

Reading and Writing in 22q11.2 Syndrome: A Systematic Review

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ABSTRACT:

22q11.2 deletion syndrome (22q11DS) is a genetic disorder characterized by a wide phenotypic variability, including congenital heart defects, distinctive facial features, short stature, and neurodevelopmental difficulties. From a cognitive perspective, individuals with 22q11DS often present with mild intellectual impairment or borderline functioning, along with deficits in attention, executive functions, and language, which may impact academic achievement.

This systematic review examines reading and writing skills in individuals with 22q11DS, with the aim of identifying characteristic literacy patterns and associated neuropsychological factors. Following PRISMA, 16 studies met the inclusion criteria. Data were analyzed using the COSMIN framework to ensure methodological quality.

Findings reveal a heterogeneous but consistent literacy profile. Reading, particularly word decoding and sight-word recognition, tends to be relatively preserved and often represents a relative strength. However, significant impairments are observed in reading comprehension, especially in tasks requiring inference and integration of information. Writing shows a similar pattern, with greater difficulties in higher-level processes such as planning and coherence. These difficulties are closely linked to deficits in working memory, executive functions, attention, and processing speed.

Overall, results highlight a dissociation between basic and complex literacy processes, emphasizing the need for interventions targeting higher-order cognitive and linguistic skills.

Keywords: 22q11.2 deletion syndrome; reading; writing; education.

1. Introduction

22q11.2 deletion syndrome (22q11DS), also known as velocardiofacial syndrome or DiGeorge syndrome, is a genetic disorder caused by a microdeletion on the long arm of chromosome 22. It is one of the most common microdeletion syndromes, with an estimated prevalence of 1:3,000–1:4,000 live births (Driscoll et al., 1993; McDonald-McGinn et al., 2015). The clinical phenotype is markedly heterogeneous and includes congenital heart defects, palatal abnormalities, immune dysfunction, endocrine abnormalities, and a wide spectrum of neuropsychological and psychiatric difficulties (Chávez, 2020).

From a neurodevelopmental perspective, 22q11DS is consistently associated with cognitive and linguistic impairments that directly impact academic learning (Laorden, 2019). Several studies have described a cognitive profile characterized by a global intelligence quotient (IQ) that is predominantly borderline or indicative of mild intellectual disability, with significant interindividual variability (De Smedt et al., 2007; Swillen et al., 1997). A recurring finding is the discrepancy between verbal and nonverbal performance, with relatively higher scores on verbal IQ compared to performance IQ, especially during childhood (Swillen & McDonald-McGinn, 2015).

22q11DS is associated with a characteristic neuropsychological profile that affects multiple cognitive domains, including attention, memory, executive functions, visuospatial processing, and processing speed (Laorden, 2019). These alterations constitute one of the main factors explaining the academic difficulties observed in this population, especially in learning to read and write (Swillen et al., 1997). Overall, individuals with 22q11DS typically present with borderline intellectual functioning or mild intellectual disability, although with high interindividual variability (De Smedt et al., 2007). One of the most consistent features of the cognitive profile is the discrepancy between verbal and nonverbal skills, with relatively better performance in verbal areas compared to visuospatial and manipulative skills (Swillen et al., 1997). This uneven cognitive pattern directly influences the development of complex academic skills, as it favors

certain basic linguistic competencies while limiting processes related to spatial organization, visual integration, and planning (Gothelf et al., 2007).

Attention deficits are among the most frequent neuropsychological challenges in 22q11DS. Several studies have described difficulties with sustained, selective, and divided attention, which affect academic performance and learning ability (Bearden et al., 2001). It is estimated that between 30% and 50% of children with this syndrome meet the diagnostic criteria for attention deficit hyperactivity disorder (ADHD) (Antshel et al., 2005; Niarchou et al., 2014). Difficulties with sustained attention result in problems maintaining focus on prolonged tasks, such as reading or writing, while deficits in selective attention interfere with the ability to filter out irrelevant stimuli (Antshel et al., 2008). These limitations lead to greater cognitive effort during learning and hinder the automatization of basic academic skills. Furthermore, it has been observed that attentional deficits in 22q11DS can increase with age, contributing to a progressive decline in academic and functional performance (Antshel et al., 2008).

Memory is another cognitive domain widely affected in 22q11DS. The scientific literature has described alterations in both working memory and episodic memory, with a differential pattern between verbal and nonverbal memory (Gothelf et al., 2007). Working memory, especially verbal working memory, often shows lower performance than expected for the individual's age (Bearden et al., 2001). This deficit is particularly relevant for learning to read and write, since working memory allows for the maintenance and manipulation of phonological information during reading encoding and written production (Alloway et al., 2009). Longitudinal studies have indicated that working memory difficulties can intensify during adolescence, affecting academic and adaptive development (Gothelf et al., 2007).

Regarding episodic memory, relatively better performance has been observed on auditory-verbal memory tasks compared to visual and spatial memory (Henry et al., 2002). This pattern is consistent with the greater relative preservation of verbal versus nonverbal skills described in the

cognitive profile of the syndrome (Bearden et al., 2001). However, although verbal memory may constitute a relative strength, it still falls below the performance observed in typically developing individuals (Bish et al., 2005).

Executive functions represent one of the domains most consistently impaired in 22q11DS. These functions include processes such as planning, cognitive flexibility, inhibitory control, abstract reasoning, and problem-solving, in both children and adults with the syndrome (Bish et al., 2005; Henry et al., 2002). Planning difficulties affect the organization of complex academic tasks, such as producing written texts or understanding lengthy texts (Simon et al., 2005). Limited cognitive flexibility can hinder adaptation to changes in task demands or the application of alternative learning strategies (Lewandowski et al., 2007). Similarly, deficits in inhibitory control are associated with impulsivity and frequent errors during tasks requiring precision and continuous monitoring (Hernández & González, 2025). From an academic perspective, executive dysfunctions directly influence reading comprehension, written expression, and mathematical problem-solving, as these processes require the simultaneous integration of multiple cognitive operations (Solot et al., 2000).

Visuospatial skills are among the most affected domains in 22q11DS and have been described as a distinctive feature of the syndrome's neuropsychological profile (Simon et al., 2005). Difficulties in this area include problems with visual perception, spatial organization, and visuomotor integration (Lewandowski et al., 2007). These impairments have significant implications for academic learning. In reading, they can affect visual word recognition, eye tracking, and spatial orientation of text (Laorden, 2019). In writing, they are associated with graphomotor difficulties, problems with the spatial organization of handwriting, and reduced legibility (Alloway et al., 2009).

Another relevant aspect of the neuropsychological profile in 22q11DS is reduced processing speed (Alloway et al., 2009). Several studies have indicated that individuals with this syndrome require more time to process visual and verbal information,

which negatively impacts academic tasks that demand speed and automation, such as fluent reading or spontaneous writing (Lewandowski et al., 2007). Slower processing speed increases cognitive load during schoolwork, contributes to mental fatigue, and limits learning efficiency (Simon et al., 2005). This factor, combined with attentional and executive deficits, significantly contributes to the characteristic academic profile of 22q11DS (Campbell et al., 2006).

Reading difficulties in 22q11DS should be understood within the context of a broader neuropsychological profile. The literature describes consistent impairments in verbal memory, attention, executive functions, and visuospatial skills (Bish et al., 2005; Swillen et al., 1997). In particular, verbal working memory has been identified as a key predictor of reading and writing performance, both in typically developing individuals and in individuals with neurodevelopmental disorders (Alloway et al., 2009).

Likewise, the visuospatial deficits characteristic of 22q11DS affect visual word recognition, eye tracking during reading, and the spatial organization of written text (Simon et al., 2005). These factors contribute to persistent reading errors and an inefficient reading experience (Laorden, 2019).

Language impairments are among the earliest and most persistent manifestations of 22q11DS (Hernández & González, 2025). Numerous studies concur in describing significant delays in the acquisition of expressive language, with late speech onset, phonological and articulatory difficulties, and frequently hypernasal speech associated with velopharyngeal anomalies (Campbell et al., 2006; Solot et al., 2000). These early difficulties constitute a key predictor of later problems in acquiring reading and writing skills (Laorden, 2019). From a phonological perspective, children with 22q11DS exhibit deficits in speech sound discrimination and phonological awareness, fundamental skills for learning to read in alphabetic systems (Lewis, 2000). These limitations directly affect grapheme-phoneme conversion and partially explain the difficulties observed in reading pseudowords and in orthographic writing (Swillen et al., 1999). At the

morphosyntactic and lexical levels, although progression is observed with age and speech therapy, development is usually slower and less efficient than in typically developing individuals (Swillen et al., 1999). Limitations in vocabulary and syntactic comprehension particularly affect higher levels of reading comprehension and the written production of structured texts (Laorden, 2019).

Reading is one of the academic areas most frequently affected in 22q11DS. Studies that have assessed reading performance using standardized tests show scores significantly lower than those expected for the chronological age, both in accuracy and reading speed (Antshel et al., 2005; De Smedt et al., 2007). Regarding decoding processes, a pattern of greater impairment in reading pseudowords compared to familiar words has been described, suggesting a deficit in the phonological reading route (Henry et al., 2002). This profile is consistent with the previously described phonological difficulties and limitations in verbal working memory, widely documented in this syndrome (Bearden et al., 2001; Gothelf et al., 2007).

Reading speed is another clearly compromised aspect. Even when accuracy is acceptable, reading is often slow and lacks automatization, increasing cognitive load and hindering text comprehension (Lewandoski et al., 2007). This slowness has been linked to deficits in processing speed, sustained attention, and executive control, domains that consistently show low performance in the 22q11DS (Antshel et al., 2008).

Reading comprehension is probably the most affected component of the reading process. Several studies indicate that children and adolescents with 22q11DS have significant difficulties integrating textual information, making inferences, and extracting the overall meaning of texts, even when basic decoding is relatively preserved (Campbell et al., 2006; Simon et al., 2008). These difficulties are explained by the interaction between linguistic limitations (vocabulary and syntax), working memory deficits, and impairments in executive functions such as planning and cognitive flexibility (Laorden, 2019).

Writing is another academic area particularly vulnerable in 22q11DS. Available studies describe difficulties in both the mechanical aspects of writing and the higher-level processes involved in written composition (Antshel et al., 2005; Campbell et al., 2006). At the orthographic level, phonologically plausible errors, omissions, and difficulties in applying arbitrary spelling rules are frequent, reflecting a fragile phonological foundation and poor automatization of the writing process (Sebastián-Lázaro et al., 2022). These difficulties persist with age and often coexist with poor reading performance, reinforcing the close relationship between the two processes (Laorden, 2019).

Regarding written expression, texts produced by students with 22q11DS are typically brief, with simple syntactic structures and limited overall coherence (Laorden, 2019). Difficulties in planning, discourse organization, and text revision have been linked to executive function impairments, which are widely documented in this syndrome (Antshel et al., 2008; Bish et al., 2005).

Despite existing evidence on reading and writing characteristics in this population, studies are heterogeneous and scattered throughout the literature, with significant methodological differences in terms of samples, instruments, and variables analyzed. This situation hinders the drawing of firm conclusions and limits the transfer of findings to clinical and educational practice. Therefore, a systematic review is needed to synthesize the available evidence on reading and writing characteristics in individuals with 22q11DS, identify the main associated neuropsychological factors, and analyze the assessment tools used. A more precise understanding of these processes will allow for the design of specific, evidence-based speech therapy and educational interventions that contribute to improving the academic performance and quality of life of the affected individuals.

2. Methodology

Strategies for article identification

This research was conducted through a systematic review of the scientific literature to analyze the reading and writing characteristics of individuals with 22q11DS. The guidelines established by the

PRISMA statement (Preferred Reporting Items for Systematic Reviews and Meta-Analyses), which provides a methodological framework to improve transparency and quality in systematic reviews (Page et al., 2021), were followed, and principles of scientific rigor were applied at all stages of the review.

The search for studies was carried out in internationally recognized databases, specifically Scopus, Dialnet, PsycINFO, Web of Science, and PubMed (selected for their relevance in the fields of neuropsychology, education, and health sciences). Additionally, to reduce publication bias, the Education Resources Information Center (ERIC) database was included. On the other hand, in order to determine the relevance of the documents found to the research intended in this review, a search strategy was devised using the DeCS descriptors “22q11”, “DiGeorge”, “velocardiofacial syndrome”, “reading”, and “writing”, as well as the Boolean operators “AND” and “OR” to obtain possible combinations. The Mendeley bibliographic manager was used for managing bibliographic citations.

Strategies for selecting articles

The following inclusion criteria were used to select articles: (1) experimental, quasi-experimental, case studies, or observational research; (2) studies directly addressing the review topic or providing relevant information for understanding the literacy profile of this population; and (3) articles written in English or Spanish. Exclusion criteria included theoretical reviews, meta-analyses, studies focused exclusively on medical or genetic aspects without cognitive or academic assessment, single-case studies without standardized tests, studies unrelated to the review topic, duplicate articles across databases, and works written in languages other than English or Spanish.

After applying these criteria, a data extraction protocol was designed to systematically code the characteristics of each study. The variables recorded

included: year of publication, sample characteristics (age and size), areas assessed, assessment instruments used, and main study findings.

Regarding the selection process, a taxonomic selection was carried out in three stages. The first stage involved reading the titles of the results obtained from searches in the different databases, with the aim of selecting articles related to the objective of the systematic review. The second stage consisted of reading the abstracts of each of the selected articles to verify that they met the previously established inclusion and exclusion criteria. Finally, the third stage consisted of a qualitative analysis of the selected articles through a comprehensive reading, as well as by using the COSMIN checklist for conducting systematic reviews (Mokkink et al., 2012). Subsequently, the data were collected from the articles, extracting the information relevant to this review.

Strategies for analyzing scientific evidence

The strategies for analyzing the scientific evidence aimed to facilitate the coding process for the characteristics and results of the selected studies. The variables coded were: citation in APA 7 format, study type, study objective, sample size, mean age of participants, area of the neuropsychological profile studied, results, and main conclusions.

A total of 6,666 documents were identified using the aforementioned search strategies. It should be noted that no additional articles were included after reviewing the references. Of these initial 6,666 articles, 140 were eliminated due to duplicates, and 36 articles were ultimately preselected based on their titles.

Subsequently, the screening phase was carried out by reading the keywords and the abstract, as well as applying the inclusion and exclusion criteria. Seventeen articles were excluded because they did not focus on the literacy profile of people with 22q11DS, two were reviews, and one was inaccessible, resulting in a final list of 16 articles for review. This process is detailed in Figure 1.

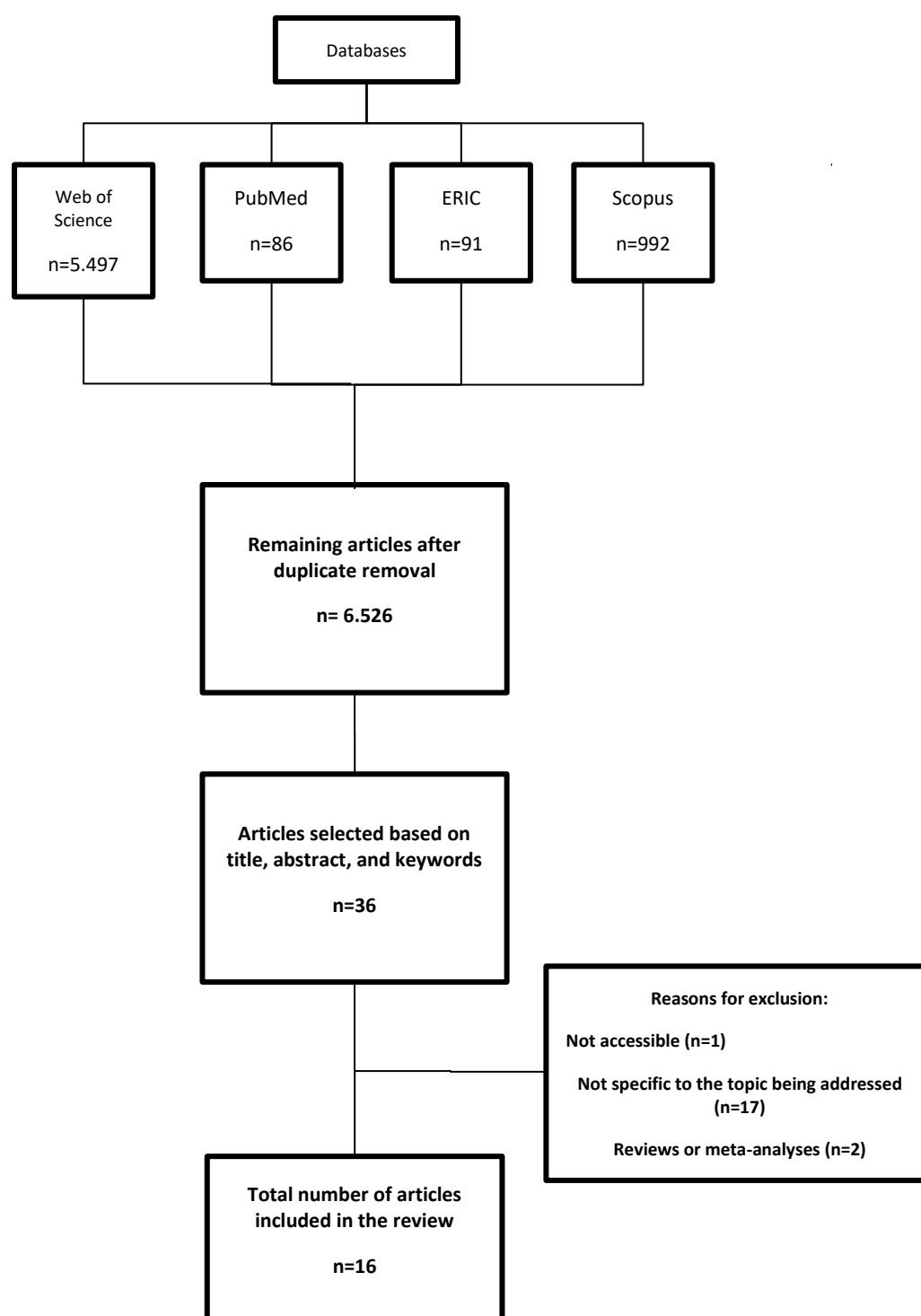


Figure 1.

Flowchart of the bibliographic selection process based on the established criteria.

3. Results

The analysis of the studies included in this review was conducted using the COSMIN (CONsensus-based Standards for the selection of health Measurement INSTRUMENTs) methodology (Mokkink et al., 2012), which allows for the

systematic evaluation of the quality of the tools used in research. This methodological approach ensures the validity and reliability of the analyzed measurements, considering aspects such as internal consistency, reliability, measurement error, content validity, and structural validity, among others. The results of this evaluation are detailed in Table 1.

Table 1.*COSMIN Methodology*

Research	A	B	C	D	E	F	G	H	I	J
Antshel et al., 2005	?	?	?	+	?	+	?	?	?	+
Antshel et al., 2014	?	?	?	+	?	+	?	?	?	+
Bearden et al., 2001	?	?	?	+	?	+	?	?	?	+
Campbell et al., 2009	?	?	?	+	?	+	?	?	?	+
Chow et al., 2006	?	?	?	+	?	+	?	?	?	+
de Smedt et al 2006	?	?	?	+	?	+	?	?	?	+
de Smedt et al 2007	?	?	?	+	?	+	?	?	?	+
de Smedt et al 2003	?	?	?	+	?	+	?	?	?	+
Hamsho et al., 2017	?	?	?	+	?	+	?	?	?	+
Jacobson et al., 2010	?	?	?	+	?	+	?	?	?	+
Kok y Solman, 1995	?	?	?	+	?	+	?	?	?	+
Lajiness-O'Neill et al., 2006	?	?	?	+	?	+	?	?	?	+
Moss et al., 1999	?	?	?	+	?	+	?	?	?	+
Swillen et al., 1999	?	?	?	+	?	+	?	?	?	+
Tobia et al., 2018	?	?	?	+	?	+	?	?	?	+
Woodin et al., 2001	?	?	?	+	?	+	?	?	?	+

Note: + positive; – negative; ? Not applicable. Table A refers to internal consistency; Table B to reliability; Table C to measurement error; Table D to content validity; Table E to structural validity; Table F to hypothesis testing; Table G to cross-cultural validity; Table H to criterion validity; Table I to responsiveness; and Table J to interpretability.

Demographic and methodological variables were also collected, such as sample size, participant age, sex ratio, and the components evaluated in each study. This data allows for the identification of common characteristics in the studied population, providing a solid basis for comparison and synthesis of the findings, as presented in Table 2.

Table 2.*Sociodemographic variables of the selected studies.*

Authors	Sample description		Study objective
	N	Average age	
Antshel et al., 2005	50 boys with 22q11, 40 girls with 22q11, 13 brothers, 17 sisters, 28 male controls and 19 female controls	11.1, 10.8, 12.3, 12.2, 10.7 and 9.2 years	Cognitive functioning
Antshel et al., 2014	80 children with 22q11, 33 siblings and 40 children with ADHD and learning difficulties	11.9, 12.2 and 12 years	Reading comprehension
Bearden et al., 2001	29 children with 22q11	10.34 years	Neurocognitive phenotype
Campbell et al., 2009	12 children with 22q11 and 12 with Williams syndrome	11 and 12 years	Cognitive characteristics
Chow et al., 2006	27 people with 22q11 and schizophrenia, and 29 with 22q11 without psychosis	30.6 and 25 years	Neurocognitive profile
de Smedt et al 2006	14 children with 22q11 and 14 controls	101.79 and 98.86 months	Mathematical skills
de Smedt et al 2007	11 children with 22q11 and 11 controls	123.46 and 127.64 months	Mathematical skills
de Smedt et al 2003	13 children with 22q11	6.4 years	Pre-academic and early academic skills
Hamsho et al., 2017	69 adolescents with 22q11 and 50 controls	12.9 and 13.02 years	Written language
Jacobson et al., 2010	31 children and adolescents with 22q11	11.8 years	Neuropsychological profile
Kok y Solman, 1995	6 children and adolescents with 22q11	10.83 years	Learning difficulties

Lajiness-O'Neill et al., 2006	14 people with 22q11 and 8 control siblings	12.6 and 11.4 years	Neuropsychological phenotype
Moss et al., 1999	33 people with 22q11	10.8 years	Psychoeducational profile
Swillen et al., 1999	9 children with 22q11	10.5 years	Neuropsychological, academic and psychosocial profile
Tobia et al., 2018	18 children and adolescents with 22q11 (9 young and 9 older)	9.87 years at the start of the study, 15.07 at the end	Cognitive and educational profile
Woodin et al., 2001	81 children with 22q11	10.6 years	Neuropsychological characteristics and behavioral phenotype

The studies analyzed in this review highlight a wide variety of objectives and findings related to the development of reading and writing skills in individuals with 22q11DS. However, it is important to note that the assessment tools used vary across studies. Table 3 shows the tools used in the different investigations.

Table 3.

Assessment instruments used in the reviewed articles.

Research	Assessment instruments used
Antshel et al., 2005	Wechsler Intelligence Scale for Children—Third Edition, Wechsler Individual Achievement Test-2nd edition, Vineland Adaptive Behavior Scales y Schedule for Affective Disorders and Schizophrenia for School-Age Children-Present and Lifetime Version
Antshel et al., 2014	WISC-III, Wechsler Individual Achievement Test (WIAT-II), Gordon Diagnostic System - Continuous Performance Test (CPT), Wisconsin Card Sorting Test (WCST), Stroop Colour-Word Test, Tower of London (TOL), California Verbal Learning Test-Children's version (CVLT-C), California Verbal Learning Test (CVLT), Schedule for Affective Disorders and Schizophrenia for School-Age Children-Present and Lifetime Version (K-SADS-PL), Autism Diagnostic Interview-Revised (ADI-R) and Behaviour Assessment Scale for Children (BASC)
Bearden et al., 2001	WRAML Verbal Learning, California Verbal Learning Test-Children's Version, CMS Dot Locations, WRAML Design Memory, WISC-III Verbal Comprehension & Perceptual Organization and Wechsler Individualized Achievement Test.
Campbell et al., 2009	Cognitive battery designed for study that evaluates cognitive function and psychoeducational skills, Wechsler Intelligence Scales for Children—third edition (UK), British Picture Vocabulary Scale, Test for the Reception of Grammar, Wechsler Objective Numerical Dimensions, Wechsler Objective Language Dimensions, Wechsler Objective Reading Dimensions, Children's Memory Scale, The Grooved Pegboard, Birmingham

	Object Recognition Battery, Theory of Mind, Strange Stories, Interactive sociability scale and Medical Research Council development of face processing skills battery
Chow et al., 2006	Structured clinical interview for DSM-IV, complete battery of neurocognitive assessment with 24 individual tests, Wechsler Adult Intelligence Scale-Revised (WAIS-R), Wide Range Achievement Test 3 (WRAT3), ToM test and Thematic Apperception Test
de Smedt et al 2006	Computerized number reading task, number comparison task, verbal counting tasks, single-digit computerized arithmetic tasks, multi-digit arithmetic tasks, verbal problem-solving tasks and Dutch One-Minute-Reading Test
de Smedt et al 2007	Computerized number reading task, number comparison task, verbal counting tasks, single-digit computerized arithmetic tasks, multi-digit arithmetic tasks, verbal problem-solving tasks and Dutch One-Minute-Reading Test
de Smedt et al 2003	Flemish-Dutch version of the Wechsler Preschool and Primary Scale of Intelligence Revised (WPPSI-R), Dutch Student Monitoring System CITO y Flemish Student Monitoring System for Reading and Spelling and the Mathematics up to Ten Test
Hamsho et al., 2017	CPE, WCST, TOL, Visual Span Test, CVLT-C, Clinical Evaluation of Language Fundamentals (CELF- IV), K-SADS-PL, WISC-III and WIAT-II
Jacobson et al., 2010	Wechsler Intelligence Scale for Children – 3rd Edition, Chil-dren's Memory Scale, Wechsler Objective Reading Dimensions (WORD) and Wechsler Objective Numerical Dimensions (WOND) test
Kok y Solman, 1995	Neale Analysis of reading ability, adaptive computer testing, WICAT Test of Basic Skills (WTBS) and Waterford Learner Profile (WLP)
Lajiness- O'Neill et al., 2006	Wechsler Intelligence Scale for Children—Third Edition, Wechsler Adult Intelligence Scale, Wide Range Achievement Test-3, Gray Oral Reading Test-3, Developmental Test of Visual–Motor Integration, Grooved Pegboard Test, Motor Free Visual Perception Test, Judgment of Line Orientation, Controlled Oral Word Association, Boston Naming Test, Tokens Test, Test of Memory and Learning, Test of Variables of Attention, Wisconsin Card Sorting Test, Stroop Test, BehaviorRating Inventory of Executive Function (BRIEF), Child Behavior Checklist, Conners' Parent Rating Scale, Children's Depression Inventory and Revised Children' Manifest Anxiety Scale
Moss et al., 1999	Wechsler Preschool and Primary Scales of Intelligence - Revised, Wechsler Intelligence Scale for Children-Third Edition, Wechsler Adult Intelligence Scale-Revised, Wechsler Individual Achievement Test, Woodcock-Johnson Tests of Achievement-Revised and CELF-R
Swillen et al., 1999	Wechsler Intelligence Scale for Children-Revised (WISC-R), Test of Visual Perceptual Skills (TVPS), Bourdon-Vos dot-test, 15 words from Rey, Name Learning of the Revised Amsterdam Child Intelligence test (RAKIT), Finger localization, Bruininks-Oseretzky test of Motor Proficiency, Visual Motor integration Test, Wisconsin Card Sorting Test (WCST), Language Test for children (TVK), Brus-One Minute Test, pseudo-word-test, Bel 0, 1, 2a y 3a, Kortrijk Arithmetic Test, Praxis, and Child Behaviour Checklist.

Tobia et al., 2018	British Ability Scales (BAS-II)
Woodin et al., 2001	Wechsler Intelligence Scale for Children—Third Edition (WISC-III), Wechsler Preschool and Primary Scales of Intelligence—Revised (WPPSI-R), Wechsler Adult Intelligence Scale (WAIS), Wechsler Individual Achievement Test, Woodcock-Johnson Tests of Achievement—Revised, Trail-Making Test, Wide Range Assessment of Memory Learning (WRAML) and Achenbach Child Behavior Checklist (CBCL)

Finally, Table 4 presents the main results relating to reading and writing in people with 22q11DS, extracted from the studies selected for this systematic review.

Table 4.

Main results related to literacy reflected in the reviewed articles.

Research	Main results
Antshel et al., 2005	Women score better than men on both composite reading and writing tests.
Antshel et al., 2014	Below-average scores in reading comprehension (worsening over time) and word reading (with stable scores). Predictors for reading comprehension include decoding skills, interference control, self-monitoring, and working memory.
Bearden et al., 2001	Participants scored higher on reading tasks than on arithmetic tasks.
Campbell et al., 2009	Both groups have difficulties in reading comprehension.
Chow et al., 2006	Participants show a relative preservation of reading and spelling skills compared to their arithmetic skills.
de Smedt et al 2006	Accuracy in reading and writing numbers is high in both groups. Reading tests show no differences between groups, with reading being preserved in children with 22q11.
de Smedt et al 2007	Reading, writing, and reading speed of numbers, as well as performance on the reading task, showed no differences between groups.
de Smedt et al 2003	The scores for reading (decoding) and spelling were within the normal range. No significant differences were found between reading and mathematics, spelling and mathematics, or reading and spelling.
Hamsho et al., 2017	Executive function and linguistic ability in childhood act as predictors of written expression skills in the 22q11 group, differing from the predictors in the control group (childhood verbal IQ).
Jacobson et al., 2010	Reading skills are in the low average range. Basic reading ranks above spelling and reading comprehension, achieving the most consistent performance and being a relatively strong point on the 22q11. Age showed a significant negative association with reading

comprehension.

Kok y Solman, 1995	Computer-assisted instruction is effective for addressing reading and writing difficulties, showing significant improvements in reading skills relative to the subject's age. The programs help students learn phonics and sight word recognition, and increase decoding ability and fluency. In reading, they exhibit difficulties with punctuation and grammar, as well as low phonemic awareness. They also experience difficulties with inferential text comprehension.
Lajiness- O'Neill et al., 2006	There are no significant differences between groups in sight-reading, spelling, or reading comprehension. Individuals with 22q11 deletion syndrome perform significantly worse on math tests than on reading and spelling.
Moss et al., 1999	Mathematical performance was significantly lower than reading and spelling. Reading comprehension scores and single-word reading scores were similar.
Swillen et al., 1999	Better scores were obtained on reading-decoding and spelling tests (with average or above-average scores) compared to arithmetic tests, as well as better scores on reading comprehension compared to decoding (although the latter difference is not statistically significant). Reading and writing skills are within the normal range.
Tobia et al., 2018	Regarding reading, approximately 75% of the younger sample and 65% of the older sample could be considered hyperlexic in both time assessments, and between 50% and 56% of each group showed a similar level of spelling. The younger group showed worse results in word reading in the second assessment despite being at the average level, and the older group showed a slight and non-significant increase in their decoding skills.
Woodin et al., 2001	Participants demonstrate below-average performance in general reading and borderline performance in mathematics. Their word recognition skills are significantly better than their reading comprehension skills. Spelling falls within the below-average range.

4. Discussion

The results of this systematic review provide an integrated and up-to-date overview of the literacy profile of individuals with 22q11DS, as well as the neuropsychological factors that explain their performance. In general, the findings confirm the existence of a heterogeneous and characteristic pattern, where reading skills, especially decoding, tend to be a relatively strong point compared to areas such as mathematics, visuospatial processing, and some complex aspects of language and reading comprehension (Antshel et al., 2005; Jacobson et al., 2010; Swillen et al., 1999).

However, this apparent strength should be interpreted with caution, since reading in this population presents significant limitations when analyzing more complex cognitive processes, such

as fluency and deep comprehension of texts (Campbell et al., 2009; Woodin et al., 2001). The reviewed studies agree that word decoding and sight reading tend to fall within low average ranges but are largely preserved in most participants, which aligns with the linguistic profile described in the syndrome, characterized by a relative advantage in verbal skills compared to nonverbal domains (Bearden et al., 2001; Swillen et al., 1997). This trend persists even in comparisons with mathematical performance, where reading typically shows significantly superior performance (Chow et al., 2006; Lajiness-O'Neill et al., 2006; Moss et al., 1999).

However, this relative strength contrasts with persistent difficulties in reading comprehension. Several studies highlight reduced scores on tasks requiring semantic integration, inference, and

retention of relevant verbal information (Antshel et al., 2014; Campbell et al., 2009; Woodin et al., 2001). This progressive decline becomes especially noticeable during adolescence, likely linked to the intensification of executive and working memory deficits described in the literature (Gothelf et al., 2007). The pattern observed in the longitudinal study by Tobia et al. (2008) illustrates this trend: although many participants exhibited a hyperlexic profile with high decoding performance relative to their age and IQ, this advantage did not translate into equivalent reading comprehension. This suggests that reading in individuals with 22q11DS may rely on mechanical processes heavily supported by visual recognition, while higher-level semantic skills, dependent on verbal working memory, executive functions, and cognitive flexibility, remain impaired.

The predictors identified by Antshel et al. (2014) reinforce this interpretation, highlighting the importance of processes such as inhibitory control, self-monitoring, and working memory in reading comprehension—all elements particularly affected in the neuropsychological profile characteristic of the syndrome. Consequently, the difficulty lies not so much in word identification as in the efficient use of linguistic information during reading, demonstrating the need for interventions focused on higher-order language processes.

Regarding writing, a similar pattern to that observed in reading is seen: better performance in basic mechanical aspects, such as phonologically

transparent spelling, and greater difficulties in tasks requiring planning, syntactic organization, and discourse coherence (Antshel et al., 2005; Hamsho et al., 2017; Laorden, 2019). Written expression appears to be strongly influenced by early executive and linguistic functioning, beyond verbal IQ, such that deficits in executive control, working memory, and flexibility directly impact the quality of the text produced (Antshel et al., 2014; Hamsho et al., 2017). Furthermore, the visuospatial difficulties characteristic of 22q11DS affect graphomotor skills, spatial organization of text, and legibility (Simon et al., 2005). The interaction of these factors contributes to weaker performance in text organization, revision, and overall writing coherence, confirming that this area constitutes a particularly demanding and vulnerable academic domain in this syndrome (Bish et al., 2005).

5. Conclusion

Taken together, the findings of this review show a consistent pattern where reading and writing in individuals with 22q11DS exhibit relative strengths in mechanical and phonological processes, but vulnerability in components requiring integration, planning, and cognitive regulation. This profile highlights the importance of assessing and intervening not only in basic skills, but also in the higher executive and linguistic processes that support textual comprehension and production, thus providing a more solid foundation for individualized educational and therapeutic strategies.

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Author Declaration

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