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Research Article

Effects of Age, Sex and Sociodemographic Variables on the Clock Test Cacho Version

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Abstract

The Clock Drawing Test Cacho Version is a widely used tool in neuropsychological assessment for the early detection of cognitive impairment. However, gender, age, and socio-demographic variables may influence its performance. The present study analyses these effects in 498 adults without subjective memory complaints. Statistical analysis was used to determine significant differences in test performance as a function of gender, age, and other socio-demographic variables. The results show a negative correlation between age and performance on the Clock Drawing Test Cacho Version ($r = -0.60$ for the order and $r = -0.57$ for the copy, $p < 0.001$), as well as significant differences according to gender, with men scoring higher on both modalities. A positive influence of educational level and reading habits on test performance was also observed. These findings highlight the importance of considering socio-demographic factors when interpreting the results of the Clock Drawing Test Cacho Version and provide important information for its use in clinical and research purposes.

Keywords: *Clock Drawing Test; Neuropsychological Assessment; Cognitive Impairment; Cognitive Reserve*

Abbreviations

CDT: Clock Drawing Test Cacho Version; CDTcm: Clock Drawing Test Cacho Version on Command; CDTcp: Clock Drawing Test Cacho Version Copied; MCI: Mild Cognitive Impairment; MMSE: Mini-Mental State Examination; MoCA: Montreal Cognitive Assessment; ERFC: Rapid Evaluation of Cognitive Functions; TMT: Trail Making Test; CRC: Cognitive Reserve Questionnaire

Introduction

Population ageing is a highly relevant phenomenon worldwide, with significant implications for public health and clinical practice [1]. With increasing life expectancy, the prevalence of neurodegenerative diseases is expected to rise, making the implementation of effective neuropsychological assessment tools for the early detection of cognitive impairment essential [2].

Among these tools, the Clock Drawing Test Cacho Version (CDT) has been shown to be a simple, rapid and valid test for assessing several cognitive functions, including visuospatial ability, planning, working memory and executive function [3]. Its utility lies in its ability to detect subtle changes in cognitive performance, making it an essential tool in the assessment of older people [4].

The CDT has been widely used in neuropsychological assessment since its initial development [5]. Its usefulness has been validated in several populations, both in healthy individuals and in patients with mild cognitive impairment (MCI) and dementia [6].

In terms of cognitive processing, the correct performance of the Clock Drawing Test Cacho Version copied (CDTcp) requires the involvement of several functions, including visuospatial perception, motor planning, working memory, and the integration of verbal commands [7]. The Clock Drawing Test Cacho Version on Command (CDTcm) assesses planning and executive control to a greater extent, whereas the copy modality focuses on visuoconstructive accuracy [3].

Recent studies have shown that the decline in CDTcp performance is particularly marked in people with neurodegenerative disorders such as Alzheimer's disease, in whom disorganisation of the elements of the clock and difficulties in placing the hands are observed [8]. In addition, scores obtained on the CDTcp have shown significant correlations with other cognitive assessment tests, such as the Mini-Mental State Examination (MMSE) and the Montreal Cognitive Assessment (MoCA), confirming its validity as a diagnostic tool [9].

Despite its extensive applicability, performance on the CDTcp is not homogeneous across individuals, as factors such as age, gender, and sociodemographic variables can significantly influence the results obtained [10]. Previous studies have shown that performance in cognitive domains declines with age, particularly in those requiring visuospatial integration and motor planning [11]. Furthermore, gender differences have been found in the performance of visuospatial tasks, with an advantage generally observed in males, whereas females tend to excel in verbal memory and verbal fluency tests [12].

Another key factor in the variability of CDTcp performance is cognitive reserve, a concept that refers to the brain's ability to resist neurodegenerative damage through the efficient use of alternative neural networks [12]. This reserve is influenced by socio-demographic variables such as educational level, occupational status, and participation in cognitively stimulating activities such as reading and lifelong learning [13]. The literature has shown that individuals with higher educational attainment and frequent reading habits perform better on neuropsychological tests, including the CDTcp, suggesting a protective effect against age-related cognitive decline [14].

Against this background, the present study aims to specifically analyse the effects of gender, age and socio-demographic buffer variables on performance on the CDT in a sample of adults without subjective memory complaints. It is hoped that the results will provide a deeper understanding of how these factors modulate performance on this test, allowing more accurate scales to be established for its use in clinical practice.

Materials and Methods

Participants

The sample consisted of 498 participants aged 55 to 97 years (M = 74.47, SD = 11.69). Individuals without a diagnosis of cognitive impairment or subjective memory complaints were included. The selection was made by purposive sampling with the help of volunteers and students from the Universidad de la Experiencia, part of the Universidad Pontificia de Salamanca.

Inclusion criteria:

- Be 55 years or older at the time of assessment.
- No evidence of cognitive impairment on the Montreal Cognitive Assessment (MoCA ≥ 24), in addition to no report of subjective memory complaints.
- To be able to carry out neuropsychological tests autonomously and without the help of others.
- Have basic literacy skills (have completed at least primary education).
- Have Spanish as native language and demonstrate sufficient oral and written comprehension to follow instructions.

- Not be under psychopharmacological treatment with drugs that may influence cognitive function (e.g. benzodiazepines, antipsychotics, antidepressants).
- No history of neurological diseases (e.g. Parkinson's disease, multiple sclerosis, history of stroke) or severe psychiatric disorders (schizophrenia, decompensated bipolar disorder).

Exclusion criteria:

- Behavioural alterations that may interfere with the assessment, as indicated by clinical history, medical history, or initial interview.
- Sensory deficits that are not resolved at the time of assessment, including severe hearing or vision problems.
- Scores on the ERFC in the borderline range or below, as determined by a cut-off point of < 46.
- Incomplete responses on more than 20% of the questionnaires administered.

Materials and instruments

Participants were assessed using the following instruments, which were selected for their validity and reliability in measuring cognitive function:

- The clock drawing test Cacho version (CDT): This test assesses visuospatial ability, executive function and motor planning using two modalities: on command (CDTcm) and copy (CDTcp). Its score makes it possible to identify patterns of cognitive impairment associated with different neurological disorders. Previous studies have shown that the CDTcp has good sensitivity and specificity in detecting mild cognitive impairment [3]. The version used in this study has shown inter-rater reliability greater than 0.85 and significant convergent validity ($p < 0.001$) with other cognitive assessment tests [9].
- Rapid evaluation of cognitive functions (ERFC): This test measures specific cognitive functions including working memory, attention and verbal fluency. Its psychometric properties have shown high internal consistency ($\alpha = 0.87$) [15].
- Trail making test (TMT): The test assesses processing speed, cognitive flexibility and divided attention. The test has two parts: TMT-A, which measures psychomotor speed, and TMT-B, which assesses task-switching ability. Its test-retest reliability has been reported to be greater than 0.70 and has been shown to be discriminative in the diagnosis of cognitive impairment [16].
- Cognitive reserve questionnaire (CRC): Administered to measure involvement in cognitively stimulating activities across the lifespan, such as educational level, time spent reading and involvement in cultural activities. The CRC has been shown to have adequate construct validity and significant correlation with tests of general cognitive function [17].
- Sociodemographic questionnaire: A questionnaire was used to collect information on variables such as age, gender, educational level, reading habits and physical activity. The inclusion of these variables allowed us to assess their possible buffering effect on CDTcp performance. Previous studies have shown that these factors can influence cognitive reserve and consequently neuropsychological performance [12].

These tests can be seen in the following table and in the annex (Table 1).

Procedure

Participants were evaluated individually in sessions of approximately 45 minutes. The CDTcp was applied under standardized conditions, ensuring the validity of the procedure. Data were anonymized and informed consent was obtained.

Instrument	Time application in minutes
Informed consent	5
Sociodemographic Questionnaire (original elaboration)	5
Clock Drawing Test Cacho Version	5
Rapid Evaluation of Cognitive Functions	15
Trail Making Test	15
Cognitive Reserve Questionnaire	5

Table 1: *Test application sequence.*

The study was approved by the Research Ethics Committee of the Universidad Pontificia de Salamanca for the favorable report on the performance of this work

Results

For data analysis, Kolmogorov-Smirnov and Shapiro-Wilk normality tests were used to determine the normality of the data; as the data did not follow a normal distribution, non-parametric tests were used, including the Kruskal-Wallis test to compare age groups and the Mann-Whitney U test to assess gender differences.

Spearman correlations were also calculated to analyse the relationship between age, level of education and performance on the CDT. Additional analyses were included to assess the influence of variables such as reading habits and physical activity. All analyses were performed using SPSS statistical software [18].

Means and standard deviations were calculated for the variables as shown in table 2.

Variable	Value
Complete Sample	(n = 498)
Age (mean and standard deviation)	74,47 (11,69)
Sex (n. %)	
Male	232 (46,6)
Female	266 (53,4)
Educational level (n. %)	
No schooling	44 (8,8)
Elementary Level	128 (25,7)
Secondary level	171 (34,3)
University level	155 (31,1)
Physical exercise hours (n. %)	
None	21 (4,2)
1-3	126 (25,3)
4-7	284 (57,0)
+8	67 (13,5)

Weekly reading hours (n.%)	
None	24 (4,8)
1-3	207 (41,6)
4-7	215 (43,2)
+8	52 (10,4)
Medication (n. %)	
Currently taking medication	404 (81,1)
Currently not taking medication	94 (18,9)

Table 2: *Description of sociodemographic variables.*

First, Kolmogorov-Smirnov and Shapiro-Wilk normality tests were performed, the results of which indicate that the scores on the Clock Drawing Test Cacho Version copied (CDTcp) and Clock Drawing Test Cacho Version on Command (CDTcm) do not follow a normal distribution ($p < 0.05$). Because of this, the use of non-parametric tests was chosen for the subsequent analyses. Table 3 presents the results of the normality tests.

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic Value	**gl**	**Sig.**	**Statistic Value**	**gl**	**Sig.**
CDTcm Score	0,25	498	0,001	0,88	498	0,001
CDTcp Score	0,255	498	0,001	0,813	498	0,001

Table 3: *Kolmogorov-Smirnov and Shapiro-Wilk normality tests.*

[a]: Lilliefors significance correction.

In addition, Q-Q plots were constructed to visualise the distribution of scores, confirming the absence of normality in the data analysed (Figure 1 and 2).

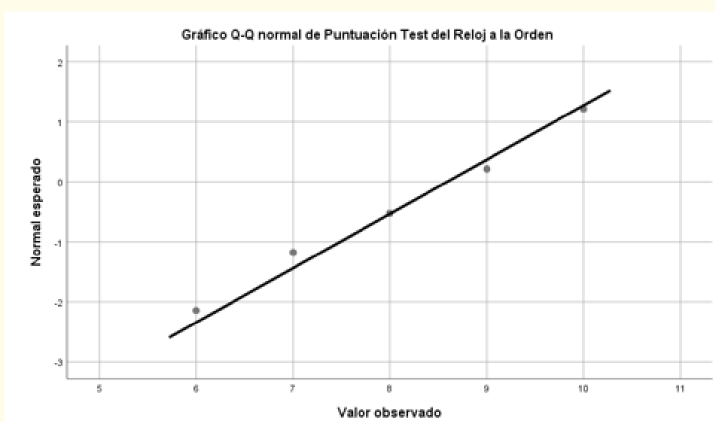

Figure 1: *Q-Q chart of the CDTcm score.*

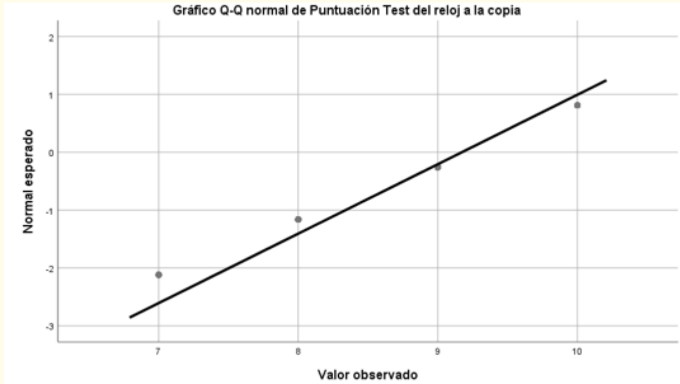

Figure 2: *Q-Q chart of the CDTcp score.*

A Kruskal-Wallis test was performed to assess the relationship between age and CDTcm and CDTcp scores. The results show significant differences between age groups ($p < 0.001$), indicating that the younger the age, the better the performance in both test modalities. Spearman's correlation confirms a significant negative relationship between age and CDTcm ($r = -0.603$, $p < 0.001$) and CDTcp ($r = -0.571$, $p < 0.001$).

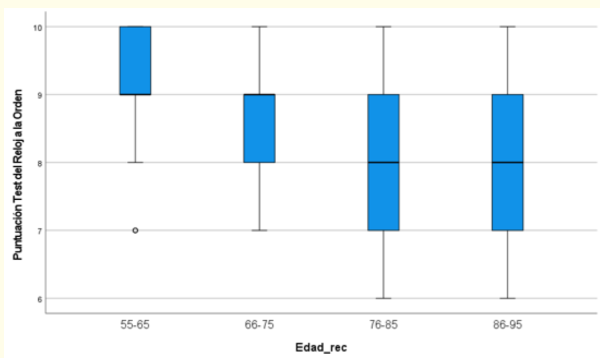

Figure 3: *Box-plot of CDTcm score with respect to age.*

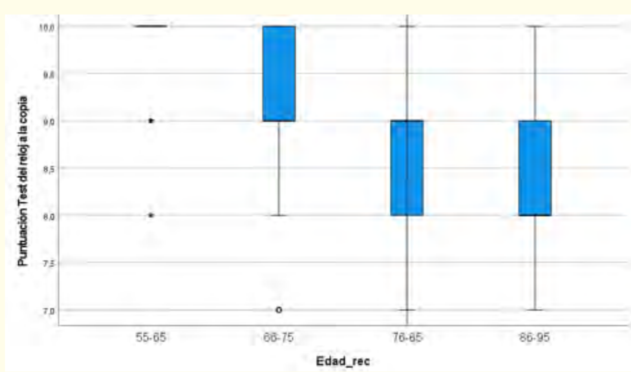

Figure 4: *Box-plot of CDTcp score with respect to age.*

The Mann-Whitney U test revealed significant differences in performance on the Clox Drawing Test-Command (CDTcm) and Copy (CDTcp) conditions according to sex ($p < .001$). Figure 5 and 6 show the distribution of scores by sex.

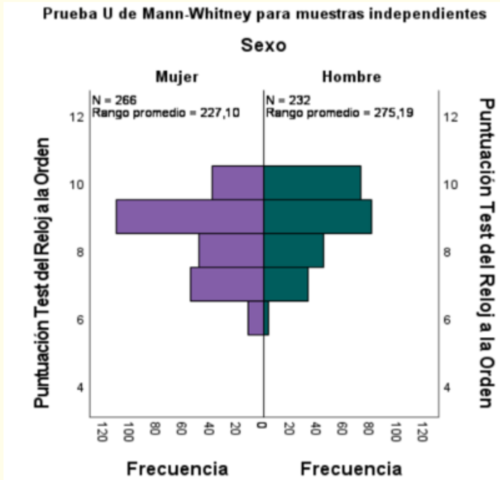

Figure 5: *Mann-Whitney U test for sex differences in the CDTcm condition.*

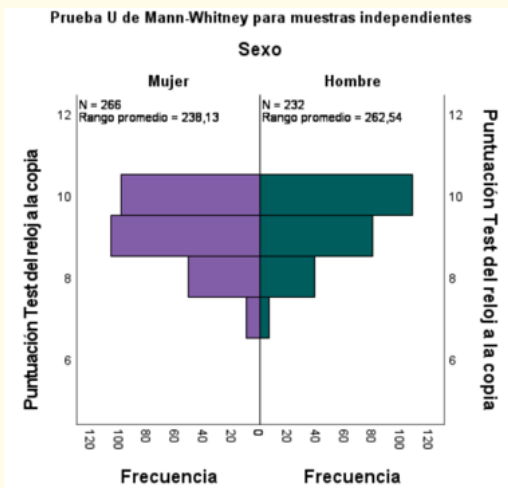

Figure 6: *Mann-Whitney U test for sex differences in the CDTcp condition.*

The Kruskal-Wallis analysis for the variable "hours of reading" indicated a significant difference for the CDTcm ($p = .023$), but not for the CDTcp ($p = .145$). However, Spearman's correlation coefficients did not reveal significant associations between hours of reading and test performance ($r = .043$, $p = .344$ for CDTcm; $r = .026$, $p = .563$ for CDTcp).

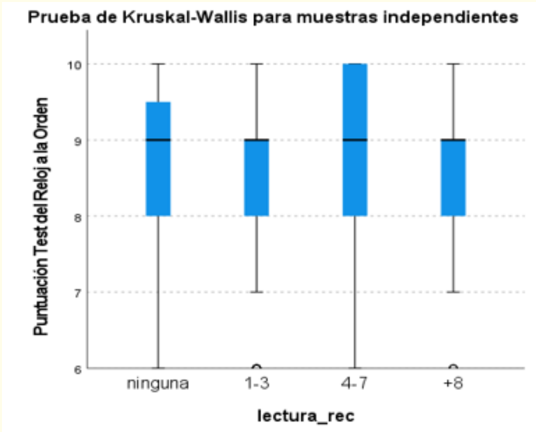

Figure 7: *Kruskall-Wallis test for reading hours and the CDTcm.*

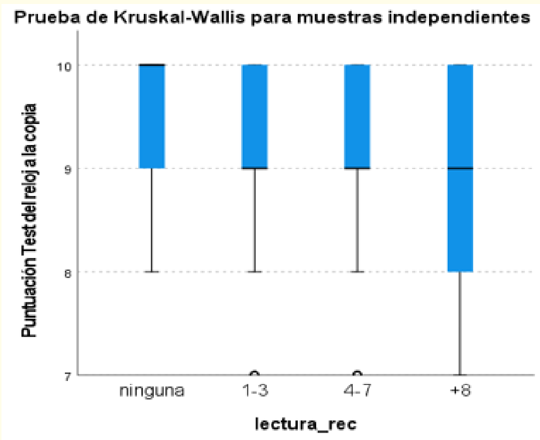

Figure 8: *Kruskall-Wallis test for reading hours and the CDTcp.*

Correlation analysis showed no significant associations between amount of exercise and CDTcm (r = -0.024, p = 0.594), but a slight association was found for CDTcp (r = -0.065, p = 0.146), suggesting a minimal effect.

The Kruskal-Wallis analysis for the variable 'reading hours' showed a significant difference for the CDTcm (p = 0.023) but not for the CDTcp (p = 0.145). However, Spearman correlation coefficients showed no significant associations between reading hours and test performance (r = 0.043, p = 0.344 for CDTcm; r = 0.026, p = 0.563 for CDTcm).

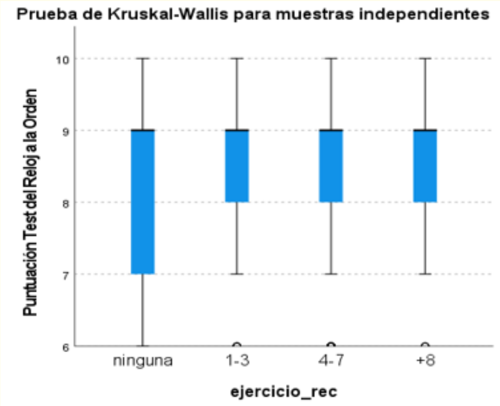

Figure 9: *Kruskall-Wallis test for hours of exercise and CDTcm.*

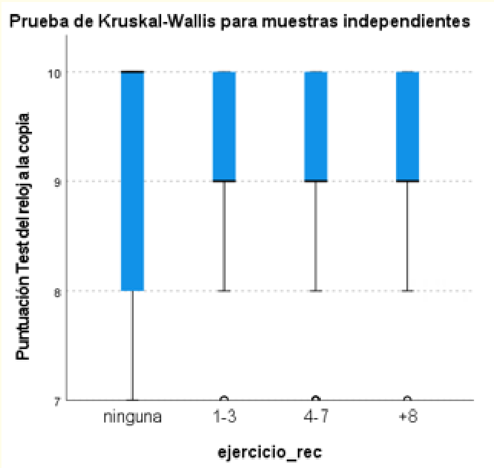

Figure 10: *Kruskall-Wallis test for hours of exercise and CDTcp.*

Using the Kruskal-Wallis test, a significant relationship was found between level of education and performance on both versions of the CDT ($p < 0.001$ for CDTcm and CDTcp). This indicates that a higher level of education is associated with better test performance (Figure 11).

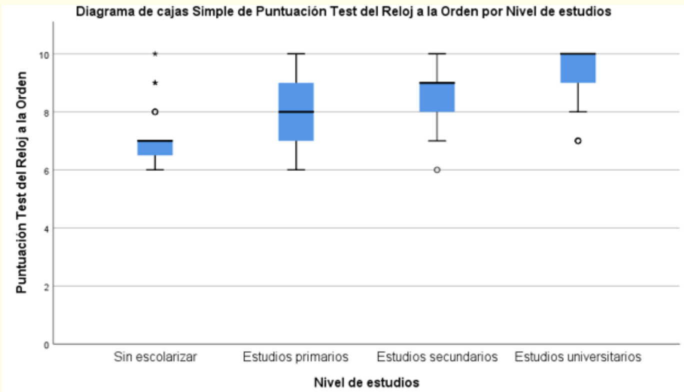

Figure 11: *Association between level of education and CDTcm implementation.*

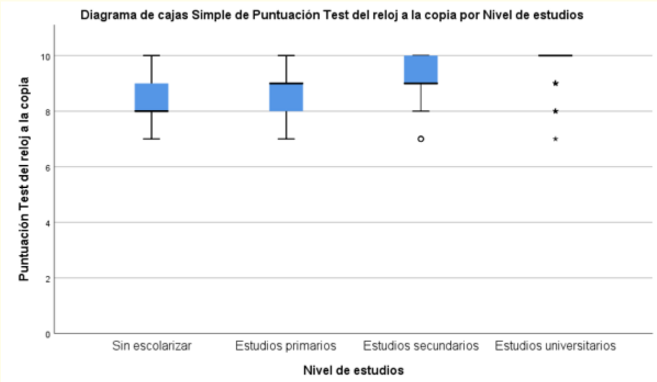

Figure 12: *Relation between level of education and CDTcp performance.*

Using the Kruskal-Wallis test, a significant relationship was found between level of education and performance on both versions of the CDT ($p < 0.001$ for CDTcm and CDTcp). This indicates that a higher level of education is associated with better test performance (Figure 11).

Discussion

The results obtained confirm the influence of age, sex and level of education on performance on the Cacho Version Clock Test. However, factors such as reading habits and physical activity did not show a significant relationship. These findings highlight the importance of taking socio-demographic variables into account when interpreting the results of the CDTcp and provide valuable information for its use in clinical and research settings.

One of the most striking findings of this study was the identification of a significant negative correlation between age and performance on the CDT, both on command (CDTcm) and copied (CDTcp). In the CDTcm, a correlation coefficient (r) of -0.603 was obtained with a p-value of 0.01, indicating a strong inverse relationship. Similarly, in the CDTcp, a correlation coefficient (r) of -0.571 was found, also with a p-value of 0.02. These results suggest that as participants get older, their scores on both tests tend to decrease. This finding is consistent with previous studies showing a decline in cognitive test performance with increasing age [19, 20]. Furthermore, [4] highlighted the usefulness of the Clock Drawing Test in differentiating between normal and pathological ageing, underlining its importance in clinical assessment. However, [21] found no significant differences between age and performance on the Clock Test.

Studies have shown [22,23] that neurobiological changes occur with aging that affect executive and visuoconstructive functions that are essential for the correct performance of CDT. These changes may include a decrease in processing speed and working memory, resulting in less efficient performance of tasks that require spatial planning and organisation.

There are mixed results in the literature regarding gender differences in CDT performance. Some studies have found no significant differences between males and females in visuospatial and executive function tasks [24]. This pattern was also observed in the study [25] where males had a higher proportion of negative test results (31.1%). However, others have suggested that cultural and educational factors may influence these abilities, which could be reflected in performance on the CDT, with [26] finding no significant differences between groups scoring above and below the 6-point threshold on the CDT, with an equal distribution between males and females.

No significant differences were found in the relationship between hours of reading and performance on the CDT (r = .043, p = .344 for CDTcm; r = .026, p = .563 for CDTcp). The correlation coefficients were r = 0.043 (p = 0.026) for the CDTcm and r = 0.026 (p = 0.563) for the CDTcp, suggesting that the amount of time spent reading does not have a significant effect on performance on this test. These results are in contrast to previous studies, which suggest that reading habits contribute to the maintenance of cognitive function [21,27]. Furthermore, [28] highlighted that reading is associated with the development of executive functions, memory and reasoning, which are essential skills for the performance of CDT. On the other hand, [27] observed that participants with a low reading level obtained better means and standard deviations in the CDTcm (9.227 ± 1.31) than those with a high reading level (9.161 ± 1.26).

Regarding the relationship between physical exercise and CDT performance, no significant correlation was found with CDTcm ($r = -0.024$, $p = 0.594$). However, a slight association was observed with the CDTcp ($r = -0.065$, $p = 0.146$), suggesting a possible effect of exercise on visuospatial abilities. Regular physical activity has been associated with improvements in various cognitive functions, including memory and attention [29]. However, evidence on its direct effects on CDT performance is limited. Factors such as intensity, frequency and type of exercise could influence the magnitude of the effect on cognitive functions assessed by the CDT. Our findings contrast with previous studies, such as that of [30], in which a physical activity-based rehabilitation programme significantly improved CDT scores. Similarly, [31] reported that the combination of physical activity and cognitive training had a positive effect on CDT performance.

Analysis using the Kruskal-Wallis test showed that educational level significantly influenced performance on the clock test, with correlation coefficients of $r = 0.01$ on both the CDTcm and CDTcp. Educational level was shown to have a positive relationship with performance on the clock test. Individuals with higher levels of education tend to score higher on this test [32]. These findings are consistent with those of [25], who found that participants with lower levels of education (basic) scored lower on the TR (61.9%), while those with higher levels of education performed better. However, in [20]study, the level of schooling was not a significant predictor of performance on the CDT. This phenomenon can be explained by cognitive reserve theory, which postulates that more education strengthens neural networks and increases the efficiency of information processing, providing protection against cognitive decline.

Conclusion

The conclusions we can draw from the results obtained in terms of the objectives set out confirm, firstly, the relationship between age and performance in the CDT.

It has been shown that, the younger the age, the greater the ability to execute the test in both modalities, both in the version on command (CDTcm) and in the copy version (CDTcp). This finding reinforces the idea that ageing has a significant impact on the visuospatial and executive skills necessary for the correct performance of the CDT.

Secondly, the results showed significant differences between males and females in the performance of the CDT, with males performing better than females. This result suggests the possible influence of socio-cultural and educational factors on the development of specific cognitive skills, particularly those related to planning and visuospatial perception.

It is also concluded that reading habits do not have a significant effect on the performance of the CDT. Despite previous evidence of the benefits of reading in maintaining cognitive function, this study has not found a conclusive relationship to support its direct influence on CDT performance.

In the same way, the practice of physical exercise did not show any significant relationship with the performance on the CDT. Despite the fact that physical activity has been widely studied for its effect on general cognitive health, the results obtained do not show a direct effect on the abilities assessed by the CDT.

Finally, educational level has been confirmed as a relevant factor in CDT performance. It was observed that individuals with higher levels of education performed better on the test, supporting the theory of cognitive reserve and its protective role against age-related decline.

This study has certain limitations. Its cross-sectional design makes it impossible to establish causal relationships, so future research should consider a longitudinal approach to assess the development of Clock Test (CT) performance over time.

Another limitation is the composition of the sample, which includes people with no history of cognitive impairment. Although this is useful for standardising the CDT, it may not accurately reflect the diversity of patients in clinical settings, affecting the applicability of normative values [33].

Furthermore, the use of screening tests may limit diagnostic accuracy, as variations in their psychometric properties require representative validations [34]. In this sense, it is recommended to unify application and scoring criteria.

The study also failed to control for some variables that could affect cognitive performance, such as drug consumption, stress or sleep quality, which have been shown to affect cognitive function [35-37]. Therefore, future research should include a more detailed control of these variables.

In addition, it would be relevant to analyse the effect of emotional state on TR, as anxiety and depression may affect cognitive performance [38].

Finally, with technological advances and the decreasing use of analogue watches, it is possible that in the future the CDT will need to be adapted to ensure its validity in new generations [39].

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This research received no external funding.

Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki, and approved by the Research Ethics Committee of the Universidad Pontificia de Salamanca for the favorable report on the performance of this work (registered: 24/11/2022)

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

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Conflicts of Interest

The authors declare no conflicts of interest.

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