale (GDS) recent evidence and development of a shorter version. Clin. Gerontol. 5 (1–2), 165–173. https://doi.org/10.1300/J018v05n01_09.

Yu, X.H., Li, X.R., Du, Z.R., Zhang, Y., Fei, Y., Tang, W.P., Li, X.W., Zhao, Q., 2024. Effects of non-pharmacological interventions for adults with subjective cognitive decline: a network meta-analysis and component network meta-analysis. BMC Med. 22 (1), 272. https://doi.org/10.1186/s12916-024-03491-z.

Yu, J., Chen, J., Yang, L., 2025. Subjective memory complaints: a conceptual analysis. J. Multidiscip. Healthc. 3967–3976. https://doi.org/10.2147/JMDH.S518951.

Zhang, Y., Chen, B., Hébert, E.T., DeFina, L.F., Leonard, D., Barlow, C.E., Pavlovic, A., Kohl 3rd, H.W., 2025. Associations of physical activity, sedentary behavior, and sleep patterns with cognitive function among middle-aged and older adults. J. Act. Sedentary Sleep Behav. 4 (1), 9. https://doi.org/10.1186/s44167-025-00079-7.