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Psychometric Properties of The Activities of Daily Living Inventory in Portuguese Older Adults

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**PSYCHOMETRIC PROPERTIES OF THE ACTIVITIES OF DAILY LIVING
INVENTORY IN PORTUGUESE OLDER ADULTS**

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Resumo

À medida que a população idosa cresce, a avaliação das Atividades de Vida Diária (AVD) tornou-se uma área central de foco na neuropsicologia, devido à sua importância na compreensão do declínio funcional e cognitivo. Apesar da sua relevância, muitos dos instrumentos atualmente disponíveis apresentam limitações consideráveis. Este trabalho tem como objetivo estudar as propriedades psicométricas de um novo instrumento, o Inventário de AVD (IAVD), num grupo controlo saudável e num grupo com Défice Cognitivo Ligeiro. O IAVD inclui duas versões: uma versão de auto e outra de heterorrelato. O inventário é dividido em quatro subseções, excluindo as questões sociodemográficas iniciais. As quatro subseções incluem: (a) AVD Básicas; (b) AVD Instrumentais; (c) AVD Avançadas; (d) outros fatores que podem afetar a funcionalidade. Este estudo foi composto por 72 participantes que foram avaliados pelos seguintes instrumentos: (a) ambas as versões do IAVD; (b) Índice de Barthel; (c) Escala de AVD Instrumentais de Lawton; (d) Addenbrooke's Cognitive Examination - III (ACE-III). Os resultados mostram que o IAVD possui tanto boa validade preditiva quanto validade convergente, com fortes correlações com os instrumentos mencionados anteriormente. Estes resultados sugerem que o IAVD é uma ferramenta válida para avaliar as AVD. Ao combinar as versões de auto e heterorrelato, o IAVD demonstra um forte potencial como uma ferramenta abrangente para detetar precocemente comprometimentos funcionais.

Palavras-chave: Atividades de Vida Diária; Avaliação Neuropsicológica

Abstract

As the aging population grows, the assessment of Activities of Daily Living has become a central area of focus in neuropsychology due to its importance in understanding functional and cognitive decline. Despite its significance, many of the existing tools currently available have considerable limitations. This work aims to study the psychometric properties of a new instrument, the ADL Inventory (ADLI) in a healthy control and Mild Cognitive Impairment group. The ADLI includes two versions: a self-report and an informant-report version. The inventory is divided into four subsections, excluding the initial sociodemographic questions. The four subsections include: (a) Basic ADL; (b) Instrumental ADL; (c) Advanced ADL; (d) other factors that can affect functionality. This study comprised 72 participants that were assessed by the following instruments: (a) both versions of the ADLI; (b) Barthel Index; (c) Lawton Instrumental Activities of Daily Living Scale; (b) Addenbrooke's Cognitive Examination - III (ACE-III). Results show that the ADLI has both good predictive and convergent validity with strong correlations with the aforementioned instruments. These results suggest that the ADLI is a valid tool for assessing ADL. By combining both self-report and informant-report versions, the ADLI demonstrates strong potential as a comprehensive tool for detecting early functional impairments.

Keywords: Activities of Daily Living; Neuropsychological Assessment

Introduction

The ageing population presents a global challenge, particularly in addressing the healthcare needs of the elderly and providing better support (Fonseca et al., 2023). In order to achieve that goal and with the focus on a better quality of life, the health status of older individuals cannot be determined solely by the presence or absence of illness (Fonseca et al., 2023). Health-related quality of life is largely determined by functional status, which assesses the person's ability to perform physical, psychological, and social activities in everyday life (Rubenstein et al., 1995).

When evaluating an individual's functional status, the assessment of Activities of Daily Living (ADL) plays a pivotal role (Klimczuk, 2016). ADL are defined as tasks that are performed in everyday life (Klimczuk, 2016). These activities determine an individual's independence from others and the ability to stay integrated in their familiar surroundings while fulfilling their social roles (Klimczuk, 2016; Romero-Ayuso et al., 2019). The ADL require different kinds of skills, including motor, cognitive, perceptual, and socio-emotional (Mlinac & Feng, 2016; Romero-Ayuso et al., 2019). Failure to perform ADL leads to reliance on other people or assistive devices, potentially creating unsafe environments and significantly diminishing quality of life (Edemekong et al., 2023).

Analysing an individual's capacity to perform daily activities is often a crucial component of neuropsychological evaluations (Farias et al., 2018). For instance, a key piece of information clinicians typically require when assessing patients is an understanding of the functional limitations or restrictions caused by a specific disease, disorder, or deficit (Romero-Ayuso et al., 2019). This is crucial to identify the obstacles that may hinder the ability to carry out ADL, especially in an early phase of disease progression (Farias et al., 2018). The significance of ADL assessment is evident in various aspects of healthcare, including predicting outcomes for hospitalised patients (Lavezza et al., 2023), the necessity of admission in a nursing home, rearrangement of living situations, as well as the evaluation of the progress and outcomes of intervention programs (Farias et al., 2018; Sikkes & de Rotrou, 2014).

When assessing ADL it is essential to recognize that the causes of impairment in daily activities can vary widely. One of the most common factors is the natural ageing process,

during which a decline in functional status and additional difficulties in some ADL are often presented. Besides ageing, several factors need to be considered, such as physical and cognitive decline, social isolation, home environment changes, and sensory changes (Edemekong et al., 2023; Sikkes & de Rotrou, 2014).

ADL can be divided into three subtypes regarding activity complexity: Basic ADL (BADL), Instrumental ADL (IADL), and Advanced ADL (AADL). BADL comprise activities considered indispensable in maintaining human life (Katz, 1983). The American Association of Occupational Therapy (AOTA) considers the following BADL: bathing, toileting and toilet hygiene, dressing, eating and swallowing, feeding, functional mobility, personal hygiene, and grooming (AOTA, 2020). IADL are activities related to the necessity of self-maintenance in the community (Katz, 1983). The AOTA considers the following IADL: care of others, care of pets, child rearing, communication management, driving and community mobility, financial management, home establishment and management, meal preparation and clean-up, religious and spiritual expression, safety and emergency maintenance, and shopping (AOTA, 2020). AADL are activities related to occupation, recreation, and community interactions (Klimczuk, 2016).

The ADL can also be organised in a hierarchical structure that outlines the sequence of deterioration in such activities as difficulties arise during the disablement process (Delva et al., 2014). Indeed, there is a pattern in the decline of ADL, where certain activities are consistently lost prior to others. It is suggested that the cognitive decline observed in individuals follows a reverse pattern to early development (Katz & Akpom, 1976; Spector et al., 1987). The fundamental skills that are acquired later in childhood are often the first to be impacted as cognitive functions deteriorate (Katz & Akpom, 1976; Spector et al., 1987). As a result, more complex abilities degrade initially, while simpler, more ingrained activities tend to be retained longer (Watson et al., 2017). In elderly, deterioration affects mobility in an early stage, followed by difficulties in IADL and, in a further stage, in BADL (Delva et al., 2014). The functional decline in BADL often leads to institutional care (Watson et al., 2017). This care can focus on rehabilitation to restore the ADL abilities or transition to long-term care as functional capacity continues to deteriorate (Watson et al., 2017).

Functionality, assessed through ADL, operates as one of the main domains to distinguish normal ageing from both Mild and Major Neurocognitive Disorder (De Vriendt et al., 2013; Gold, 2012; Winblad et al., 2004). Mild Neurocognitive Disorder (MiLD), traditionally known as Mild Cognitive Impairment (MCI), has been used as a term to describe a transitional stage between normal cognitive functioning and Major Neurocognitive Disorder,

such as early dementia (Winblad et al., 2004). MCI is historically recognized as a grey area between the cognitive changes of ageing and very early dementia, and was always considered a prodromal stage of dementia related to Alzheimer's Disease (Petersen et al., 2014). In fact, the concept of MCI was designed to grasp the more subtle initial cognitive deterioration (De Vriendt et al., 2021). Nowadays, the American Psychiatry Association (APA), in the Diagnostic and Statistical Manual of Mental Disorders 5th edition (DSM-5), defines the criteria for MiLD as the following: (a) evidence of cognitive decline in one or more cognitive domains obtained through patient, informant or clinician reports, or an assessment objective; (b) preserved functional independence; (c) cognitive deficits do not occur exclusively during episodes of delirium; (d) cognitive deficits cannot be better explained by another condition (e.g., depression); (e) absence of dementia (APA, 2013). MCI can be divided into two subtypes: amnesic and non-amnesic, depending on whether memory is impaired or not (Petersen & Morris, 2005). MCI can be further subclassified into single-domain or multiple-domain categories, regarding whether one or more cognitive functions are affected (Petersen & Morris, 2005). Commonly, amnesic MCI that progresses to dementia typically develops into AD or vascular dementia, while non-amnesic MCI is more likely to evolve into frontotemporal or Lewy body dementia (Molano et al., 2010). Several risk factors are associated with MCI, with the most prevalent one being age (Sanford, 2017). Others include being male (Petersen et al., 2010), the presence of vascular risk factors, and history of cognitive impairment in the family (Sanford, 2017).

The difference between MCI and dementia mainly lies in how significantly cognitive decline disrupts a person's ability to perform ADL and manage everyday tasks (De Vriendt et al., 2021). In dementia, cognitive decline significantly reduces an individual's independence in managing daily activities, whereas in MCI, people generally maintain their autonomy (Krell-Roesch et al., 2019). Despite that, current research shows that MCI patients may not have a completely preserved functionality status, especially considering IADL, when compared to those cognitively unimpaired (Jefferson et al., 2008; Nygard, 2003). It is important to understand that the degree of impairment in performing ADL is a major indicator of potential future decline and the onset of dementia (Lindbergh et al., 2016). This is especially true when considering IADL impairment in MCI patients (Reppermund et al., 2011). Some evidence points towards mild deficits regarding functionality appearing in MCI, although it is still not completely clear which particular domains, if any, are compromised, as the nature of disturbance of IADL in MCI has not received much attention so far (Jekel et al., 2015; Reppermund et al., 2011). More recently, literature shows that IADL that require better

neuropsychological functioning, such as managing finances, seem to be more significantly impacted in patients with MCI (Henriques et al., 2023).

The IADL performance has been linked to cognitive abilities in several studies (Farias et al., 2003; Reppermund et al., 2011). Accordingly, MCI patients show deficits in more complex ADL, meaning those requiring higher cognitive demands (De Vriendt et al., 2013; De Vriendt et al., 2021). Although executive functioning is the domain most consistently linked to IADL functioning (Amanzio et al., 2018; Farias et al., 2003; Lewis & Miller, 2007; Reppermund et al., 2011), attention and memory have also shown associations with IADL (Farias et al., 2008; Reppermund et al., 2011). Within the spectrum of executive functions, literature shows variable results. Some research indicates that planning is crucial for preserving functional ability in later life (Lewis & Miller, 2007). Other studies suggest that deficits in shifting and abstract reasoning may have a more significant impact on IADL than other aspects of executive functioning (Nguyen et al., 2019). Finally, some argue that the decline in IADL appears to be associated with deficits in response inhibition, self-monitoring, and cognitive flexibility (Amanzio et al., 2018). This seems to indicate that individuals with significant impairments in executive functioning are more prone to difficulties with IADL than those whose neurocognitive challenges are confined to other cognitive abilities (Nguyen et al., 2019). The reported crucial role of executive functioning in IADL can be linked to the hierarchy of ADL. The IADL tend to be affected first because they rely more on higher-order cognitive skills, such as executive functions, while BADL are less dependent on these cognitive functions (Sikkes & de Rotrou, 2014). This suggests that executive dysfunction may serve as an early indicator for detecting IADL deficits (Nguyen et al., 2020). Consequently, a more in-depth cognitive assessment, integrating direct ADL evaluations with cognitive and motor tests, may shed greater light on the neuropsychological deficits responsible for ADL impairments (Mlinac & Feng, 2016). Especially in the context of MCI, it is important to highlight the usefulness of comparing performance across various neuropsychological variables with everyday functioning (Jekel et al., 2015). By enhancing our understanding of the neuropsychological profile and the particular ADL impairments associated with MCI, the comprehension of each case and the needs of affected individuals can be more thoroughly met.

Focusing on gaining a more comprehensive understanding of MCI, it is important to recognize a key point. Although many MCI cases progress to dementia, it is important to note that not all MCI represents early AD (Petersen et al., 2014; Petersen, 2016), i.e., not all cases of MCI lead to dementia, and not all are progressive, with distinct disorders being associated with an MCI state (Sanford, 2017). Hence, early screening and diagnosis of MCI are crucial

for several reasons. First and foremost, identifying cognitive decline at an early stage allows for timely interventions that can mitigate further deterioration. This proactive approach may not only delay the onset of dementia but could also potentially prevent its progression altogether (Sanford, 2017). Considering that not all MCI represents early AD, it is relevant to look into MCI etiologies. MCI etiologies are in fact very variable, and can be divided into degenerative, vascular, psychiatric and medical, although the most prevalent one is degenerative, especially due to AD (Petersen, 2016). However, even in degenerative MCI, with annual progression rates to dementia estimated at 8% to 15%, most patients tend to remain in an MCI state for an extended period (Beach et al., 2012). While the various etiologies of MCI are well understood, the literature continues to primarily focus on the progression of MCI towards AD, often overlooking other causes and potential outcomes associated with MCI. This constitutes a limitation when studying functionality in MCI patients. Another limitation is related to the fact that most literature does not address ADL and its impairment as a continuum. Literature primarily focuses on ADL impairment at the dementia stage and disregards previous signs and stages of ADL dysfunction.

This is also true when talking about the instruments designed to assess functionality as of today. In fact, many instruments were originally developed for patients diagnosed with dementia, which can significantly restrict the range of functional domains evaluated (Moore et al., 2007). It is especially important to assess ADL functioning in prodromal stages of dementia, such as MCI, exploring the longitudinal progression of ADL deficits in older adults. Despite that, clinicians and researchers are currently left without much guidance about how to assess IADL impairment in MCI, due to a lack of agreement and uniformity. Although there are some options, a widely accepted procedure or “gold standard” does not exist (Shaikh et al., 2023). Due to this shortcoming, conclusions regarding statistical indices of existing measures, such as convergent validity, are limited (Romero-Ayuso et al., 2019).

Existing ADL evaluation tools can be grouped into four categories: self-report, informant-based, performance-based measures, and technology-based methods (e.g., virtual reality and gaming approaches) (Mlinac & Feng, 2016; Romero-Ayuso et al., 2019).

Self-report scales and questionnaires are the most straightforward and direct approach to measure IADL (Sikkes & de Rotrou, 2014). The most prevalent problem when using self-reports in patients with cognitive decline is that impaired awareness of their condition may lead to inaccurate responses (Graham et al., 2005). However, some literature shows that self-reported decline occurred before informant-reported decline in individuals who later developed

MCI (Caselli et al., 2014). As such, self-report measures can be a reliable source of information in an early phase of cognitive deterioration (Sikkes & de Rotrou, 2014).

Informant-based approaches are the most commonly used method when assessing IADL (Sikkes & de Rotrou, 2014). Due to the informant's capacity to compare the patient's current abilities to their functioning in previous years, they are believed to offer a more objective perspective on the extent of decline (Sikkes & de Rotrou, 2014). However, it is crucial to determine if an informant is actually reliable, determining important variables such as familiarity with the patients, the amount of time spent with them, and the nature of the activities shared (Farias et al., 2008). Additionally, understanding the relationship with potential sources of bias is fundamental (Sikkes & de Rotrou, 2014). Current literature shows that informants experiencing significant depressive symptoms and feelings of burden are likely to overstate the negative aspects of the patient's condition, potentially leading to suboptimal approaches in the patients care (Schulz et al., 2013). The opposite scenario is also plausible, meaning overestimating the patient's real abilities (Mlinac & Feng, 2016).

Performance-based measures entail presenting participants with functional tasks in a standardised manner (Moore et al., 2007). This type of measures have been designed to objectively assess functional capabilities related to IADL, determining an individual's degree of functioning (Romero-Ayuso et al., 2019; Sikkes & de Rotrou, 2014). The scenarios assessed through performance-based measures should reflect real-world complexity while being relevant and practical for daily life, incorporating specific guidelines regarding the context and execution of the activities involved (Romero-Ayuso et al., 2019). They can be important in an early detection of dysfunction in IADL since elderly people may not show a reduction in the total number of activities completed, but could experience changes in how often they are performed and the quality of that performance (Romero-Ayuso et al., 2019). However, they are extremely time consuming and only a restricted number of activities can be evaluated (Sikkes & de Rotrou, 2014). In addition, performance-based measures may not accurately reflect the individual's actual functioning, as the testing environment may not replicate the adaptations made in their home setting (Moore et al., 2007). Finally, most performance-based measures fail to capture the multi-task component of everyday functioning, as most focus on performing one specific task at a time (Moore et al., 2007).

Technology-based methods, such as the ones using virtual reality, are now being more widely used to overcome some limitations of performance-based measures. Virtual reality technology enables immersion in realistic scenarios, allowing for the observation of a patient's performance in IADL within a controlled environment (Romero-Ayuso et al., 2019). However,

their use remains limited, likely due to challenges in implementation, elevated cost, and time demands (Romero-Ayuso et al., 2019).

Numerous efforts have been undertaken to develop assessment tools that are sensitive, easy to administer, and cost-effective for evaluating ADL (De Vriendt et al., 2021). However, despite the wide range of available report-based tools, many of these assessments rely on inconsistent and vague definitions of ADL (De Vriendt et al., 2021; Romero-Ayuso et al., 2019). Additionally, they often suffer from methodological issues, such as weak psychometric validity, oversimplified scoring systems (e.g., ability to perform or not a specific ADL), and a failure to consider underlying causes of impairment (De Vriendt et al., 2021; Romero-Ayuso et al., 2019). Specifically in the context of MCI, available measures of ADL present a high variability in finding discreet impairments (De Vriendt et al., 2013) and neglect of other relevant factors, such as familiarity with the task and the environments in which the task is performed, sensory impairments, and gender-specific expectations (Pinto et al., 2024).

Considering these limitations, the Instrumental Activities of Daily Living - Inventory (ADLI) tries to address the necessity of an instrument that allows for a complete and strict functionality assessment (Pinto et al., 2024). Advantages of the ADLI include: (a) being organised by presence or absence of difficulties; (b) the response scale ranging between 0 and 10, allowing a greater discrimination level of difficulties or impairment on ADL, while providing an improved measure of changes in functionality over time; (c) accounting for two levels of difficulty in IADL; (d) incorporating both self-report and informant-report forms, and (e) considering the effects of factors such as routine versus novelty, familiar versus new environments, sensory impairments, and gender-specific expectations (Pinto et al., 2024).

The ADLI can become particularly relevant in the Portuguese context when we consider the country's age distribution tendency in recent decades. According to Portugal's National Statistics Institute (INE), in 2021 the ageing index, which compares the population aged 65 years and over (elderly population) with the population aged 0 to 14 years (young population), reached a value of 185 elderly people for every 100 young people. The elderly population amounted to almost 2.5 million people, with the number of individuals aged 65 or over increasing by about 21% over the last decade, currently representing more than 23% of the Portuguese population. As the elderly population grows, the need for resources and infrastructure to support them becomes increasingly urgent. This demographic shift has significant implications for public health systems, social services, and long-term care strategies. Among these, neuropsychological instruments will be essential for providing

comprehensive and reliable assessments to clinicians, aiding in the early diagnosis, monitoring, and managing the cognitive health in the ageing population.

As there is no consensus on the optimal assessment for older adults, it is fundamental to have a good insight of the psychometric properties of the various scales used, in order to ensure a good decision about which tool to use for a particular patient or general condition (Kelbling et al., 2023). In fact, most ADL assessment tools lack adequate psychometric information, leaving only a few well-documented, valid, and reliable measures available for assessing ADL in community-dwelling older populations (Hopman-Rock et al., 2019). In a systematic review, Hopman-Rock and colleagues (2019) found that only 10% of papers regarding ADL instruments offer valuable data on their reliability and validity within an older population.

Considering that and following the recommendations of the ADLI original paper (Pinto et al., 2024), this study aims to (a) explore the psychometric properties of the ADL-I in Portuguese healthy older adults and MCI patients, and (b) understand if the ADL-I can discriminate between healthy and MCI participants in ADL and cognitive functioning. It will also aim to study the convergent validity between the ADL-I and the remaining ADL assessment instruments.

Method

Participants

A total of 72 participants (40 female) were recruited by convenience from the community using a snowball method. Sociodemographic and clinical characteristics of the sample are presented in Table 1.

The assessments were either carried out in people's homes or in nursing homes, recruiting participants towards both clinical and healthy control samples. The inclusion criteria were the following: (a) portuguese nationality; (b) portuguese as the native language; (c) sixty-five years or older. Exclusion criteria were the following: (a) motor or sensory impairment that prevents the completion of the tasks; (b) illiteracy; (c) clinical diagnosis of dementia; (d) clinical history of neuropsychiatric disease.

Participants were further divided into an MCI group ($n = 18$, 14 female) and a control group ($n = 54$, 26 female), depending on whether they scored higher or lower than 82 (cutoff

that differentiates the control and mild cognitive impairment groups) in the Addenbrooke's Cognitive Examination – III (ACE-III; Hsieh et al., 2013; Portuguese version by Machado et al., 2015; Peixoto et al., 2018).

Table 1

Sociodemographic and Clinical Characteristics of the Sample

Sociodemographic and clinical variables	Participants (n = 72)	Control group (n = 54)	MCI group (n = 18)
Age in years (<i>M ± SD</i>)	75.07 ± 7.40	74.07 ± 6.79	78.06 ± 8.52
Years of formal education (<i>M ± SD</i>)	5.82 ± 3.86	6.33 ± 4.19	4.28 ± 2.05
ACE-III Total (<i>M ± SD</i>)	85.82 ± 5.69	88.17 ± 4.10	78.78 ± 3.54
ACE-III Attention (<i>M ± SD</i>)	16.64 ± 1.19	17 ± 0.87	15.56 ± 1.39
ACE-III Memory (<i>M ± SD</i>)	22.03 ± 2.51	22.59 ± 2.15	20.33 ± 2.79
ACE-III Fluency (<i>M ± SD</i>)	8.64 ± 1.92	9.22 ± 1.71	6.89 ± 1.37
ACE-III Language (<i>M ± SD</i>)	24.33 ± 1.63	24.93 ± 1.04	22.56 ± 1.79
ACE-III Visuospatial (<i>M ± SD</i>)	14.18 ± 1.42	14.43 ± 1.44	13.44 ± 1.10

Note. ACE-III: Addenbrooke's Cognitive Examination – III.

Instruments

Clinical assessment procedures included a complete evaluation of functionality (Basic and Instrumental ADL) and global cognitive function. Functionality was measured by 3 different instruments. The first 2 evaluated ADL functioning, addressing both basic and instrumental levels of complexity of ADL. BADL was assessed by the Barthel Index (Mahoney & Barthel, 1965; Portuguese version by Aet al., 2007), and IADL by the Lawton Instrumental Activities of Daily Living Scale (Lawton & Brody, 1969; Portuguese version by Araújo et al., 2008). Finally, the ADLI (Pinto et al., 2024) was used to assess both levels of ADL functioning.

The Barthel Index is an instrument designed to assess independence in 10 different BADL. Every BADL is assessed according to whether the person can perform the activity alone, with help, or not at all (Mahoney & Barthel, 1965). A higher total score (maximum of 100) means a greater ability to function independently (Mahoney & Barthel, 1965).

The Lawton Instrumental Activities of Daily Living Scale is designed to evaluate IADL functioning. It measures 8 domains or areas of function, and scores range from 0 to 8, with the latter corresponding to someone independent and with high functionality (Lawton & Brody,

1969). The eight domains are the following: (a) ability to use the telephone; (b) shopping; (c) food preparation; (d) housekeeping; (e) laundry; (f) mode of transportation; (g) responsibility for own medication; (h) ability to handle finances (Lawton & Brody, 1969; Araújo et al., 2008).

The ADLI includes two versions: a self-report and an informant-report version. The inventory is divided into four subsections, excluding the initial sociodemographic questions (Pinto et al., 2024). Specifically, the sociodemographic part includes information about the living conditions and context and the perceived need for help in functionality. The first subsection is focused on BADL, including questions about basic human functioning and motor aspects that were adapted from the Barthel Index (Mahoney & Barthel, 1965) and the Katz Index of Independence in Activities of Daily Living (Katz, 1983). The second subsection includes assessment of IADL previously selected by the AOTA (AOTA, 2020), while the third subsection assesses AADL, that were based on the advanced-Activities of Daily Living Tool (De Vriendt et al., 2013). Finally, the fourth subsection includes questions about other factors that can affect functionality namely: routine vs. novelty; familiar vs. novel context; sensory acuity deficits; and gendered expectations (Pinto et al., 2024). Moreover, the ADLI includes supplementary materials that specify the particular functions targeted by each item (e.g., executive functioning) (Pinto et al., 2024)

The ACE-III (Hsieh et al., 2013; Portuguese version by Machado et al., 2015) was used to measure global cognitive functioning. The ACE-III is a neurocognitive assessment tool designed to evaluate five cognitive domains (Hsieh et al., 2013; Machado et al., 2015). It includes attention (max score = 18 points), assessed through orientation, immediate verbal evocation of words and serial subtraction tasks; memory (max score = 26 points), evaluated by verbal delayed recall (free recall and recognition), verbal learning and semantic memory tasks; verbal fluency (max score = 14 points), including phonetic and semantic fluency tasks; language (max score = 26 points), assessed through comprehension, repetition, naming, reading, and writing tasks; and visuospatial abilities (max score = 16 points), including visuoconstructive tasks (e.g., copying a cube and drawing a clock) and spatial perceptive tasks (e.g., counting dots and identifying incomplete letters) (Hsieh et al., 2013; Machado et al., 2015). The instrument is scored out of 100, with higher scores indicating better cognitive performance. The Portuguese version of ACE-III has very good reliability and high diagnostic capacity in the context of MCI (Peixoto et al., 2018). In the Portuguese study, the MCI group obtained worst results when compared to the control group in most of the domains, except for the Attention and Visuospatial domains (Peixoto et al., 2018).

Procedures

The present study is part of an ongoing study approved by the Ethical Commission (Ref.^a 2024-02-01). After informed consent, all participants underwent an assessment protocol starting with a semi-structured interview to collect the sociodemographic characteristics. The neuropsychological assessment took place within a private room in a single session. The instruments were administered in a counterbalanced order among the participants to control for fatigue effects. The informant-report version of ADLI was completed by a family member in all cases, except for the institutionalised participants. For these participants the informant-report version of ADLI was completed by a nursing home worker who they had daily contact with. Of the 72 participants, only 65 had the ADLI informant-based version completed by a third party. Descriptive statistics were computed to assess the clinical and sociodemographic characteristics of the sample (see table 1). Pearson's correlations were used to assess both predictive and convergent validity. A Mann-Whitney U Test was conducted to determine whether there were significant differences in Barthel Index, Lawton Instrumental Activities of Daily Living Scale, ADLI self-report, and ADLI informant-report total scores between MCI and control groups. A Mann-Whitney U Test was used, due to the assumption of normality being violated, as indicated by the Shapiro-Wilk test (all $W < 0.74$, $p < .001$). Additionally, the assumption of homogeneity of variances was also violated in all four metrics, as indicated by Levene's test (all $F > 6.94$, $p < .011$). Given that the assumptions of normality ($W = .98$, $p = .276$) and homogeneity of variances ($F < 1$) were not violated for the ACE-III total scores, an independent samples t-test was conducted.

All analyses were conducted in IBM SPSS Statistics Version 29.0.2.0, with $\alpha = .05$ as the threshold for statistical significance. The p-values were corrected using the FDR method for multiple correlations whenever necessary.

Results

Table 1 presents descriptive statistics regarding cognitive functioning in the ACE-III, including total and domain scores. Descriptive statistics related to ADL performance in the Barthel Index, Lawton Instrumental Activities of Daily Living Scale, and both self and informant-report versions of the ADLI are presented in Table 2.

Table 2*Descriptive Statistics: ADL Performance*

ADL Questionnaires	Participants (n = 72)	Control group (n = 54)	MCI group (n = 18)
Barthel Index Total ($M \pm SD$)	19.22 $\pm$ 2.18	19.67 $\pm$ 1.08	17.89 $\pm$ 3.71
Lawton IADL Scale Total ($M \pm SD$)	20.03 $\pm$ 4.92	21.07 $\pm$ 3.87	16.89 $\pm$ 6.36
ADLI Self-report Total ($M \pm SD$)	1628.15 $\pm$ 403.37	1716.11 $\pm$ 320.57	1364.28 $\pm$ 510.73
ADLI – BADL ($M \pm SD$)	197.19 $\pm$ 15.42	200.89 $\pm$ 8.95	186.11 $\pm$ 23.88
ADLI – IADL ($M \pm SD$)	466.93 $\pm$ 133.82	496.04 $\pm$ 108.04	379.61 $\pm$ 166.21
ADLI – AADL ($M \pm SD$)	482.01 $\pm$ 131.29	509.59 $\pm$ 105.04	399.28 $\pm$ 167.10
ADLI Informant-report Total ($M \pm SD$)	1120.11 $\pm$ 301.09	1175.42 $\pm$ 248.94	935.73 $\pm$ 387.53
ADLI – BADL ($M \pm SD$)	193.35 $\pm$ 19.67	198.54 $\pm$ 11.14	176.07 $\pm$ 30.29
ADLI – IADL ($M \pm SD$)	456.71 $\pm$ 142.43	479.96 $\pm$ 122.21	379.20 $\pm$ 179.16
ADLI – AADL ($M \pm SD$)	470.05 $\pm$ 145.79	496.92 $\pm$ 120.53	380.47 $\pm$ 187.44

Note. IADL = Instrumental Activities of Daily Living; ADLI = Activities of Daily Living Inventory; BADL = Basic Activities of Daily Living; AADL = Advanced Activities of Daily Living.

In relation to convergent validity (see Table 3), BADL scores obtained both in the self-report ($r = .77, p < .001$) and informant-report ($r = .80, p < .001$) versions of the ADLI significantly and positively correlated with the Barthel Index. The same was true for the assessment of IADL. Scores obtained in both versions of the ADLI correlated with the Lawton Instrumental Activities of Daily Living Scale (both $r > .87, p < .001$).

Table 3*ADLI Convergent Validity*

Variables	Bivariate Correlations	
	Barthel Index total	Lawton IADL
Self-report ADLI - BADL	.77**	
Self-report ADLI-IADL		.88**
Informant- report ADLI-BADL	.80**	
Informant- report ADLI-IADL		.88**

** $p < .01$

Note. ADLI = Activities of Daily Living Inventory; BADL = Basic Activities of Daily Living; IADL = Instrumental Activities of Daily Living.

Regarding predictive validity (see Table 4), BADL, IADL, and AADL scores, as well as the total scores of the ADLI self-report (all $r > .40, p < .001$) and ADLI informant-report (all $r > .41, p < .001$) showed significant positive correlations with ACE-III total scores. This was also the case regarding ACE-III language subscore (all $r > .40, p < .001$) and attention subscore (all $r > .30, p < .010$). The BADL, IADL, AADL, and total scores of the ADLI self-

report version were significantly correlated with ACE-III fluency subscore (all $r > .23, p < .05$). Only the BADL score of the ADLI informant-report version was significantly correlated with the ACE-III fluency subscore ($r = .32, p = .009$). Regarding the visuospatial subscore of the ACE-III, only the BADL score of the ADLI informant-report version was significantly correlated ($r = .30, p = .02$). No significant correlations were found between ADLI and ACE-III memory subscore (all $r < .24, p > .05$).

Table 4

Predictive Validity of the ADLI

Variables	Bivariate Correlations					
	ACE-III total	ACE-III attention	ACE-III memory	ACE-III fluency	ACE-III language	ACE-III visuospatial
Self-report						
ADLI Total	.48**	.40**	.20	.25*	.59**	.20
ADLI – BADL	.40**	.30*	.08	.40**	.40**	.19
ADLI – IADL	.48**	.41**	.23	.23*	.57**	.20
ADLI – AADL	.46**	.38**	.19	.24*	.59**	.20
Informant-report						
ADLI Total	.44**	.36**	.20	.19	.57**	.22
ADLI – BADL	.53**	.37**	.24	.32**	.60**	.30*
ADLI – IADL	.41**	.33**	.20	.16	.54**	.20
ADLI – AADL	.43**	.36**	.18	.19	.57**	.21

* $p < .05$; ** $p < .01$

Note. ACE-III = Addenbrooke's Cognitive Examination-III; ADLI = Activities of Daily Living Inventory; BADL = Basic Activities of Daily Living; IADL = Instrumental Activities of Daily Living; AADL = Advanced Activities of Daily Living.

Regarding the domains targeted in the ADLI (see Table 5) most correlated positively and significantly with ACE-III total scores in both versions. In the ADLI self-report, only olfactory perception, taste perception, and expressive language abilities were not significantly correlated with ACE-III total score (all $r < .23, p > .05$). All other domains showed a significant and positive correlation with the ACE-III total score (all $r > .25, p < .034$).

In the ADLI informant-report version (see Table 6) only olfactory perception, expressive language abilities, and updating were not significantly correlated with ACE-III total score (all $r < .24, p > .05$). All other domains showed a significant and positive correlation with the ACE-III total score (all $r > .26, p < .037$).

Table 5*Bivariate Correlations between ADLI Self-Report Cognitive Subscales and ACE-III*

Variables	Bivariate Correlations
	ACE-III total
Physical functioning	.42**
Sensory perception	.41**
Visual perception	.42**
Colour and size perception	.30*
Tactile perception	.34**
Olfactory perception	-.04
Taste perception	.13
Orientation	.45**
Spatial orientation	.44**
Temporal orientation	.35**
Attention	.47***
Sustained attention	.43**
Divided attention	.47**
Selective attention	.36**
Language	.35**
Comprehension	.33**
Receptive language abilities	.49**
Expressive language abilities	.23
Numerical reasoning	.48**
Memory	.48**
Retrieval of information	.47**
Prospective memory	.35**
Encoding	.37**
Retrieval of semantic memory	.44**
Retention of information	.37**
Reasoning	.25*
Executive function	.46**
Planning	.47**
Organization	.43**
Sequencing	.49**
Problem Solving	.44**
Decision Making	.41**
Temporal Estimation	.43**
Judgement	.44**
Shifting	.39**
Updating	.26*
Inhibition	.39**

* $p < .05$; ** $p < .01$

Table 6*Bivariate Correlations between ADLI Informant-Report Cognitive Subscores and ACE-III*

Variables	Bivariate Correlations
	ACE-III total
Physical functioning	.52**
Sensory perception	.34**
Visual perception	.34**
Colour and size perception	.26*
Tactile perception	.33**
Olfactory perception	.07
Taste perception	.41**
Orientation	.43**
Spatial orientation	.44**
Temporal orientation	.35**
Attention	.48**
Sustained attention	.46**
Divided attention	.47**
Selective attention	.40**
Language	.31*
Comprehension	.36**
Receptive language abilities	.29*
Expressive language abilities	.24
Numerical reasoning	.36**
Memory	.40**
Retrieval of information	.39**
Prospective memory	.37**
Encoding	.36**
Retrieval of semantic memory	.29*
Retention of information	.39**
Reasoning	.45**
Executive function	.43**
Planning	.46**
Organization	.42**
Sequencing	.41**
Problem Solving	.44**
Decision Making	.39**
Temporal Estimation	.47**
Judgement	.43**
Shifting	.51**
Updating	.21
Inhibition	.38**

* $p < .05$; ** $p < .01$

Results of the Mann-Whitney U Test (see Table 7) indicate there is a significant difference in the distributions of scores between the MCI and control groups in the Barthel Index, $U = 301,50$, $Z = -3.30$, $p < .001$, $r = .31$, Lawton Instrumental Activities of Daily Living Scale, $U = 273$, $Z = -3.01$, $p = .003$, $r = .28$, ADLI self-report, $U = 231$, $Z = -3.32$, $p < .001$, $r = .24$, and ADLI informant-report total scores $U = 213$, $Z = -2.52$, $p = .012$, $r = .22$.

Table 7

Mann-Whitney U Test: Control versus MCI group

Instruments	<i>U</i>	<i>Z</i>	<i>r</i>
Barthel Index	301.50**	-3.30	.31
Lawton IADL	273*	-3.01	.28
ADLI Self-report	231**	-3.32	.24
ADLI Informant-report	213*	-2.52	.22

* $p < .05$; ** $p < .01$

Note. IADL = Instrumental Activities of Daily Living; ADLI = Activities of Daily Living Inventory.

The independent t-test result show that the means of the ACE-III total scores differed significantly between groups, $t(70) = -8.68$, $p < .001$). The effect size for the difference between groups was calculated using Cohen's d , resulting in a value of 2.45, considered to be a very large effect.

Discussion

Building on the recommendations of the original ADLI paper (Pinto et al., 2024), this study explored the psychometric properties of the ADLI in a sample of Portuguese older adults, including two groups, an MCI group and a healthy control group. This research assesses the ADLI's capability to differentiate between these two groups, focusing on both their performance in ADL and cognitive functioning. In addition, the study explores the convergent validity of the ADLI by comparing its results with those of other established ADL assessment tools, providing an evaluation of its effectiveness and validity.

Regarding convergent validity, both versions of the ADLI showed very strong correlations with the Barthel Index, a standardised scale for assessing BADL performance, and considered to be one of most valid and reliable (Hopman-Rock et al., 2019). The same is true when looking into the correlations with the Lawton Instrumental Activities of Daily Living

Scale. The strong correlation coefficient between the ADLI and these two properly standardised and validated instruments suggests substantial potential for the future application of the ADLI in clinical settings. In this study, the differences between the self-report and informant-report versions of the ADLI were minimal, with subjects rating themselves slightly higher in the BADL and IADI subsections of the ADLI. This result may be explained due to, in cases where subjects show minimal or no objective impairment, it is uncertain whether the subject or the informant offers the more clinically relevant account, with the two producing similar results (Caselli et al., 2014). Given that most of the sample was healthy, with limited variability anticipated in both BADL and IADL performance, these results were expected. It is essential to recognize that both self-reports and informant-based reports are subject to biases. In self-reports, impaired self-awareness may result in inaccurate responses (Graham et al., 2005). In informant reports, various factors, such as feelings of burden, can exaggerate the negative aspects of the patient's condition, while others might inflate the perceived abilities of their relatives (Mlinac & Feng, 2016; Schulz et al., 2013). Therefore, utilising both self and informant-based instruments, such as in the ADLI, is crucial to minimise these biases.

Focusing on predictive validity, the results demonstrate that both versions of the ADLI exhibited strong correlations with ACE-III total scores across all four metrics, namely AADL, IADL, BADL, and total score. This indicates that the ADLI ensures an adequate level of predictive validity.

Examining the association with cognitive functioning, when looking into the specific domains of the ACE-III, only attention and language show consistent correlations with ADLI. Focusing on attention, it can be argued that it may serve as an underlying cognitive skill that supports executive functions. Executive functioning is the domain most consistently linked to IADL functioning (Amanzio et al., 2018; Farias et al., 2003; Lewis & Miller, 2007; Reppermund et al., 2011). Since executive functioning is deemed essential for planning and executing ADL, deficits in attention could directly impact ADL performance. Additionally, one could suggest that the cognitive load involved in managing ADL might place a greater emphasis on attention and language, making these domains more relevant to ADL performance.

Interestingly, the BADL score of the ADLI showed a higher correlation coefficient with the ACE-III fluency subscore. Fluency may often reflect a person's ability to think quickly and organise thoughts. It can be argued that fluency may be an indicator of overall cognitive processing speed, which could translate to quicker and more efficient completion of BADL. Contrariwise, no significant correlations were found between ADLI and ACE-III memory

subscore. Although other cognitive functions, such as executive functioning, have been associated, memory continues to be a vastly reported cognitive domain linked to IADL capability (Farias et al., 2008; Reppermund et al., 2011). While this is true, there are several factors that can obscure the effects of memory impairment on ADL performance. Since most ADL are highly familiar and practised frequently, it can be argued that they may not heavily depend on memory. In line with this argument, our results show that other cognitive functions may play a bigger part than memory by itself in ADL performance. Even in subjects with memory impairments, they can offset the challenges by using various strategies. One example are compensatory strategies, such as using reminders, or assistive devices, which allow them to manage daily tasks despite said impairments (Lin et al., 2020). Additionally, individuals with memory impairments can receive support that enables them to successfully perform ADL through personnel assistance, especially since most are “generally motivated to enhance their compensatory strategy use” (Goldstein et al., 2024)

Most of the domains targeted in the ADLI correlated with ACE-III total scores in both the self and informant-report versions. Looking closely, the highest correlation coefficient in the informant-report version was with ADL that involved physical functioning. Cognitive decline is often linked to reduced motor skills and physical functioning (Gray et al., 2021). In fact, declines in physical functioning can predict cognitive decline, with changes in both measures being linked even in cognitively healthy individuals (Chen et al., 2018; Clouston et al., 2013). As such, it is expected that the two measures exhibit such high correlation coefficients.

In the self-report version, the highest correlation coefficients were with tasks that encompassed sequencing and receptive language abilities. Sequencing is considered part of the executive functioning, being fundamental in “serial order processing, detection of repeated pattern, and feedforward control” (Molinari et al., 2018). As anticipated, sequencing, along with other executive functions, demonstrated high correlation coefficients with the ACE-III, as executive functioning is the domain most consistently linked to IADL functioning (Amanzio et al., 2018; Farias et al., 2003; Lewis & Miller, 2007; Reppermund et al., 2011). In fact, when analysing a model of factors that influence ADL performance in individuals with MCI, the results show that specific cognitive subdomains such as planning, organisation, and problem-solving were incorporated into the model, along with executive function as a whole (Bruderer-Hofstetter et al., 2020). All of the activities that involved these cognitive processes demonstrated some of the higher correlation coefficients with the ACE-III in this study. Other studies corroborate these findings, with a meta-analysis revealing that executive functioning

contributes for the largest portion of variance (37%) in functional outcomes among MCI patients (McAlister et al., 2016). Therefore, it was anticipated that ADL requiring some sort of executive functioning would show strong correlations with the ACE-III, as many tasks in this cognitive evaluation, especially those targeting attention and fluency domains, emphasise executive functioning (Matias-Guiu et al., 2017). As for language, some studies have explored the relationship between language and ADL performance, with results showing that deficits in language can lead to difficulties in both BADL and IADL, such as managing medication and finances (Lee et al., 2019). In fact, deficits in receptive language abilities have been found in individuals with MCI or early dementia, and these deficits are often correlated with overall cognitive decline (Raimo et al., 2024). As such, the connection between language abilities, overall cognitive function, and functional independence is not unexpected.

An analysis of the results between the MCI and healthy samples revealed statistically significant differences across all measures. In all the measures used, the MCI participants consistently had lower scores compared to the healthy control group. All these results were expected, as differences in functionality and cognition between MCI and healthy participants have been widely documented in the literature (De Vriendt et al., 2013; De Vriendt et al., 2021; Henriques et al., 2023; Jefferson et al., 2008). The results regarding the Barthel Index are surprising, since ADL deficits in MCI patients compared to healthy individuals primarily fall within the IADL domain rather than in BADL. A review of 37 studies found that 35 reported some level of impairment, either global or within specific IADL in MCI patients (Jekel et al., 2015). Regarding BADL, no significant deficits are typically reported, and it has even been suggested that their preservation should be a diagnostic criterion for MCI (Winblad et al., 2004).

This study has limitations that should be acknowledged. First, there was a substantial disparity in the number of participants between the two groups. The healthy control group comprised 54 participants, while the MCI group had only 18. This imbalance in group sizes can create challenges for statistical analyses, making it more difficult to detect significant differences or correlations. Additionally, this uneven distribution can lead to skewed results, complicating the interpretability of the findings when comparing both groups. A more balanced sample size would have allowed for stronger evidence regarding the differences in performance between healthy individuals and those with MCI.

Secondly, most of the participants were restricted to a small geographic area. They were mostly from a small city in the countryside of Portugal, which is generally more aged and less developed compared to the coastal regions. This results in the sample's characteristics being

more homogeneous, which may not accurately reflect the diverse features of the population. Specifically regarding education years, the sample was quite homogeneous, as most elderly participants were not able to advance their formal education beyond the first 4 years of schooling.

Another limitation is related to the assessment of BADL and IADL using the Barthel Index and the Lawton Instrumental Activities of Daily Living Scale, respectively. In these cases, only self-reported data was obtained. However, as previously mentioned, obtaining responses solely from the participants presents a potential bias, as self-reports may not always be entirely accurate. To improve the reliability of the data, it would have been valuable to also involve informants in this phase of the assessment process. Furthermore, incorporating informant responses could have strengthened the analysis of correlations between these ADL measures and the ADLI, ensuring more accurate interpretations of the participants functional capacity. Future studies should ensure that all measures assessing ADL are completed by both the participant and a reliable informant.

Regarding the criterion used to differentiate participants between the healthy control group and the MCI group, while the selection was based on a validated instrument, the distinction between the groups felt somewhat limited. The criterion employed may not have been sufficiently comprehensive to capture the subtle differences between healthy ageing and MCI. A more thorough assessment would likely have provided a more clear and reliable distinction between the two groups, but time constraints and the necessity in avoiding overburdening participants led the decision to use only this criterion, instead of a more extensive assessment.

Estimation of test-retest reliability can be crucial for an instrument like the ADLI, particularly when addressing functional change over time. Despite that, revisiting participants for follow-up assessments in a suitable time interval posed a significant challenge that could not be overcome. For criterion validity, the absence of gold standards for ADL assessment or participants' classification in this domain, made the task unfeasible.

Considering the findings and limitations of this study, it is possible to point to potential areas for further exploration in future research. Future research should first focus on expanding the sample size and including participants from a wider range of geographic regions. This would provide a more comprehensive representation of the population, increasing the overall generalizability of the findings. With that objective in mind, it is also crucial to assess the ADLI effectiveness in various settings, including daycare centres and nursing homes. While this study included a small portion of participants from these environments, involving a larger sample of

individuals in these settings would provide valuable insights into the ADLIs applicability and reliability.

It is also of importance to expand the clinical sample to include not only more individuals with MCI, but also with other conditions, namely those with dementia. Expanding the dataset to include a dementia group would provide a more complete understanding of the ADLI and its sensitivity to note changes in ADL across multiple conditions, with varying degrees of severity. This procedure will help determine how effectively the instrument captures variations in ADL performance as cognitive impairment progresses. A more complete assessment of participants it is also of interest to explore how the instrument performs across different subgroups within the MCI and dementia population, since those with amnesic MCI versus non-amnesic MCI or frontotemporal versus Lewy body dementia can face different difficulties in ADL. These analyses will be useful to explore the possibility of establishing cut-off scores for distinguishing between different levels of functional ability, taking into account not only what is considered a normal performance based on demographic variables, such as age or sex, but also differences between specific conditions.

Future research should also prioritise advancing the study of the psychometric properties of the ADLI that could not be thoroughly examined in this study. Of particular importance is the assessment of test-retest reliability, which is essential for evaluating the stability of the measures over time, as well as changes in ADL performance across repeated assessments.

Finally, despite this study analysing the relationship between the ADLI and the ACE-III, it is important to compare the ADLI outcomes with other validated measures of cognitive functioning to shed further light on the relationship between them. Those could be other measures of global cognitive function, such as the Montreal Cognitive Assessment (MoCA), or instruments that target specific cognitive domains, such as executive functioning.

Conclusion

In conclusion, this study provides valuable insights into the psychometric properties of the newly developed ADLI among healthy elderly and MCI participants. The findings show that the ADLI has promising validity, making it a potentially useful tool for assessing ADL in both clinical practice and research. However, more research is needed to analyse the psychometric qualities of this instrument, as well as its applicability across multiple settings

and populations. By advancing our understanding of ADL assessment through the development of a more effective instrument, the ADLI can play a relevant role in the care and management of elderly individuals, ultimately improving their quality of life due to a better detection of difficulties in everyday living.

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