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Review

Cognitive stimulation and psychosocial results in older adults: A systematic review and meta-analysis

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HIGHLIGHTS

- Personalized/adapted cognitive stimulation improves quality of life in older adults.
- Future studies are needed to study long-term effects of CS especially in healthy cognitive ageing.
- It is advisable to study the use of only CS or CS and pharmacological treatment.

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ABSTRACT

Introduction: Cognitive stimulation (CS) is a popular and cost-effective intervention, which applies different types of techniques focused on cognitive skills and can be administered by different professionals. CS can be defined as activities that involve cognitive processing usually conducted in a social context and often in a group. Therefore, CS can improve psychosocial functioning and quality of life (QoL), depression, anxiety and activities of daily living (ADLs) independent of the pharmacological treatment such as acetylcholinesterase inhibitors. The objective of this systematic review and meta-analysis was to evaluate the effects of CS on psychosocial outcomes in older adults (aged 65 years or over), with healthy cognitive ageing, mild cognitive impairment (MCI), and dementia.

Methods: PubMed, Scopus and Web of Science databases were examined from inception to October 2021. A total of 1,997 studies were initially identified in these databases. After discarding studies that did not meet the inclusion criteria, 30 studies were finally included in the systematic review and the meta-analysis performed with robust variance estimator (RVE) due the inclusion of studies with repeated measurements. The quality assessment tools from the National Institutes of Health were used to evaluate the quality of the studies.

Results: CS was significantly associated with a higher QoL in participants who received personalized/adapted CS (RVE = 0.11±0.19 [-0.76, 0.99], t(1.86) = 0.6, $p = 0.61$). .

Conclusion: Personalized/adapted CS seems to improve QoL in older adults.

Abbreviations

ACE-III The Addenbrooke's Cognitive Examination
AChEIs acetylcholinesterase inhibitors
AD Alzheimer..s disease
ADAS-Cog Alzheimer disease assessment scale-cognitive

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ADLs	activities of daily living
CS	Cognitive stimulation
GDS	Global deterioration scale
MCI	Mild cognitive impairment
MEC-35	Spanish version of Mini-Mental State Examination
MMSE	Mini-Mental State Examination
MoCA	Montreal Cognitive Assessment score
PDD	Parkinson's disease dementia
QoL	Quality of life
TAU	Treatment as usual

1. Introduction

Although the overall rate of global population growth is slowing, the rate of population ageing is increasing (Pol, 2017). Older adults exhibit a spectrum of cognitive abilities, ranging from normal or healthy cognitive ageing to mild cognitive impairment (MCI) to dementia (Bennett et al., 2002). Among the factors that differentiate normal cognition or healthy cognitive ageing and MCI, from dementia is the maintenance of basic and instrumental activities of daily living (ADLs) (Lee et al., 2019). While the quality of life (QoL) does not necessarily decline as dementia progresses, it is highly influenced by the mood of the person with dementia. In addition, improvements in cognition and mood can lead to an increased QoL (Smit et al., 2006).

Several studies have showed that the severity of both anxiety and depression worsen neurological and cognitive symptoms, which has a critical impact on ADLs (Stogmann et al., 2015). Furthermore, symptoms of depression in MCI may be predictive of higher rates of progression to dementia due to Alzheimer's Disease (AD) (Cooper et al., 2015).

One of the evidence-based psychosocial intervention therapies used internationally for people with mild-to-moderate dementia is Cognitive Stimulation (CS) (Lobbia et al., 2019). CS can be defined as activities that involve cognitive processing usually conducted in a social context and often in group (Clare & Woods, 2004) with a frequency of around 45 min, twice a week (Woods et al., 2023).

CS is a popular and cost-effective intervention (Dickinson et al., 2017), which applies different types of techniques focused on cognitive skills and can be administered by different professionals, including nurses, occupational therapists, psychologists, social workers (Lobbia et al., 2019) or caregivers (Singh & Gaikwad, 2021). In addition, the involvement of a caregiver in the management of the CS may encourage intergenerational activities (Kor et al., 2022).

CS includes a wide range of activities aimed at stimulating thinking and memory, including discussion of past and present events and topics of interest, word games, puzzles, music and creative hands-on activities (Woods et al., 2023). CS may offer beneficial effects on cognitive reserve and dementia risk (Collins et al., 2021), so it is essential to start it as soon as possible (Woods et al., 2012). Cognitive reserve offers an explanation for the unequal predisposition to different age-related brain changes among older adults, while some subjects are resistant to these changes while preserving their neuropsychological construct (Stern, 2012).CS can improve psychosocial functioning and QoL (Djabelkhir et al., 2017). These positive effects are independent of the pharmacological treatment frequently used in AD, such as acetylcholinesterase inhibitors (AChEIs) (Aguirre et al., 2013)

Different reviews and meta-analyses have evaluated the impact of CS on psychosocial variables such as QoL (Aguirre et al., 2013; Cafferata et al., 2021; Chen, 2022; Kim et al., 2017; Sun et al., 2022; Wong et al., 2021; Woods et al., 2012), ADLs (Aguirre et al., 2013; Cafferata et al., 2021; Chen, 2022; Kim et al., 2017; Woods et al., 2012), depression (Aguirre et al., 2013; Cafferata et al., 2021; Chen, 2022; Kim et al., 2017; Saragih et al., 2022; Wong et al., 2021; Woods et al., 2012), anxiety (Aguirre et al., 2013; Cafferata et al., 2021; Chen, 2022; Gibbor et al., 2020; Woods et al., 2012), well-being (Aguirre et al., 2013; Woods et al., 2012) and loneliness (Lobbia et al., 2019). However, these studies only included persons with dementia. In addition, a recent meta-analysis conducted in people with dementia a small but clinically relevant benefit on quality of life and mood was found (Woods et al., 2023).

On this basis, this systematic review and meta-analysis evaluate the impact of CS (independently or together with pharmacological treatment, particularly AChEIs) on psychosocial outcomes (such as QoL, ADLs, mood (depression and anxiety), self-esteem, and loneliness) in older adults with healthy cognitive ageing, MCI, and dementia.

2. Methods

This systematic review adheres to the PRISMA-S (Preferred Reporting Items for Systematic reviews and Meta-Analyses) (Rethlefsen et al., 2021) (see supplementary file 1, Table 1) and was registered in the PROSPERO database (ID number: CRD42021238120).

2.1. Search strategy

Three electronic databases; ie., PubMed, Web of Science and Scopus were used in this study. The specific search parameters used in all online databases are shown in supplementary file 2, Table 2. The search terms were adjusted to each respective database. The search was conducted from inception to October 2021. When possible, the search included a vocabulary thesaurus (list of MeSH terms in PubMed). First, the CS related terms were combined. Secondly, the mental and cognitive outcome related terms were combined as follows: "healthy cognitive ageing" OR "cognitive impairment" OR "Alzheimer" OR "dementia" OR "Parkinson" OR "Lewy Body Disease" OR "Pick Disease" OR "Huntington's Disease". Finally, both the CS and the mental and cognitive outcome terms were combined with "AND.".

2.2. Eligibility criteria

A specific question was constructed according to the PICOS (Participants, Interventions, Control, Outcomes, Study Design) principle (Table 1).

The following inclusion criteria were applied: (1) original studies (randomized controlled trials (RCTs), clinical trials, observational studies, and pre-post studies); (2) studies performed in humans; (3) studies written in English or Spanish; (4) participants over 65 years of mean age and (5) studies with (5.1) healthy cognitive ageing participants with normal levels of cognitive functioning, (that is, i.e., Mini-Mental State Examination score $>$ 24, Spanish version of Mini-Mental State Examination score $>$ 27 or Montreal Cognitive Assessment score (MoCA) $\geq$ 26) or (5.2) participants diagnosed of MCI, that is i.e., Mini-Mental State Examination score $\geq$ 24, Spanish version of Mini-Mental State Examination score 24–27; Clinical Dementia Rating score 0.5, and National Institute of Neurological and Communicative Criteria for Disorders and Stroke-Alzheimer's disease and Related Disorders Association (NINCDS-ADRDA) (McKhann et al., 1984), Petersen (Petersen, 2004; Petersen et al., 1999), Gauthier et al., 2006; Winblad et al., 2004,

Table 1
PICOS criteria for inclusion and exclusion of studies.

Parameter	
Participants	Older adults over 65 years with healthy cognitive ageing, mild cognitive impairment, and dementia.
Interventions	Cognitive stimulation according to the classification of Clare & Woods, 2003.
Control/comparator group	Passive (no intervention, treatment as usual) or active controls (same or different intervention than intervention group).
Outcomes	Evaluate psychosocial variables, at least one of them (activities of daily living, mood-depression, mood-anxiety, quality of life, self-esteem, loneliness).
Study design	Randomized controlled trials, clinical trials, observational and pre-post studies

Spector (Spector et al., 2003; Spector et al. 2006) Diagnostic and Statistical Manual of Mental Disorders 5 (DSM5) (American Psychiatric Association, 2013), or (5.3) criteria for dementia, that is probable AD, patients diagnosed of AD, vascular dementia, Parkinsonś Disease dementia and other types of dementia (e.g., assessed with by a neurologist or psychiatrist or neuropsychological tests, Statistical Manual of Mental Disorders DSM, the National Institute of Neurological Disorders and Stroke, Association International Neurosciences and the Association Internationale pour la Recherche et l'Enseignement en Neurosciences (NINDS-AIREN) (Román et al., 1993), or a MoCA score 12–25 and Mini-Mental State Examination score 10–25). Parkinson's disease dementia (PDD) or PDD-MCI according to Emre et al. (2007); Litvan et al. (2012) and dementia with Lewy bodies according to McKeith et al. (2017). Furthermore, cognitive decline ranging from MCI to dementia according to scores of the GDS between 3 and 5.

The following exclusion criteria were applied: (1) articles that did not provide original data (e.g., systematic reviews, meta-analyses, literature reviews); (2) participants diagnosed with other cognitive impairments different to MCI and dementia; (3) studies that included other types of cognitive intervention different than CS; (4) articles that did not provide a control group.

2.3. Study selection and data extraction

Two authors (IG-S, EC) independently searched each database to obtain publications. Agreement between the authors was found for 90% of the publications, while the remaining discrepancies were resolved by discussion. Relevant articles were obtained in full and assessed against the inclusion and exclusion criteria. Disagreements between the reviewers were resolved by consensus, when consensus could not be reached, arbitration by a third reviewer was applied (AA).

2.4. Publication bias and risk of bias

Publication bias was examined by performing Egger's Regression Test for Funnel Plot Asymmetry (Egger et al., 1997). Further confirmation was obtained through visual inspection of funnel plot symmetry, plotting the effect size in relation to the standard error. Funnel plots were created using JAMOVI (Jamovi, 2021) to investigate publication bias. Publication bias was assessed by the Egger linear regression test, following the guidelines provided by Peters et al. (2006). Thus, funnel plots were created and tests were carried out when the meta-analysis had more than 10 studies, as a small number of studies lowers the test power to a point where it is too low to distinguish chance from actual asymmetry (Sterne et al., 2011).

Additionally, the revised Cochrane risk of bias tool for randomized trials (RoB 2) (Higgins & Thompson, 2002) and non-randomized (ROBINS-I) (Sterne et al., 2011) were used to assess the risk of bias of the studies included in the present systematic review and meta-analyses. For each study, two co-authors (IGS-EC) independently assessed the risk of bias. The ratings assigned with respect to each study's risk of bias are summarized in the risk of bias tables, Supplementary file 6, Table 6a and Supplementary file 7, Table 6b.

2.5. Statistical analyses to conduct the meta-analyses

All the studies included in the present meta-analysis and systematic review met the established inclusion criteria. However, when extracting the data, some information was missing. Although corresponding authors were contacted to collect the missing information to conduct the meta-analyses (Leroi et al., 2019; Lok et al., 2019; Marinho et al., 2021; Middelstadt et al., 2016; Oliveira et al., 2021); only two authors responded and gave us the required missing data (Leroi et al., 2019; Lok et al., 2019). Moreover, due to the small number of the studies with participants either with a healthy cognitive ageing or MCI, those investigations including healthy cognitive ageing or MCI were merged when conducting the analyses.

The following subgroups were analysed: 1) cognitive status ("healthy cognitive ageing-MCI"; or "dementia"); 2) age ("≤75 years/ ">75 years"); 3) type of CS ("computerized CS"; or "traditional CS"); 4) "personalized-adapted CS" or "non-personalized/non-adapted CS"; 5) duration total of intervention ("short-term" (duration of the CS is less than 3 months); "maintenance or medium-term" (duration of the CS is between 3 and 6 months); or "long-term" (duration of the CS is more than 12 months) (Aguirre et al., 2010); 6) duration of session (30 min/session; ⟨ 45 min/session; or ⟩ 45 min/session); 7) "Low risk", "Some concerns" and "High risk" to assess the risk of bias in randomized trials (Higgins & Thompson, 2002) 8) "alone CS" or "CS + AChEIs"; 9) origin of the studies ("America", "Asia", or "Europe") and 10) "basic ADLs" or "instrumental ADLs"; as long as the information was available. The gender of the participants could not be analysed.

A meta-analysis was performed analysing the level of significance between treatment and control groups using the standardized mean difference (SMD). The random effects model was applied given the heterogeneity between studies. Heterogeneity was analysed by estimating the between-study variance τ (calculated with the DerSimonian-Laird estimator with Hartung-Knapp correction), with Cochran's Q test as well as with the I^2 estimator, the latter being defined as unimportant (<30%), moderate (30%−50%), large (50%−75%) and important (>75%) heterogeneity. Subgroup analyses were performed to explore the heterogeneity detected in each of the five psychosocial variables assessed. R Ver. 4.1.3 (R Foundation for Statistical Computing, Institute for Statistics and Mathematics, Welthandelsplatz 1, 1020 Vienna, Austria) was used for statistical analysis.

Due to the inclusion of studies in which data were assessed at various different time points throughout follow-up, standard errors were adjusted using the robust variance estimator (RVE) proposed by Tipton and Pustejovsky (2015) and applying the Satterthwaite adjustment to the degrees of freedom. The effect size calculated was defined as small (<0.2), moderate (0.2–0.8) and large (>0.8).

When these studies reported median and interquartile range, rather than mean and standard deviation, these were calculated using the appropriate formulas (Luo et al., 2018; Shi et al., 2020).

We combined RCTs with two parallel groups with two-group quaxi-experimental studies without randomization on the variables depression, QoL and ADLs, following the procedure described by Efthimiou et al. (2017), performing a sensitivity analysis on the meta-analysis with all studies (naive pooling), assigning non-RCTs a variance weight of 0. 2, 0.5 and 0.8 and only with RCTs, taking as a selection criterion the model with the closest results to the meta-analysis only with RCTs.

3. Results

3.1. Study selection

The initial search provided a total of 2108 records. The process used to detect duplicates was carried out through Microsoft Excel and the process was repeated twice, with a final manual revision. After removing duplicates and including studies identified through reference scanning, 1997 potentially relevant studies were found, which were further filtered based on their title and abstract, remaining 64. After reading the full texts, 30 articles were finally included in the systematic review and the meta-analysis. The PRISMA diagram for the study selection is detailed in Fig. 1 and studies excluded by text complete (see Supplementary file 3, Table 3).

17 studies evaluated ADLs (Alves et al., 2014; Calatayud et al., 2018; Capotosto et al., 2017; Carbone et al., 2021; Fernández Calvo et al., 2010; Folkerts et al., 2018; Gómez-Soria et al., 2021, 2021; Gomez-Soria et al., 2020; Juárez-Cedillo et al., 2020; Justo-Henriques et al., 2019, 2021; Miranda-Castillo et al., 2013; Oliveira et al., 2021; Orgeta et al., 2015; Orrell et al., 2014; Piras et al., 2017), 17 studies evaluated QoL (Alvares-Pereira et al., 2020; Alves et al., 2014; Capotosto et al., 2017;

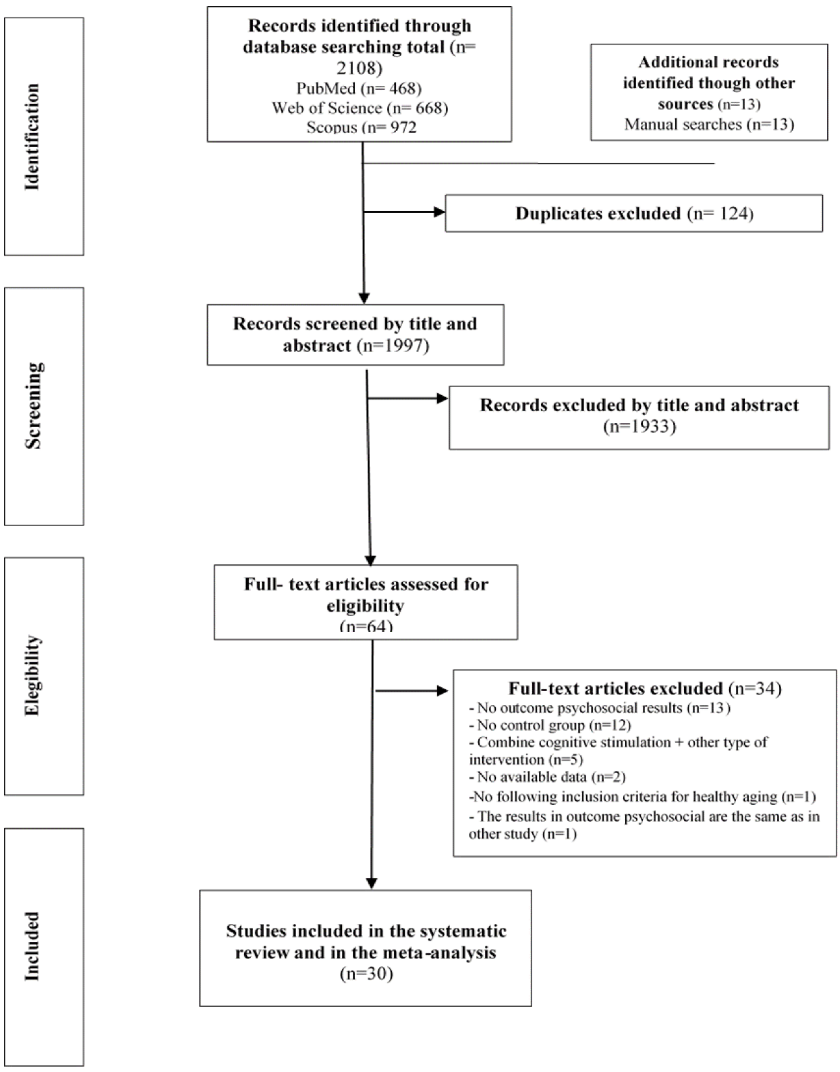

Fig. 1. PRISMA Diagram- the process of study selection.
From: Rethlefsen, M. L., Kirtley, S., Waffenschmidt, S., Ayala, A. P., Moher, D., Page, M. J., & Koffel, J. B. (2021). PRISMA-S: an extension to the PRISMA Statement for Reporting Literature Searches in Systematic Reviews. *Systematic Reviews, 10*(1), 1–19. https://doi.org/10.1186/S13643-020-01542-Z

Carbone et al., 2021; Coen et al., 2011; Cove et al., 2014; Djabelkhir et al., 2017; Folkerts et al., 2018; Gibbor et al., 2020; Leroi et al., 2019; Lok et al., 2019; Miranda-Castillo et al., 2013; Orgeta et al., 2015; Orrell et al., 2014; Piras et al., 2017; Spector et al., 2003; Tsai et al., 2008), 23 studies evaluated mood-depression (Alvares-Pereira et al., 2020; Alves et al., 2014; Capotosto et al., 2017; Carbone et al., 2021; Ciarmiello et al., 2015; Coen et al., 2011; Djabelkhir et al., 2017; Fernández Calvo et al., 2010; Folkerts et al., 2018; Gomez-Soria et al., 2020; Gómez-Soria et al., 2021, 2021; Juárez-Cedillo et al., 2020; Justo-Henriques et al., 2019, 2021; Liu et al., 2021; Leroi et al., 2019; Oliveira et al., 2021; Orgeta et al., 2015; Piras et al., 2017; Spector et al., 2003; Tarnanas, Tsolakis & Tsolaki, 2014; Tsai et al., 2008), and 12 studies evaluated mood-anxiety (Alvares-Pereira et al., 2020; Capotosto et al., 2017; Coen et al., 2011; Djabelkhir et al., 2017; Gomez-Soria et al., 2020; Gómez-Soria et al., 2021; Gómez-Soria et al., 2021; Leroi et al., 2019; Niuet al., 2010; Spector et al., 2003; Tsai et al., 2008). (Fig. 2)

In the Fernández Calvo et al. (2010) study, one group performs CS individually and other in group.

3.2. Study characteristics

The main characteristics of the participants and CS were extracted from the selected studies and can be consulted in Table 2. Additionally, the cognitive functions and activities of CS are shown (see supplementary file 4, Table 4). Measurements and the observed effect included in psychosocial variables in each individual study is available in supplementary file 5, Table 5.

A total of 2.403 participants (60.4% females) were analysed. The mean age of the participants was 78.8 years. Regarding the origin of the studies 80% were conducted in Europe, 13.3% in Asia, and 6.7% in America. 3.3% of studies included participants with healthy cognitive ageing, 30% of studies included participants with MCI. 56.7% of the studies included participants with dementia and 10% of the studies included both, MCI and dementia.

The intervention providers were nurses ($n = 1$), neuropsychologist ($n = 4$), occupational therapists ($n = 5$), psychologists ($n = 3$), psychologist and therapeutic assistants ($n = 1$) therapists ($n = 3$), careers ($n = 2$), and a team of professionals ($n = 2$). In 9 studies they did not specify which professional carried out the intervention. The study settings were residential care ($n = 7$), community ($n = 19$) and residential care together community ($n = 4$).

Interventions carried out were diverse: 27 studies included traditional interventions and 3 studies computerized interventions. Furthermore, in 13 studies adjusted the level of difficulty of the CS or personalized the intervention. Regarding the pharmacological treatment, in 5 studies participants did not take AChEIs, in 3 studies

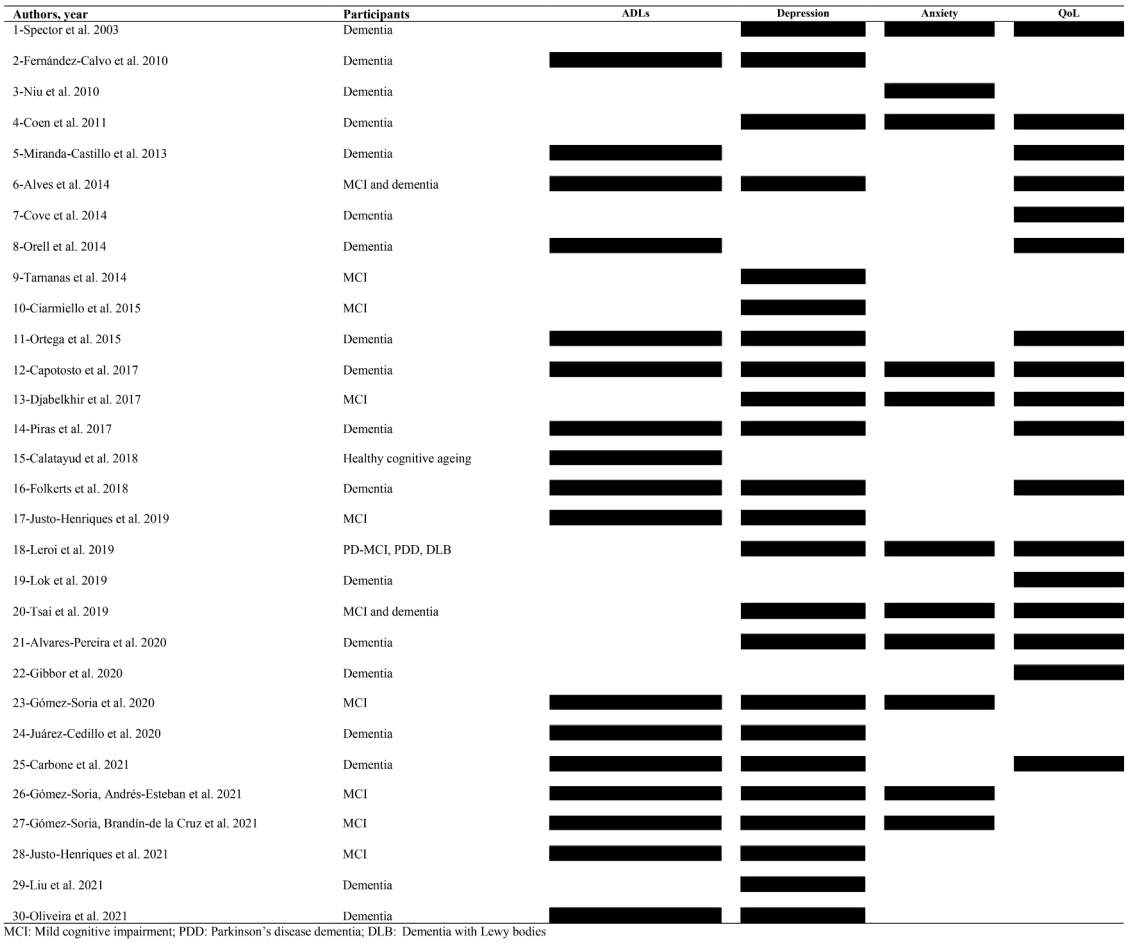

Fig. 2. Psychosocial variables included in the meta-analysis.
ADLs: Activities of daily Living;; DLB: dementia with Lewy bodies; MCI: Mild cognitive Impairment; PDD: Parkinson's disease dementia; PD-MCI: mild cognitive impairment or dementia; QoL: Quality of life.

participants took AChEIs and 21 studies did not specify the medications. In the study of Orrell et al. (2014), subgroup analyses were also carried out, differentiating between the participants who only CS and those who also were under pharmacological treatment with AChEIs.

There were some differences regarding the type of control used. Six studies included an active control group. Tarnanas et al. (2014), included an active and passive control group. Orrell et al. (2014) included treatment as usual (TAU) and in a subgroup also included AChEIs. In 22 studies participants received their TAU. Moreover, in 2 studies the participants were in wait-list for intervention.

3.3. Risk of bias in individual studies

The risk of bias assessment for all included studies is summarized in Fig. 3a for randomized studies and Fig. 3b for non-randomiezed studies. On the one hand, regarding randomized studies, 5 were in the "Low risk" category, 8 in the "High risk" category and 10 in the "Some concerns" category. The categories with the highest "Low risk" are detection bias, followed by selection bias. On the other hand the other seven non-randomized studies are in the "Low risk" category.

3.4. Effects of CS in relation to psychosocial variables in older adults

3.4.1. Mood-depression

The sensitivity analysis shows how the meta-analysis with RCTs alone is non-significant, the inclusion of non-randomized studies maintains non-significance, increases the confidence intervals and decreases the precision of the results, with the variance weighting factor of 0.5 in the non-randomized studies being the closest to the results with RCTs alone.

As shown in Fig.4.a., the effect size is large and not significant in favour of the control group (RVE $= -1.74 \pm 0.86$ [−3.53, 0.04], t(19.59) $= -2.04$, $p = 0.06$) . The presence of high values for $\tau 2$ (2.85) is verified and the significant Cochrane's Q test ($p < 0.001$) and the I^2 value of 98% indicate significant heterogeneity.

Overall, in all subgroups there was a not significant effect of large with higher scores in the control group but with significant heterogeneity (see **Supplementary files 9–17,** Fig. 1**a–i.**).Subgroup analyses hardly change the heterogeneity detected with non-significant effects, indicating that the source of between-study variability is due to some other uncontrolled variable. For the variable Subgroup duration of session, a reduction of heterogeneity is observed in the subgroup Mood-Depression 30 min/session to moderate; also for the variable Mood-Depression Origin of the studies, in the subgroup Mood-Depression Origin of the studies: Asia the heterogeneity becomes null and decreases to large in the subgroup Mood-Depression Origin of the studies: America although in both cases the effects are not significant, indicating that it is the studies in the subgroup Mood-Depression Origin of the studies: Europe that are responsible for the variability detected.

Publication bias was detected for the estimation of the mean change of depression (Egger test, $p < 0.001$) (Fig.5**.a.**)

3.4.2. QoL

The sensitivity analysis shows that the meta-analysis with RCTs

Table 2
Main characteristics of the participants and CS.

Study (Author, year)	CS (AChEIs) (Individual or group	Control group	Frequency (duration, session/week, duration)	Cognitive status (Diagnosis criteria)	N (male/female)	Professionals that administered the intervention	Country Setting	Mean age (Standard deviation)	Education (Standard deviation)	Baseline score global cognition	Main Results
1-Spector et al., 2003	CS adapted. (AChEIs not specified) (Group)	TAU	45 min/session Twice a week 7 weeks, 14 sessions (Short-Term)	Dementia DSM–IV	201 (43/158) IG: 115 CG: 86	ns	UK (Day centers and residential care)	85.3 (7.0)	ns	MMSE 14.4 (3.8)	QoL: sd. Depression and anxiety: No sd.
2-Fernández-Calvo et al. 2010	Multimodal CS (AChEIs not specified) (Individual and group)	TAU	60 min/session Three times a week 3 months, 36 sessions (Maintenance)	AD probably NINCDS-ADRDA; McKhann et al., 1984	45 (25/20) GI individual format: 15 GI group format: 15 GC: 15	ns	Spain (Association of Alzheimer's patients)	75.33 (4.76)	7.38 (2.93)	MMSE 18.97 (2.44)	Depression individual format: sd. ADLs: No sd.
3-Niu et al., 2010	CS (AChEIs not specified) (Individual)	**Active** Communication exercise.	45 min/session Twice a week 10 weeks, 20 sessions (Short-Term)	AD probably NINCDS-ADRDA McKhann et al., 1984	32 (25/7) GI:16 GC:16	Trained Therapists	China (Military sanitarium)	79.85 (4.31)	10.68 (1.88)	MMSE 17.12 (3.13)	Anxiety: No sd.
4-Coen et al., 2011	CS (AChEIs not specified) (Group)	TAU	45 min/session Twice a week 7 weeks, 14 sessions (Short-Term)	Mild to moderate dementia Spector et al., 2003	27 (13/14) IG: 14 CG: 13	Occupational Therapists	Ireland (Residential care)	79.85 (5.6)	ns	MMSE 16.9 (5.05)	QoL, depression and anxiety: No sd.
5-Miranda-Castillo et al., 2013	CS (Group)	TAU	45 min/session Twice a week 7 weeks, 14 sessions (Short-Term)	Mild to moderate AD DSM-IV-TR	22 (8/14) IG: 12 CG: 12	ns	Chile (Residential care)	83.65 (9.95)	91.9% Basic	MMSE 19 (3.95)	BADLs: no sd. QoL IG: sd
6-Alves et al., 2014	CS adapted (AChEIs not specified) (Group)	TAU Wait-list/brief intervention	60 min/session Three times a week, except the last week twice a week 1.5 months, 17 sessions (Short-Term)	From MCI to mild to moderate dementia GDS 3–5	17 (4/13) IG:10 CG:7	Psychologist and therapeutic assistants	Portugal (Day centers and residential care)	78.65 (10.72)	1.98 (2.33)	MMSE 18.06 (4,64)	QoL, depression and IADLs: No sd
7-Cove et al., 2014	CS adapted Home-based CS adapted (AChEIs not specified) (Individual)	TAU Wait-list	45 min/session Once a week 14 weeks, 14 sessions (Short-Term)	Dementia DSM IV MMSE 18–24	59 (36/32) IG: 24 CG: 13 IG plus carer training	Carer Using the guiding principles of CS	UK (Community)	76.37 (6.55)	ns	MMSE 22.65	QoL: No sd
8-Orrell et al., 2014 RCT	Alone CS and CS + AChEIs (Group)	TAU AChEIs	45 min/session Once a week 24 weeks, 24 sessions (Maintenance)	Dementia DSM-IV	236 (86/150) Alone CS: 81 CS+AChEIs:42 TAU:79 AChEIs: 34	ns	London (Residential care, and community)	83.1 (7.55)	ns	MMSE 17.8 (5.5)	QoL at three and six months: sd. and ADLs at three months: sd.
9-Tarnanas et al. 2014	Computerized CS (AChEIs not specified)	**Active** Learning-based memory training.	90-min session Twice a week 5 months, 40	MCI Petersen's criteria	95 (41/54) IG: 32	Psychologists	Greece (Day Clinic)	70.37 (4.4)	ns	MMSE 26.4 (3.43)	Depression: No sd.

(*continued on next page*)

Table 2 (*continued*)

Study (Author, year)	CS (AChEIs) (Individual or group	Control group	Frequency (duration, session/week, duration)	Cognitive status (Diagnosis criteria)	N (male/female)	Professionals that administered the intervention	Country Setting	Mean age (Standard deviation)	Education (Standard deviation)	Baseline score global cognition	Main Results
	(Group)	**Passive** No-contact	sessions (Maintenance)	1999, 2004	CAG: 39 CG: 34						
10-Ciarmiello et al., 2015	CS (Group)	**Active** Informal meeting	45 min/session Twice a week 4 months, 32 sessions (Maintenance)	MCI MMSE ≥ 24	30 (12/17) IG: 15 CG: 15	Experienced Neuropsychologist	Italy (Hospitals Neurology Unit)	71.59 (7.13)	8.56 (2.82)	MMSE 27.85 (1.84)	Depression: No sd.
11-Orgeta et al., 2015	Home-based CS+ AChEIs (Individual)	**TAU**	30 min/session Three times weekly 25 weeks, 75 sessions (Maintenance)	Dementia DSM-IV MMSE > 10	356 (191/165) IG: 180 CG: 176	Family carers Carer training and support was provided by the research (team mental health nurses, clinical psychologists, occupational therapists or research assistants)	UK (Community)	78.2	Highest level of education School leaver (14–16 years) 60%	MMSE 21.22 (4.30)	QoL, depression, BADLs: No sd.
12-Capotosto et al., 2017	CS adapted (Group)	**Active** Educational activities.	45 min/session Twice a week 7 weeks, 14 sessions (Short-Term)	Mild to moderate dementia Spector et al., 2006	39 (12/27) IG: 20 CG: 19	ns	Italy (Residential care)	88.25 (5.15)	6.15 (2.60)	MMSE 18.25 (3.39)	ADLs, depression, anxiety, QoL and loneliness: sd.
13-Djabelkhir et al., 2017	Computerized CS (AChEIs not specified) (Group)	**Active** Computerized CE and stimulate social interactions.	90 min/session Once a week 3 months, 12 sessions (Maintenance)	MCI Petersen, 2004 and Winblad et al., 2004.	20 (6/14) IG: 10 CG: 10	Neuropsychologist	France (Community)	76.7 (6.7)	52.2% Degree or higher	MMSE 27.55 (1.95)	Depression, anxiety and QoL: No sd. Self-esteem: sd.
14-Piras et al. 2017	CS (Group)	**Active** Educational activities.	45 min/session Twice a week 7 weeks, 14 sessions (Short-Term)	Vascular dementia NINDS-AIREN Román et al., 1993	35 (7/28) IG: 21 CG: 14	ns	Italy (Residential care)	84.62 (8.06)	5.27 (2.46)	MMSE 19.66 (4.04)	ADLs, depression and loneliness: no sd Trend towards improvement in perceveid QoL.
15-Calatayud et al., 2018	CS personalized and adapted (AChEIs not specified) (Group)	TAU	45 min/session Once a week 10 weeks, 10 sessions (Short-Term)	Healthy Cognitive Ageing ME-35 > 27	201 (69/132) IG: 100 CG: 101	Trained Occupational Therapist	Spain (Health centre)	72.91 (5.69)	51% Complete primaries	MEC-35 31.34 (2.14)	ADLs: No sd.
16-Folkerts et al., 2018	CS (AChEIs not specified) (Group)	TAU	60 min/session Twice a week 8 weeks, 16 sessions (Short-Term)	PDD By neurologist or psychiatrist MMSE 10–25	12 (10/2) IG: 6 CG: 6	Trained Psychologist	Netherlands (Residential care)	76.59 (7.26)	9.84 (1.08)	MMSE 17.84 (5.55)	Depression: sd. QoL: No sd. BADLs. Deteriorated sd
17- Justo-Henriques et al., 2019	CS (AChEIs not specified) (Group)	TAU	45 min/session Twice a week 44 weeks, 88 Sessions (Long-Term)	Mild Neurocognitive disorder DSM 5	30 (8/22) IG: 15 CG: 15	Experienced Therapist	Portugal (Day centre and community)	78.8 (11.6)	66.6% > 4 years	MMSE 19.95 (3.55)	BADLs: No sd Depression: sd
18-Leroi et al., 2019	Home-based, CS (AChEIs not specified) (Individual)	TAU	30 min/session Two to three times per week.	PD-MCI (Level 1), PDD (probable or possible) Emre et al., 2007; Litvan et al., 2012,	76 (60/16) IG:38 CG:38	A specially trained implementer (eg, nurse, therapist or researcher) will visit the dyad at home and	UK (Community)	74.75	Up to 18-year-old schooling Further	ACE-III 63.24	QoL, depression, anxiety and ADLs: No sd

(*continued on next page*)

Table 2 (*continued*)

Study (Author, year)	CS (AChEIs) (Individual or group	Control group	Frequency (duration, session/week, duration)	Cognitive status (Diagnosis criteria)	N (male/female)	Professionals that administered the intervention	Country Setting	Mean age (Standard deviation)	Education (Standard deviation)	Baseline score global cognition	Main Results
			10 weeks (Short-term)	or DLB (probable or possible) McKeith et al., 2017		provide therapy training to the companion			education and higher		
19- Lok et al., 2019	CS + AChEIs. (Group)	TAU	45 min/session Twice a week 7 weeks, 14 sessions (Short-Term)	AD By International Working Group MMSE 13–24	60 (30/30) GI: 30 GC: 30	Nurse	Turkey (Neurology Polyclinic)	ns	60.05% Higher	MMSE 17.05	QoL: sd.
20- Tsai et al., 2019	CS adapted (Group)	TAU	90 min/session Once a week, 14 weeks, 14 sessions (Short-term)	MCI and mild moderate dementia MMSE 14–27	25 (6/19) IG: 12 CG:13	Occupational therapists, social workers, nurse, day care centre supervisors, and occupational therapist students.	Taiwan (Day centre)	77.71 (5.66)	Illiterates 19.55% Literates with no schooling 8% Primary school 20.2% Secondary school 32.05% High school 11.85% College 4.15% Unknown 4.15%	MMSE 20.26	QoL depression and anxiety: No sd
21-Alvares-Pereira et al., 2020	CS (AChEIs not specified) (Group).	TAU	45–60 min/ session Twice a week 7 weeks, 14 sessions (Short-Term)	Neurocognitive disorder (dementia) DSM5	100 (9/91) IG: 50 CG: 50	ns	Portugal (Residential care, psychogeriatric and rehabilitation centre)	83.60 (7.64)	55.65% ≤4 years	ns	Depression, anxiety and QoL: No sd.
22-Gibbor et al., 2020	CS adapted (AChEIs not specified) (Individual)	TAU	45 min/session Twice a week 7 weeks, 14 sessions (Short-Term)	Mild to moderate dementia DSM-IV	33 (17/16) IG 17 CG: 16	ns	UK (Residential care)	81.85 (10.31)	ns	MMSE 21.70 (3.51)	QoL: sd.
23-Gomez-Soria et al., 2020	CS personalized and adapted (AChEIs not specified) (Group)	TAU	45 min/session Once a week 10 weeks, 10 sessions (Short-Term)	MCI MEC-35: 24–27	122 (28/94) IG: 54 CG: 68	Trained Occupational Therapist	Spain (Health center)	74.99 (6.02)	Primary 88.78% Secondary 11.05%	MEC-35 25.91 (1.03)	BADLs' sd. IADLs, Depression, and anxiety No sd.
24-Juárez-Cedillo et al., 2020	Multicomponent CS adapted + AChEIs (Group)	TAU	90 min/session Twice a week 8 weeks, 16 sessions (Short-Term)	Mild neurocognitive disorder DSM5 and NINCDS-ADRDA	67 (21/46) IG: 39 CG: 28	Neuropsychologist	Mexico (Institute of Social Security)	77.7 (8.15)	14.5% None 24% 4 years 61.5 <3 years	MMSE 22.4 (0.8)	ADLs and depression: No sd.
25-Carbone et al., 2021	CS adapted (AChEIs not	**Active** Educational	45 min/session. Twice a week 7 weeks, 14	Major neurocognitive disorder.	225 (76/149)	Trained Psychologists	Italy (Residential care or day centers)	83.66 (8.10)	6.47 (3.67)	MMSE 20.04 (4.19)	ADLs, depression and QoL: No sd.

(*continued on next page*)

Table 2 (*continued*)

Study (Author, year)	CS (AChEIs) (Individual or group	Control group	Frequency (duration, session/week, duration)	Cognitive status (Diagnosis criteria)	N (male/female)	Professionals that administered the intervention	Country Setting	Mean age (Standard deviation)	Education (Standard deviation)	Baseline score global cognition	Main Results
	specified) (Group)	activities.	sessions (Short-Term)	DSM 5 Mild-to-moderate Dementia. Spector et al., 2003	IG: 123 CG: 102						
26-Gómez-Soria et al., 2021	CS personalized and adapted (AChEIs not specified) (Group)	TAU	45 min/session Once a week 10 weeks, 10 sessions (Short-Term)	MCI MEC-35: 24–27	29 (6/23) IG: 15 CG: 14	Trained Occupational Therapist	Spain (Health centre)	72.7 (5.05)	Primary 48.3% Secondary 51.7%	MEC-35 26.14 (0,92)	ADLs, depression, and anxiety: No sd.
27-Gómez-Soria et al., 2021	CS personalized and adapted (AChEIs not specified) (Group)	TAU	45 min/session Once a week 10 weeks, 10 sessions (Short-Term)	MCI MEC-35: 24–27	50 (11/39) IG: 23 CG: 27	Trained Occupational Therapist	Spain (Health centre)	74.32 (5.47)	Primary complete 44%	MEC.35 25.87 (1.058)	ADL, depression, and anxiety: No sd.
28- Justo-Henriques et al. 2021	CS (AChEIs not specified) (Individual)	TAU.	45 min/session Twice a week 44 weeks, 88 sessions (Long-Term)	Mild neurocognitive disorder DSM 5	82 (24/58) IG: 41 CG: 41	Trained Therapists	Portugal (Psychosocial support organization)	79.3 (10)	76.8% 1–4 years	MMSE 19.9 (3.3)	BADL: No sd. Condition factor depression: sd.
29-Liu et al., 2021	CS adaptated (AChEIs not specified) (Group)	TAU	45 min/session Twice a week 7 weeks, 14 sessions (Short-Term)	Mild to moderate dementia. Clinical diagnosis MMSE > 18	29 (10/19) IG: 16 CG: 13	ns	China (Community)	80.29 (6.16)	4.78 (4.67)	ADAS-Cog 21.54 (8.29)	Depression: No sd.
30-Oliveira et al., 2021	Computerized CS (AChEIs not specified) (Group)	TAU .	45 min/session Twice a week 6 weeks, 12 sessions (Short-Term)	Major neurocognitive disorders due to AD By a psychologist	17 (5/12) IG: 10 CG: 7	Clinical Neuropsychologist	Portugal (Residential care)	83.24 (5.66)	23.5% Higher	MMSE 15.8 (7.01)	IADLs: sd. Depression and anxietyu: No sd.

ACE-III: The Addenbrooke's Cognitive Examination; AChEIs: Acetylcholinesterase inhibitors; AD: Alzheimer's disease; ADAS-Cog: Alzheimer's Disease Assessment Scale; BADL: Basic ADLs; CAG: Control active group; CE: Cognitive Engagement; CDR: Clinical Dementia Rating; CS: Cognitive stimulation; CG: Control Group; DLB: dementia with Lewy bodies; DSM-IV: Diagnostic and Statistical Manual of Mental Disorders (4th ed); DSM-IV-TR: Diagnostic and Statistical Manual of Mental Disorders (4th edn) (Text Revision); DSM5: Neurocognitive Disorder Diagnostic and Statistical Manual of Mental Disorders, 5th edition: IADL: Instrumental ADLs;; ICD-10: International Classification of Diseases 10th Revision; IG: Intervention Group; MEC-35: Spanish version of the MMSE; MMSE: Mini-Mental State Examination; MoCA: Montreal Cognitive Assessment; NINCDS-ADRDA: National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer's Disease and Related Disorders Association; NINDS-AIREN: National Institute of Neurological Disorders and Stroke - Association International Neurosciences; PDD: Parkinson's disease dementia; PD-MCI: mild cognitive impairment or dementia; RCT: Randomized controlled trial; TAU: Treatment as usual. ns: not specified. sd: significant differences.

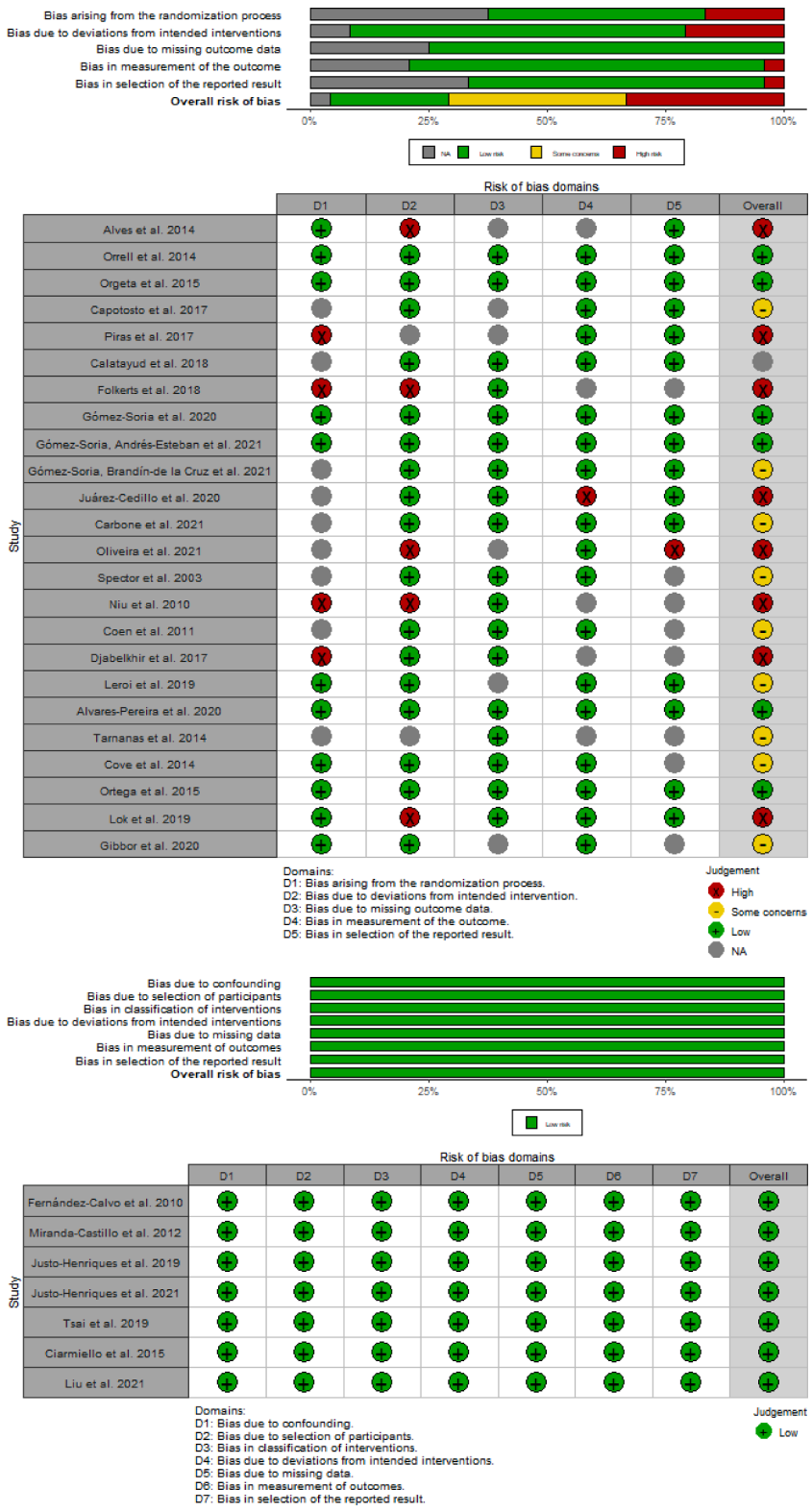

Fig. 3. a. Randomized studies, risk of bias assessment tools RoB 2. Fig. 3b. Non randomized studies, risk of bias assesment (ROBINS-I).

alone is non-significant, the inclusion of non-randomized studies increases the confidence intervals, decreasing the precision of the results, which also become significant, with the analysis with non-randomized studies without weighting (naive pooling) being the closest to the results with RCTs alone with lower confidence intervals. The inclusion of the Miranda-Castillo et al. (2013) study, the only non-RCT study with a large and significant effect size in favour of the treatment group (SMD = 9.812 (6.522, 13.102) is the one that causes the final significant effect, so it is decided to eliminate it from the analysis. Regarding the QoL, Fig. 3.**b.** shows that the effect size is moderate and not significant in favour of the control group (RVE = 0.93±0.41 [−0.03, 1.89], t(7.64) = 2.25, $p = 0.06$) . The presence of moderate values for τ^2 (1.87) was verified and the significant Cochrane's Q test ($p < 0.001$) and the I^2 value of 98% indicated a large heterogeneity.

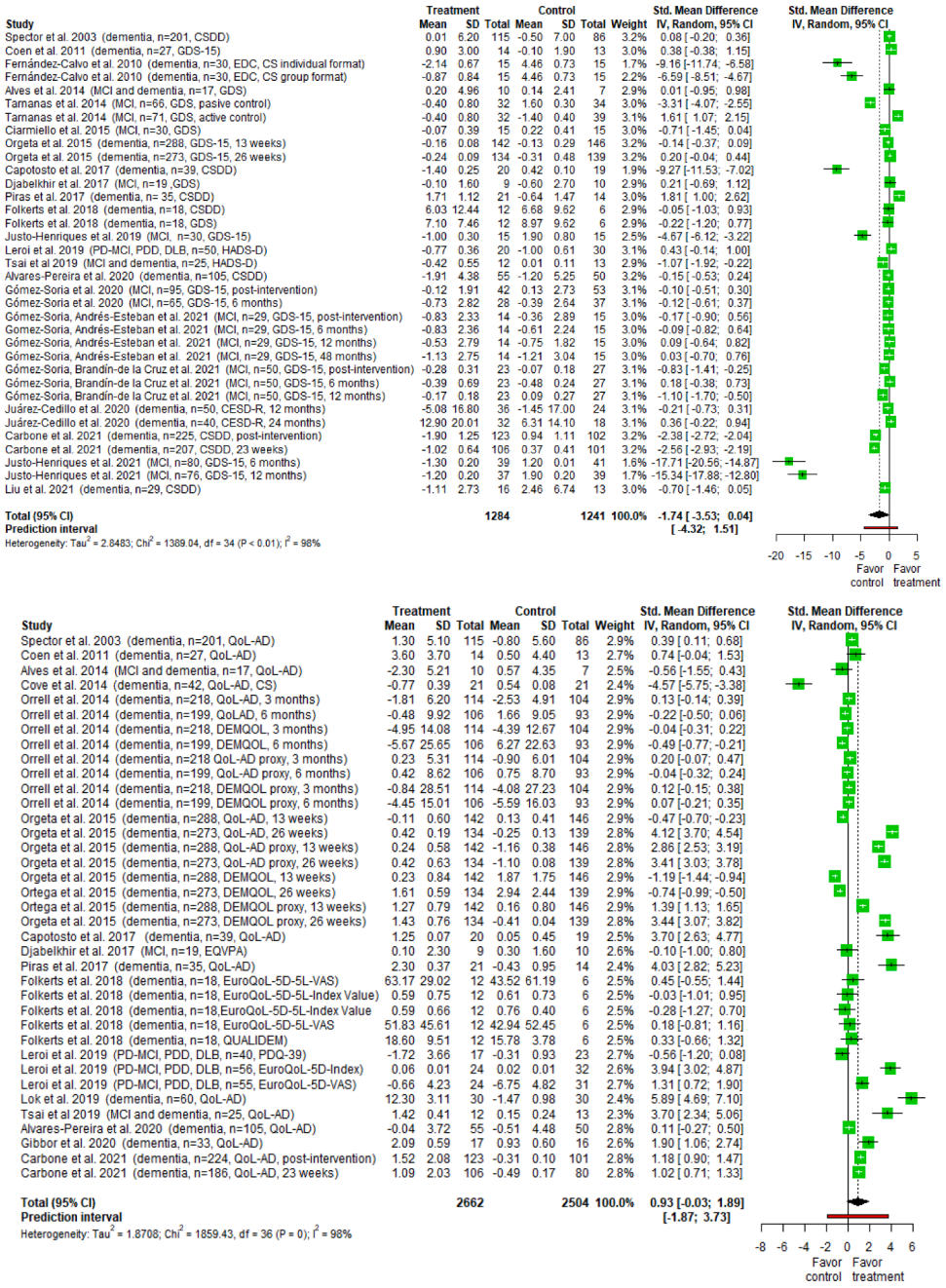

Fig. 4. Forest plot of effect sizes (ESs) of CS from the studies that assessed psychosocial variables in older adults- 4a. Mood-Depression 4b. QoL 4c. ADLs. 4d. Mood-Anxiety.

None of the other subgroup analyses showed significant effects, although higher scores were found in the treatment group with a significant heterogeneity, only in the subgroup "personalized-adapted/non-personalized-non-adapted". High values for $\tau 2$ (1.51) were found to be present. The significant Cochrane's Q test ($p < 0.001$) and the I^2 value of 98% indicate significant heterogeneity. The effect size is large and not significant in favour of the treatment group (RVE = 0.83±0.35 [−0.01, 1.66], t(6.33) = 2.38, $p = 0.05$). The subgroup analysis does not modify the heterogeneity neither in the QoL Personalized/adapted CS group (I^2 of 98% increasing to 99%) but in the QoL Non-personalized/non-adapted CS group (I^2 of 98% decreasing to 76%); on the other hand, a large and significant effect in favour of the treatment group is observed in the QoL Personalized/adapted CS group (RVE = 1. 4 ± 0.43 [0.14, 2.67], t(3.54) = 3.24, $p = 0.04$) while in the QoL Non-personalized/non-adapted CS group the effect is moderate and not significant in favour of the treatment group (RVE = 0.11±0.19 [−0.76, 0.99], t(1.86) = 0.6, $p = 0.61$) (see **Supplementary file 18,** Fig. 2.**a)**. Other subgroups (see **Supplementary files 19–23,** Fig. 2.**b–f)** did not show significant differences.

Publication bias was detected for the estimation of the mean change in the QoL (Egger test, $p = 0.003$) (Fig.5.**b.**).

3.4.3. ADLs

The sensitivity analysis shows that the meta-analysis with RCTs alone is non-significant, the inclusion of non-randomized studies maintains non-significance, increases the confidence intervals and decreases the precision of the results, being the analysis with non-randomized studies without weighting (naive pooling) the closest to

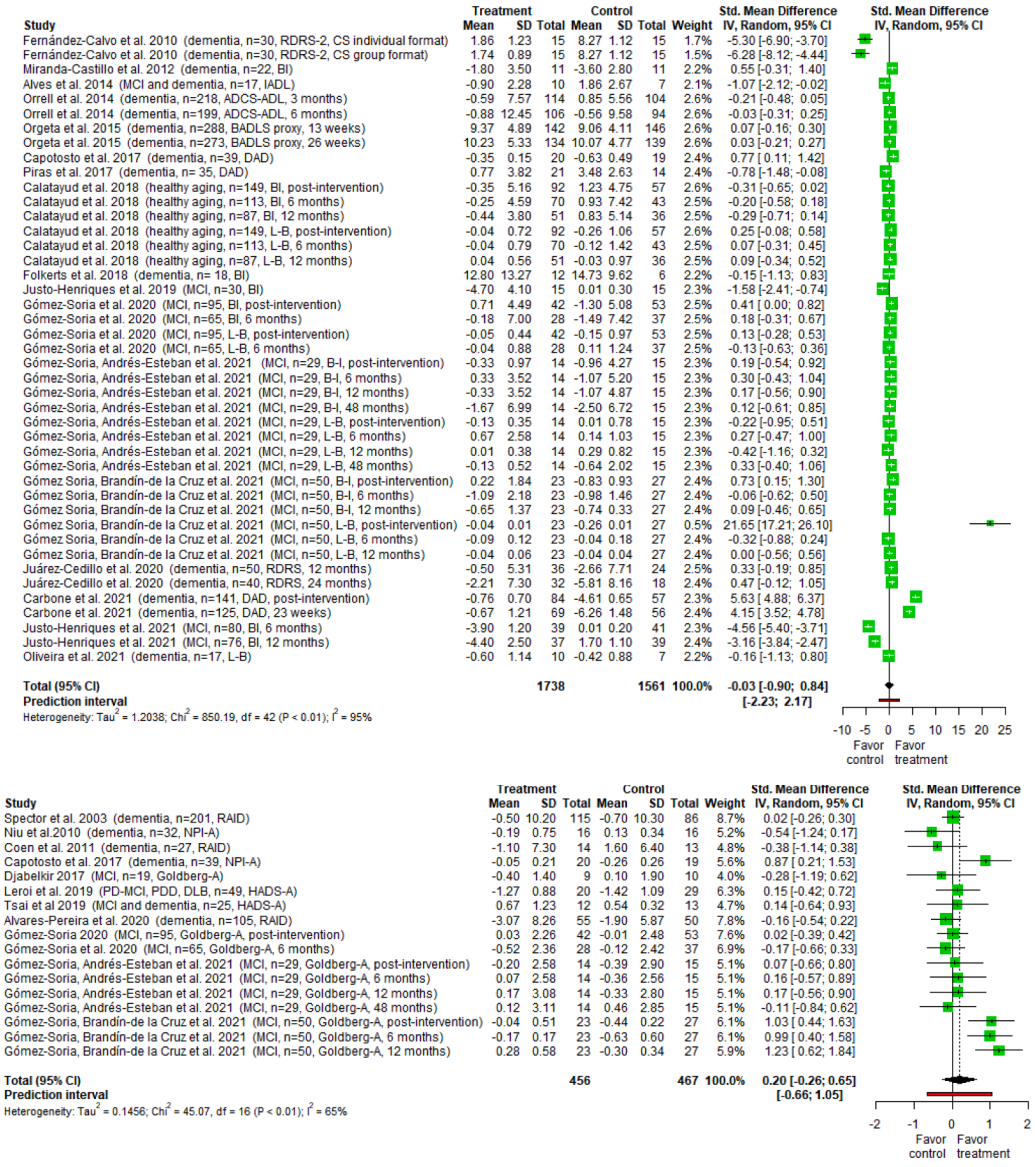

Fig. 4. (*continued*).

the results with RCTs alone with lower confidence intervals.

In relation to ADLs, the effect size is moderate and not significant in favour of the control group (RVE = 0.93±0.41 [−0.03, 1.89], t(7.64) = 2.25, $p = 0.06$) . The presence of high values for τ^2 (1.2) was verified. The significant Cochrane's Q test ($p < 0.001$) and the 95% I^2 value indicate significant heterogeneity (Fig.4**.c.**).

None of the subgroups showed significant differences with higher scores in the control group and significant heterogeneity (see **supplementary files 23–31,** Fig. 3.**a–i.**), indicating that the source of between-study variability is due to some other uncontrolled variable; only in the subgroup "Origin of the studies: America" and the subgroup "30 min/session" are there a marked reduction in heterogeneity to zero.

Publication bias was detected for the studies that included ADLs (Egger test, $p < 0.001$) **(**Fig.5**.c.).**

3.4.4. Mood-anxiety

As shown in Fig. 3.**d.** no statistically significant differences were found between CS (independently or together with AChEIs) and the control groups regarding anxiety (RVE = 0.2 ± 0.2 [−0.26, 0.65], t (7.83) = 1, $p = 0.35$). The presence of high values for τ^2 (0.15) is verified and the significant Cochrane's Q test ($p < 0.001$) and the I^2 value of 65% indicate significant heterogeneity.

None of the subgroups showed significant effects. The subgroup analyses showed strong reductions in heterogeneity and "Origin of the studies: Europe was responsible for the heterogeneity detected (see **supplementary files 32–37, figures 4.a.−4.f**).

Publication bias was not detected for the estimation of the mean change of anxiety (Egger test, $p = 0.948$) (Fig.5**.d.**)

4. Discussion

This systematic review and meta-analysis assess the impact of CS (independently or together with pharmacological treatment, particularly AChEIs) on psychosocial outcomes such as QoL, ADLs, mood, self-esteem or loneliness in older adults with healthy cognitive ageing, MCI, and dementia.

Our results based on personalized/adapted CS administration in older adults, showed a higher QoL, in participants with healthy cognitive ageing, MCI, and dementia. Other authors also found similar results in, QoL (Aguirre et al., 2013; Kim et al., 2017; Sun et al., 2022; Woods et al., 2012); however, some studies do not specify whether CS was personalized/adapted.

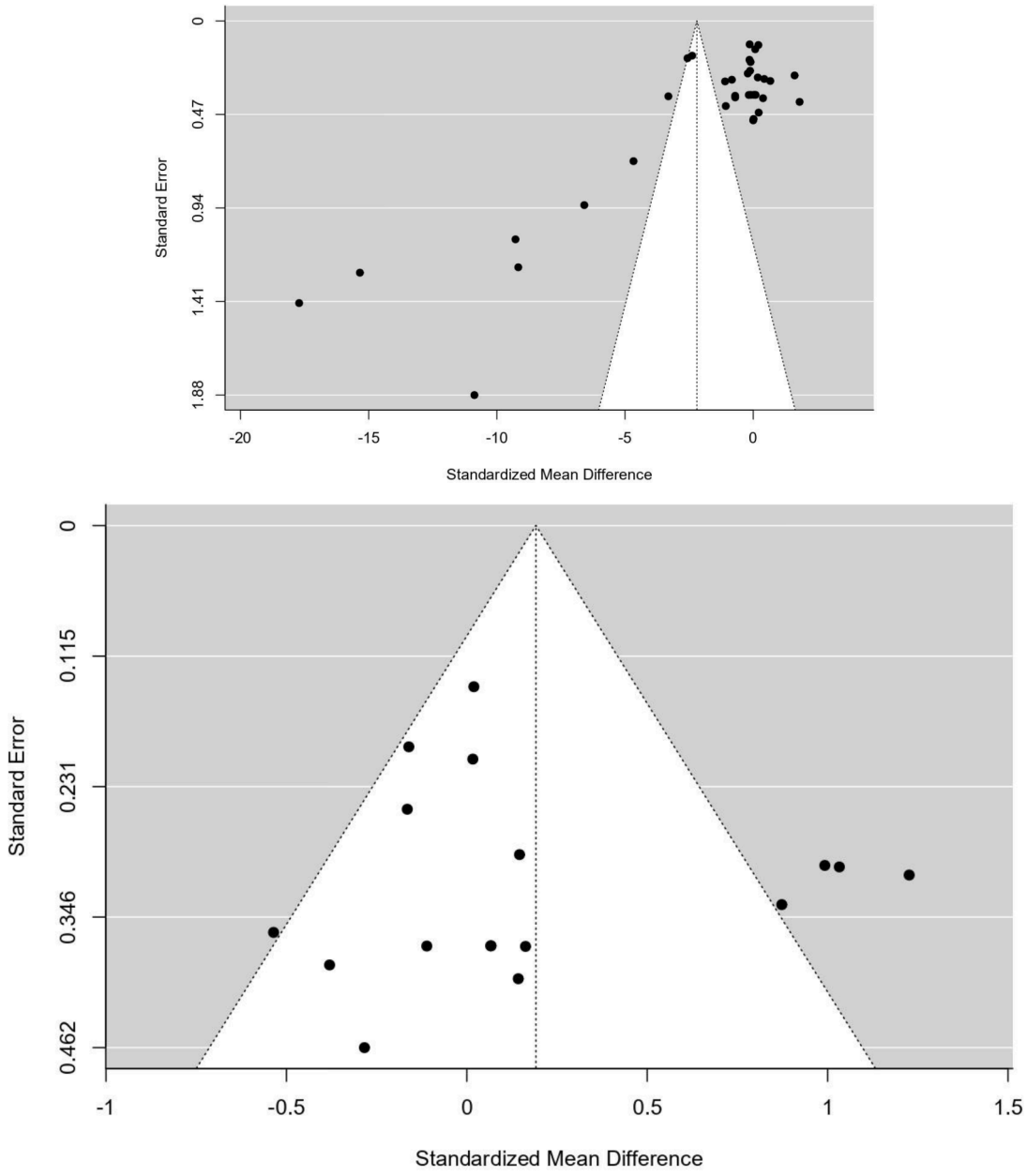

Fig. 5. Funnel plots for publication bias of the effects of CS in psychosocial variables in older adults. 5a. Mood-Depression 5b. QoL 5c. ADLs 5d. Mood-Anxiety.

We suggest adapting the activities to participants' specific cognitive levels (Calatayud et al., 2022; Gómez-Soria et al., 2021), personal preferences and limitations of the participants (Félix et al., 2020), as it has been shown to improve cognition and cognitive aspects such as global and spatial global and spatial orientation (Gómez-Soria et al., 2021). To have satisfactory sessions it is essential to achieve an adequate selection of CS tasks, that is, to adapt the cognitive level, to be interesting and avoid boredom, to have meaning for the person who performs them and to be close to the issues of everyday life (Muñoz Marrón, 2009). Personalized/adapted CS is a way to engage participants in activities and increased their participation (Félix et al., 2020).

Our results showed that CS was not associated with higher levels in anxiety. Indeed, more than half of the studies described normal values before and post-intervention. In addition, the control group decreased its scores in 4 studies. Similarly to our findings, others authors did not find significant differences either ADLs (Aguirre et al., 2013; Woods et al., 2012), or anxiety (Aguirre et al., 2013; Cafferata et al., 2021; Chen, 2022; Woods et al., 2012) or depression (Chen, 2022; Wong et al., 2021; Woods et al., 2012). To date, no previous systematic reviews or meta-analyses based on CS have been carried out including participants with healthy cognitive ageing or MCI besides dementia. Moreover, a high number of subgroup analyses were conducted to analyse the effect that cognitive status, age, number of sessions and duration, type of CS, treatment and personalization or adaptation, the quality of studies, and origin of the studies, could have on the psychosocial outcomes assessed.

Regarding the duration of CS programs and depression, we did not find any study evaluating the effects of CS at the level of depressive symptoms. However, on the one hand, Chen et al. (2019) concluded that "CS and AChEIs" were effective in AD, regardless of whether short-term, maintenance, or long-term CS was applied; although the latter appears to be more effective on cognitive function. On the other hand, Brown et al. (2019) showed that maintenance CS might be cost-effective compared to standard treatment for participants who lived alone and those with higher levels of cognitive functioning. Wong et al. (2021)

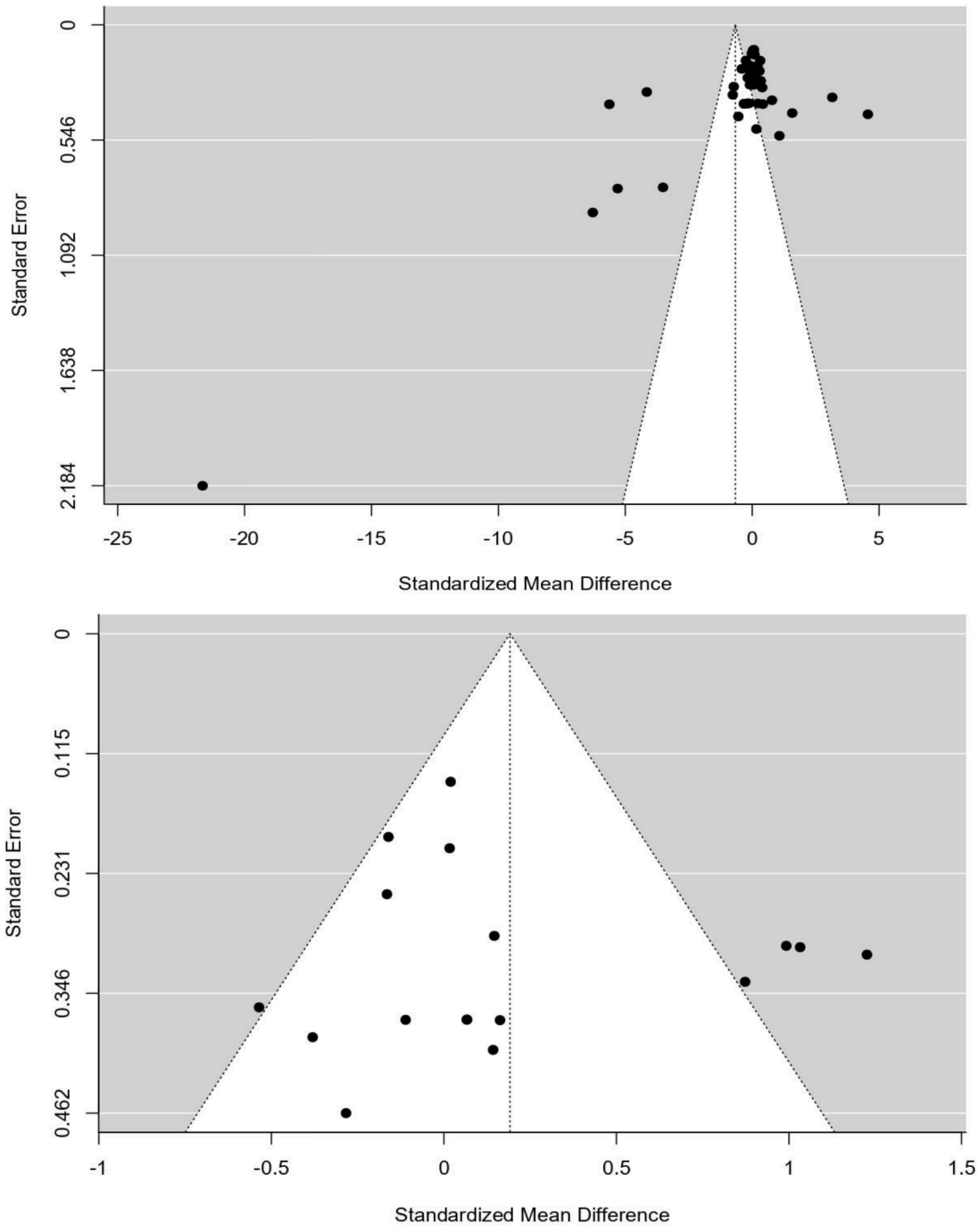

Fig. 5. (*continued*).

performed a subgroup analysis based in the CS duration and they did not find significant differences between ≤3 months and >3 months. Besides, Jean et al., (2010) found that applying fewer sessions (between 6 and 20) was more cost-effective for clinical purposes. In terms of duration, CS programs with more than 12 weeks showed no extra benefits compared to shorter programs. Therefore, the 12-week programs seem to be a good option, especially to reduce the risks of attrition.

In reference to the duration of CS session, different authors recommended 45 min per session (Abraha et al., 2017; Aguirre et al., 2013; Aguirre et al., 2014; Clare & Woods, 2004; Comas-Herrera & Knapp, 2016; Knapp et al., 2006; Orrell et al., 2014; Spector et al., 2006; Woods et al., 2012; Yamanaka et al., 2013). About the quality of studies, research that assessed the role of music-based interventions in dementia patients, van der Steen et al. (2018), found a moderate-quality evidence that music-based interventions reduced depressive symptoms and with a low-quality evidence that these interventions may improve QoL in persons with dementia. Our study found that "traditional CS" obtained better results than "computerized CS" in reducing levels of depression. However, Acosta et al. (2022), found that computerized CS can offer a more personalized and a more flexible approach compared to traditional CS.

In relation to the origin of the studies, Aguirre et al. (2014), proposed practical recommendations that provide guidance on how to culturally adapt the content and structure of CS to make it more appropriate for other cultures without compromising its effectiveness. The recommendations were based on clinical and practical experience, in addition to

evidence from the most common frameworks that have been used to adapt CS to other cultures.

Regarding participants that received "alone CS", in the study by D'Onofrio et al. (2015) the treatment of rivastigmine transdermal patch with CS in AD patients improved significantly their depressive symptoms. In other studies, the combination of CS and AChEIs, had more benefits than "alone CS" or "alone AChEIs" in memory (Devita et al., 2021), cognition and QoL (D'Amico et al., 2015). Besides, "alone CS" showed significant improvements compared with "alone AChEIs" (Devita et al., 2021). Other investigations have suggested that CS was effective irrespective of whether or not AChEIs were prescribed (Aguirre et al., 2013; Streater et al., 2016; Woods et al., 2012).

The lack of access to medical treatment for older adults with multiple comorbidities in a resource-limited setting is a challenge that need to be addressed to check whether CS is clinically effective and financially sustainable. On the one hand, in the long-term appropriate referral pathways to primary and secondary services should be established. On the other hand, from a practical and economic point of view, CS is suitable for use in low-resource countries, as it can be applied by formal and informal caregivers to be used for routine use (Mkenda et al., 2018).

Furthermore, the timing of CS sessions could be adapted according the lack of transport infrastructure and road networks in some countries and taking into account rural areas (Mkenda et al., 2018). In addition it would be very interesting if the CS could be culturally modified for the targeted environment (Mahmood et al., 2012). This notwithstanding the fact that the group format is linked to positive experiences in terms of communication skills and a supportive environment (Spector et al., 2011); as well as having implications for climate change.

4.1. Limitations

Concerning the limitations of the present systematic review and meta-analysis. Firstly, the overall quality of the evidence was limited due to the poor methodological quality of the included studies (Sun et al., 2022; Wong et al., 2021). Some studies lacked details in their methods of blinding participants (Sun et al., 2022). The absence of randomization in some studies was particularly problematic (Chao et al., 2020). Secondly, heterogeneity could not be explained by the results of subgroup analyses (Wong et al., 2021). Thirdly, the sample size of most of the studies was relatively small in some studies, although this is also common in other meta-analyses (Sun et al., 2022). Fourthly, although, we have carried out a search in three different databases, it would have been interesting to add some other databases.

4.2. Future lines of research

Futures studies are needed to study what are the most beneficial contents, frequencies, durations, formats, number of sessions, strategies and activities of CS (Spector et al., 2012). Future research regarding the long-term effects of CS should be investigated (Cafferata et al., 2021; Chao et al., 2020) especially in healthy cognitive ageing and MCI (La Rue, 2010). Moreover, it would be of great interest to encourage older adults with dementia to complete the CS sessions and to not drop out of the intervention. To this end, nurses could take into account in a creative and enjoyable way according to patient́s preferences (Qiao et al., 2018). In addition, it would be necessary to know if the participants with CS take any pharmacological treatment to better differentiate between 1) those who are taking pharmacological drugs and receive CS, 2) those who only receive CS and 3) those who only take drugs. Moreover, the differences in function of gender of the participants could be taken into account.

Moreover, our meta-analysis, based on the study of CS programs in older adults, may have implications for climate change and sustainability due to its relationship with global demographic ageing, and driven by the need to provide a sustainable solution to the increasing prevalence of age-related cognitive decline. The implementation of computerized products will reduce the costs of interventions for citizens with cognitive decline, contributing to the sustainability and efficiency of healthcare systems. Moreover, these products will be in line with policies on health, education and science (Apóstolo et al., 2019).

The inclusion of the recommendations in the educational materials in computerized CS programs will allow them to be successfully replicated in different contexts. It would also be highly desirable to scale up the creation of such programs in order to achieve a greater benefit that contributes to increasing life expectancy and avoiding/preventing unnecessary/too early institutionalization of older adults (Apóstolo et al., 2019). In addition, CS computerized CS could be viewed as the zero-emissions energy for sustainable development (Lutz, 2017).

Although technology-based interventions have gained some popularity in research over the past two decades, their uptake in policy and practice has been slow (Astell et al., 2019). However, with the reduced availability of support services, technology-based interventions that can be accessed remotely by people with cognitive impairment could be one way to bridge this gap (Liu et al., 2021).

5. Conclusions

Our findings suggest that personalized/adapted CS improves QoL in the older adults with healthy cognitive ageing, MCI, or dementia. However, CS seemed not to improve anxiety and depression levels and ADLs. CS programs in older adults may have implications for climate change and sustainability due to their relationship with global demographic ageing, and driven by the need to provide a sustainable solution to the increasing prevalence of age-related cognitive decline. Health care teams play a crucial role in the implementation and/or supervision of CS programs to be beneficial to older adults with and without dementia in any care setting.

IRB protocol/human subjects approval

Not applicable

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Availability of data, code, and materials

Data sharing is in a Supplementary Document.

CRediT authorship contribution statement

Isabel Gómez-Soria: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Isabel Iguacel:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Juan Nicolás Cuenca-Zaldívar:** Visualization, Validation, Supervision, Software, Methodology, Investigation, Formal analysis, Data curation. **Alejandra Aguilar-Latorre:** Writing – review & editing, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation. **Patricia Peralta-Marrupe:** Writing – review & editing. **Eva Latorre:** Writing – review & editing. **Estela Calatayud:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of Competing Interest

The Authors declare that there is no conflict of interest.

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Supplementary materials

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