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Norma-Latina neuropsychological battery: a validation of a tool for children with Intellectual Disability from Colombia

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ABSTRACT

Objective: *Individuals with Intellectual Disability (ID) usually experience cognitive difficulties, among others. The objective was to validate the Norma-Latina battery in a group of children with ID from Bogota, Colombia.*
Methods: *The sample consisted of 132 Colombian children with ID and 132 Healthy Control (HC) matched by sociodemographic characteristics. Wilcoxon rank-sum test was employed to compare 25 raw test-scores, cognitive domains, and low scores between groups. Additionally, area under the curve (AUC), Youden Index (J), and Index of Union (IU) were used to define the optimal cutoff-point to discriminate between ID and HC groups.*
Results: *Children with ID performed worse than HC in all cognitive domains (executive functions, language, learning and memory, and speed processing). AUC showed good accuracy in discriminating between individuals with ID and HC (AUC>.94).*
Conclusions: *The results strongly support the applicability of the Norma-Latina battery for Colombian children, and it shows capacity of discrimination in ID patients.*

Key words:

Intellectual Disability; validation; Norma-Latina; battery; children; adolescents.

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INTRODUCTION

According to the American Association on Intellectual and Developmental Disabilities[1], intellectual disability (ID) is "characterized by significant limitations in both intellectual functioning and adaptive behavior, which covers many everyday social and practical skills". People with ID usually suffer physical, behavioral, emotional, and cognitive deficits that could lead to everyday problems at school[2,3], family[3,3], and social interactions[2,3], affecting their quality of life (QoL)[3,4].

Regarding cognitive deficits, individuals with ID often experience problems in reasoning[5,6], learning and memory[5,7], attention[7], problem-solving[7], inhibitory control[8], and language functions[3,6]. Thus, the evaluation, diagnosis, and intervention are the main priority in rehabilitation services[9].

Today, there are varying instruments to evaluate the physical injury[3,10]community participation, and quality of life (QoL, emotion[10,11], behavior[12], and QoL-[3]community participation, and quality of life (QoL of children with ID. However, there are limited neuropsychological batteries designed to measure the main cognitive deficits related to ID. Instead, several individual neuropsychological instruments are used to assess different cognitive domains along with intelligence tests and functional independence scales. Neuropsychologists usually are not aware of the validity of the elected battery to discriminate between youth with ID and healthy children (HC). However, recently the NIH-Toolbox Cognitive battery has been developed in the United States of America and validated for children with ID, with good psychometric data[13].

In Latin America (LA), approximately 4.6% of the population has ID[14], and the majority do not receive any intervention for health care and social services. Due to the lack of validated neuropsychological tests, children with ID in this region are often misdiagnosed. Rivera and Arango-Lasprilla[15] conducted a normative study with people between 6 and 17 years old from 13 different LA countries for the ten most common neuropsychological tests. However, the usefulness of this battery has no study references in youth with ID. Therefore, the purpose of this article is to validate the Norma-Latina battery in a group of children with ID from Bogota, Colombia.

The use of culturally appropriate, validated neuropsychological instruments will help with the identification and differentiation of children with ID and HC. Therefore, this study will help caregivers and clinicians to better understand ID presentation and to offer improved tailored services that will assist the integration of these children into their home, academic, and society[16].

METHODS

Participants

The sample consisted of 264 Colombian participants. The ID group consisted of 132 children, mainly girls (50.5%) being the mean age 10.0 (SD=2.5) and an average parent education (MPE) of 8.2 (SD=2.6) years. The HC group, selected from normative data study[15,17], consisted of 132 children paired for age (p=.891;r=0.99), sex (p=.644;r=0.99) and MPE (see Table 1).

Table 1. Comparison of the samples.

		Group								
		HC (*n*=132)			ID (*n*=132)			Statistic	p value	Effect size (r)
		Median	Min	Max	Median	Min	Max			
Age		10.1	7.0	15.0	10.1	7.0	15.0	W=8796.5	.891	r=0.99
MPE		8.3	2.5	13.0	8.9	2.0	13.0	W=8995.0	.644	r=0.99
Sex	Girls		52	49.5%		53	50.5%	0.0	1.00	Phi= 0.89
	Boys		80	50.3%		79	49.7%			

Note: HC = Healthy Control; ID = Intellectual Disability; MPE = Mean Parent Education

For the ID sample, the involvement basis were: a) be in the age-range of 6 to 17 years old, b) having a mild or moderate ID, without significant discrepancies (>1 SD) between their intellectual scores on the Wechsler Intelligence Scale for Children-IV[18], and c) having the informed consent of their primary caregiver. The nonadmission basis were: a) have been diagnosed with a mental illness, b) having any sensory, verbal or motor impairment that affect test performance, and c) having consumed alcohol or other substances of abuse.

The inclusion criteria for HC were: a) be in the age-range of 6 to 17 years old, b) Spanish as mother tongue, c) intelligence quotient score ≥80 in the Test of Nonverbal Intelligence-2[19], Children's Depression Inventory score of <19[20], and e) being matriculated in any school modalities. Exclusion criteria were: a) having a central nervous system disease associated with neuropsychological problems, b) having consumed alcohol or other substances of abuse, c) having any active or uncontrolled systemic illness correlated to cognitive impairment, d) having a history of mental disorder, e) having severe sensory deficits that affect test performance, f) currently taking any medication that could modify the cognition, g) having ID, learning or neurodevelopmental disorders, h) suffered pre-, peri-, or postnatal problems, and i) scored >5 on the Alcohol Use Disorders Identification Test–Consumption[21] for participants ≥12 years old.

Measures

The neuropsychological battery consisted of 25 test-scores; the most widely used by LA professionals[22] and are part of the Norma-Latina studies in adults[23] and children[15] population. The tests are: Rey-Osterrieth Complex Figure (ROCF; copy and immediate memory), Learning and Verbal Memory Test (TAMV-I; Free recall, memory delay and recognition), Modified Wisconsin Card Sorting Test (M-WCST; correct, perseverative errors and total errors), Shortened version of Token Test, Stroop Color and Word Test (total words, total colors, total words-colors, and interference), Peabody Picture Vocabulary Test (PPVT-III), Verbal Fluency Test (VFT; letters F/A/S/M/R/P, animals and fruits), Symbol Digit Modalities Test (SDMT), and Trail Making Test (TMT A-B).

Procedure

This study was approved by 'Masked'. The ID participants were recruit from educational institutions. Before start with the assessment, informed consent was required for all custodians and youth aged ≥12 years. For children <12 years, a signature of agreement as required. The Norma-Latina battery was evaluated individually in a single day. Data collection was between January 2016 to May 2017[15,17].

Analysis Method

Kolmogorov-Smirnov test was used to measure normality in demographic variables and neuropsychological test-scores. Since most of the test-scores, age and MPE did not have a normal distribution, the Wilcoxon rank-sum test was employed to check there were no differences in age or MPE. Chi-square test was utilized to analyze qualitative variables. The Wilcoxon rank-sum test was used to estimate difference between the groups in each of the 25 raw tests-scores.

Using the normative data from Arango-Lasprilla and Rivera[15], raw scores were transformed into z-scores and percentiles. Percentiles were used to estimate the quantity of low-scores at various cut-off: below the 25th, 16th, 10th, 5th and 2nd. Z-scores (z_i) were used to design four different cognitive domains (z_c)[24,25] using Stouffer's Z-method: learning and memory (5 test-scores), language (10 test-scores), executive function (6 test-scores), and speed processing (4 test-scores; see Appendix A).

For all comparisons analyses effect size (r) for non-parametric test were estimated ($r=|z|/\sqrt{n}$; Field et al., 2012, p. 665) with the cutoff-point of 0.20, 0.50, and 0.80 as small, medium and large effect sizes, respectively[26]although not comprehensive, presentation of required sample sizes is provided. Effect-size indexes and conventional values for these are given for operationally defined small, medium, and large effects. The sample sizes necessary for .80 power to detect effects at these levels are tabled for 8 standard statistical tests: (1. In Chi-square test case, effect size was estimate using Phi Correlation Coefficient (φ).

For neuropsychological battery discrimination between ID and HC children, a series of Receiver Operating Characteristics (ROC curve) study were guided using the quantity of low-scores to each cutoff-point and cognitive domain. The area under the curve (AUC) was examined to calculate the accuracy of the ROC curve, which has two associated indices to maintain accuracy and minimize differences between sensitivity and specificity. Furthermore, Youden Index (J) and Index of Union (IU) were analyzed in order to define the optimal cutoff-point for the 10th and the 5th percentiles, regarding the number of low-scores, to discriminate ID or HC participants. IU shows the optimal cutoff-point (c) that has the maximum values of sensitivity and specificity, minimizing the differences between them[27]. The formula is $IUc = (|Se(c) - (AUC| + |Sp(c) - AUC)$. Regarding Youden[28], it is used to measure how effective a diagnostic marker is and makes it possible to select an optimal cut-off point. Its value ranges from 0 to 1 and it is described as follows: $J = max_c\{Se(c) + Sp(c) - 1\}$. All analyzes were performed using R project 4.0.5[29]. The *pROC* package[30] was used for analyze ROC curves.

RESULTS

Wilcoxon rank-sum tests showed that individuals with ID have a statistically significant lower performance on 24 of the 25 neuropsychological raw test-scores relative to HC (see Table 2). The greatest difference was observed on the TAMV-I (memory delay; $p<.001$; $r=0.83$) and the smallest

Table 2. Comparison between HC and ID groups on neuropsychological test scores.

Test-Score	Group	Median	Min.	Max.	W	*p value*	Effect size (*r*)
PPVT-III	HC	108.0	27	159	9227.5	<.001	.82†††
	ID	27.0	7	53			
SDMT	HC	29.0	8	75	9123.5	<.001	.80†††
	ID	5.0	0	23			
TMT-A	HC	31.0	12	137	579.5	<.001	.73†††
	ID	89.0	29	230			
TMT-B	HC	62.5	10	280	1022.5	<.001	.65†††
	ID	163.0	63	362			
ROCF copy	HC	30.0	10	36	6947	<.001	.41††
	ID	21.5	3	36			
ROCF memory	HC	15.0	1	34	6850.5	<.001	.39††
	ID	8.5	0	26			
M-WCST Categories	HC	4.0	0	6	6749.5	<.001	.38††
	ID	3.0	0	6.			
M-WCST Perseveration errors	HC	4.0	0	38	2247	<.001	.43††
	ID	9.0	0	32			
M-WCST Total errors	HC	15.0	0	42	4138	0.18	.09
	ID	17.5	2	36			
Token Test	HC	32.0	16	36	8565	<.001	.70†††
	ID	21.0	3	33			
Stroop words	HC	70.5	24	111	6934.5	<.001	.41††
	ID	53.5	21	90			
Stroop colors	HC	45.0	24	80	7556.5	<.001	.52†††
	ID	32.0	9	61			
Stroop Interference	HC	-1.0	-22.0	19	5944	.001	.23†
	ID	-3.5	-14.91	5			

Table 2. Comparison between HC and ID groups on neuropsychological test scores. (continuation),

Test-Score	Group	Median	Min.	Max.	W	*p value*	Effect size (*r*)
Stroop Word-Color	HC	25.0	7	53	7388.5	<.001	.49††
	ID	16.0	3	34			
VFT Letter F	HC	5.0	1	16	6834.5	<.001	.40††
	ID	3.0	0	11			
VFT Letter A	HC	6.0	0	19	6924.5	<.001	.41††
	ID	4.0	0	11			
VFT Letter S	HC	6.0	1	16	6840	<.001	.39††
	ID	4.0	0	10			
VFT Letter M	HC	6.0	0	14	6887	<.001	.40††
	ID	4.0	0	11			
VFT Letter R	HC	6.0	1	13	7236	<.001	.46††
	ID	3.0	0	9			
VFT Letter P	HC	7.0	0	18	7332	<.001	.48††
	ID	4.0	0.00	12			
VFT Animals	HC	13.0	1.00	24	8052.5	<.001	.61†††
	ID	7.0	1.00	16			
VFT Fruits	HC	10.0	2.00	18	7278	<.001	.47††
	ID	7.0	0.00	15			
TAMV-I Free recall	HC	30.0	13.00	44	7948.5	<.001	.59†††
	ID	19.5	2.00	33			
TAMV-I Memory delay	HC	30.0	9.00	44	9275.5	<.001	.83†††
	ID	10.0	0.00	12			
TAMV-I Recognition	HC	12.0	1.00	12	8659.5	<.001	.74†††
	ID	2.0	0.00	12			

Note: HC = Healthy Control; ID = Intellectual Disability; Min = Minimum; Max = Maximum; M-WCST = Modified Wisconsin Cart Sorting Test; ROCF = Rey-Osterrieth Complex Figure; SDMT = Symbol Digit Modalities Test; TMT = Trail Making Test; VFT = Verbal Fluency; PPVT-III =Test Peabody Picture Vocabulary Test; Stroop = Stroop Color and Word Test; TAMV-I = Learning and Verbal Memory Test.† = Small effect, †† = Medium effect; ††† = Large effect

on M-WCST (total errors; p=.18; r=0.09). The 52.0% of effect sizes were medium and 40.0% large.

The conversion of raw scores into percentiles was done using Colombian normative data[17]. The Wilcoxon rank-sum test showed significant dissimilarities in the distributions of quantity of low-scores between the ID and HC participants (p's<.001; see Table 3). Here, the ID group presented a higher quantity of low-scores at every percentile cut-off (25th, 16th, 10th, 5th and 2nd). For instance, at the <10th percentile cut-off, the ID sample had a median of 11 low-scores, in contrast to the HC group which had a median of 1 low-score. Large effect sizes (r >.89) were shown in all measurements. Good accuracy in discriminating between individuals with ID and HC at each cut-off point (25th percentile [AUC=. 949; $CI_{95\%}$=.923, .970], 16th [AUC=.961; $CI_{95\%}$=.939, .979], 10th [AUC=.975; $CI_{95\%}$=.958, .990], 5th [AUC=.980; $CI_{95\%}$=.962, .995], and 2nd [AUC=.988; $CI_{95\%}$=.975, .997]) was demonstrated with the AUCs values (see Table 3 and Figure 1).

The J and IU were used to calculate the optimal cutoff-point to discriminate between HC and ID subjects, based on the quantity of low-scores (see Table 4). The results revealed that the optimal cut-off-points for the 5th percentile were ≥3 and ≥4, although the IU showed that the best cutoff-point was ≥3 (Sensitivity=.985 and Specificity=.917). The optimized cutoff-point for the 10th percentile was ≥5 (Sensitivity=.924 and Specificity=.932).

Table 3. Comparison between groups on the number of test scores falling below specified percentile cutoffs and associated ROC Curve characteristics.

Cutoff	Group	Median	Min.	Max.	W	*p value*	Effect size (r)	ROC		
								AUC	Lower bound	Upper bound
<25th percentile	**HC**	4	0	24	893.5	<.001	.89†††	.949	.923	.970
	ID	16.5	0	23						
<16th percentile	**HC**	3	0	23	683.0	<.001	.92†††	.961	.939	.979
	ID	13	0	13						
<10th percentile	**HC**	1	0	37	435.5	<.001	.95†††	.975	.958	.990
	ID	11	0	13						
<5th percentile	**HC**	1	0	60	343.5	<.001	.96†††	.980	.962	.994
	ID	9	0	15						
<2nd percentile	**HC**	0	0	76	215.0	<.001	.98†††	.988	.975	.997
	ID	7	0	21						

Note: HC = Healthy Control; ID = Intellectual Disability; Min = Minimum; Max = Maximum; ††† = Large effect; Lower bound and upper bound refer to the 95% confidence intervals of the AUC.

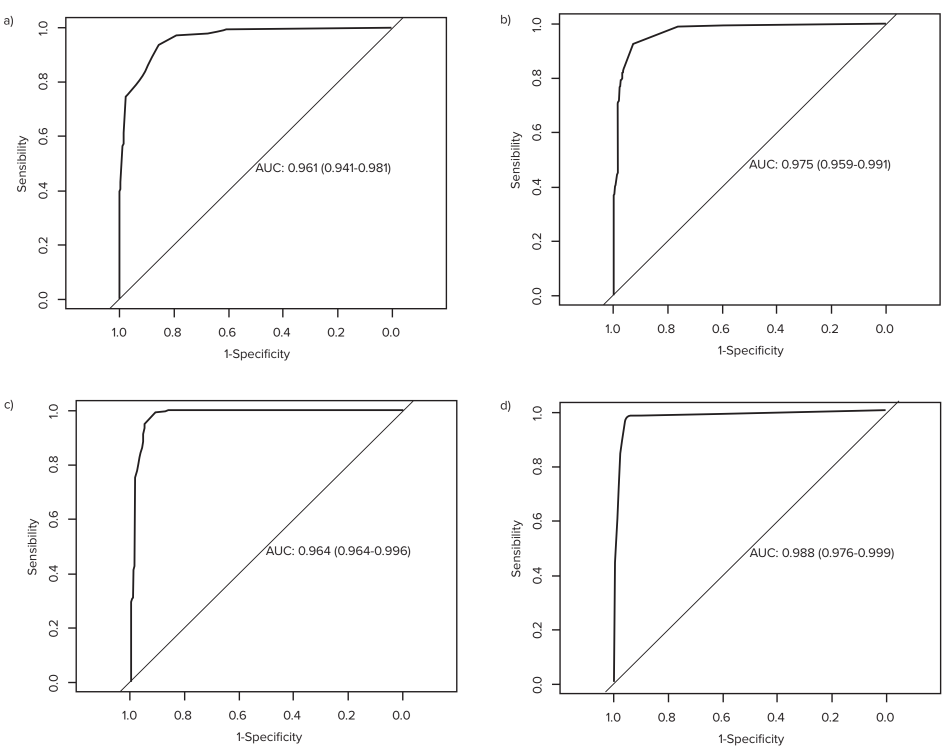

Figure 1. ROC Curve and AUCs of the 16th, 10th, 5th and 2nd low scores.
Note: a) ROC curve and AUC of the 16th percentile; b) ROC curve and AUC of the 10th percentile; c) ROC curve and AUC of the 5th percentile; d) ROC curve and AUC of the 2nd percentile

Table 4. Cut-points and associated sensitivity and specificity values.

Threshold (c)	<5th percentile				<10th percentile			
	Se	Sp	J	IU	Se	Sp	J	IU
≥2	.992	.864	0.856	0,128	.992	.659	0.652	0.333
≥3	.985	.917	0.902	0.068	.992	.765	0.758	0.227
≥4	.947	.947	0.894	0.066	.962	.856	0.818	0.132
≥5	.848	.962	0.810	0.150	.924	.932	0.856	0.094
≥6	.742	.985	0.727	0.243	.841	.962	0.803	0.147
≥7	.629	.985	0.614	0.356	.773	.977	0.750	0.205

Note: *Se = Sensitivity; Sp = Specificity; J =Youden index; IU = Index of Union.*

As for the cognitive domains, all showed significant differences in the results (see Table 5) between groups (executive functions [W=7878; *p*<.001; *r*=0.575]); (language [W=8472; *p*<.001; *r*=0.682]); (learning and memory [W=9290; *p*<.001; *r*=0.828]); (Speed Processing [W=9034; *p*<.001; *r*=0.782]), where ID group presented lower z-scores compared to the HC subjects (see Figure 1). For each cognitive domain, the AUCs suggested high precision in discriminating between individuals with ID and HC (AUC's >.905, $CI_{95\%}$=.860 - .951; see Figure 2).

DISCUSSION

This study aimed to validate Norma-Latina battery for an ID group from Colombia, and how their profile compares with their respective non-clinical counterparts. To our knowledge, this is the first validation of a neuropsychological battery for this particular clinical population in LA.

Analyses revealed children with ID performed significantly worse than HC on 24 of the 25 measures. Therefore, this significant discrepancy shows that almost all cognitive measures of Norma-Latina could be helpful in discriminating between ID and HC samples.

The most significant difference was seen on the TAMV-I Memory delay score. When considering the cognitive domains, learning and memory scores had also the largest effect sizes, when compared to the other cognitive domains. This appears to

Table 5. Average performance between groups by cognitive domain and associated ROC Curve characteristics.

Domain	Group	Mean (SD)	Median	W	Sig.	Effect size (r)	ROC		
							AUC	Lower bound	Upper bound
Executive Function	HC	-0.04 (1.49)	0.01	7878	< .001	.575†††	.845	.788	.902
	ID	-2.32 (1.83)	-2.08						
Language	HC	0.09 (1.95)	-0.06	8472	< .001	.682†††	.909	.863	.954
	ID	-4.30 (2.89)	-4.08						
Learning and Memory	HC	4.81 (2.00)	5.13	9290	< .001	.828†††	.996	.991	1.000
	ID	-3.12 (1.82)	-3.04						
Speed Processing	HC	-0.32 (1.34)	-0.05	9034	< .001	.782†††	. 969	.944	.994
	ID	-4.92 (2.32)	-4.47						

Note: HC = Healthy Control; ID = Intellectual Disability; SD = Standard Deviation; †† = Medium effect; ††† = Large effect.

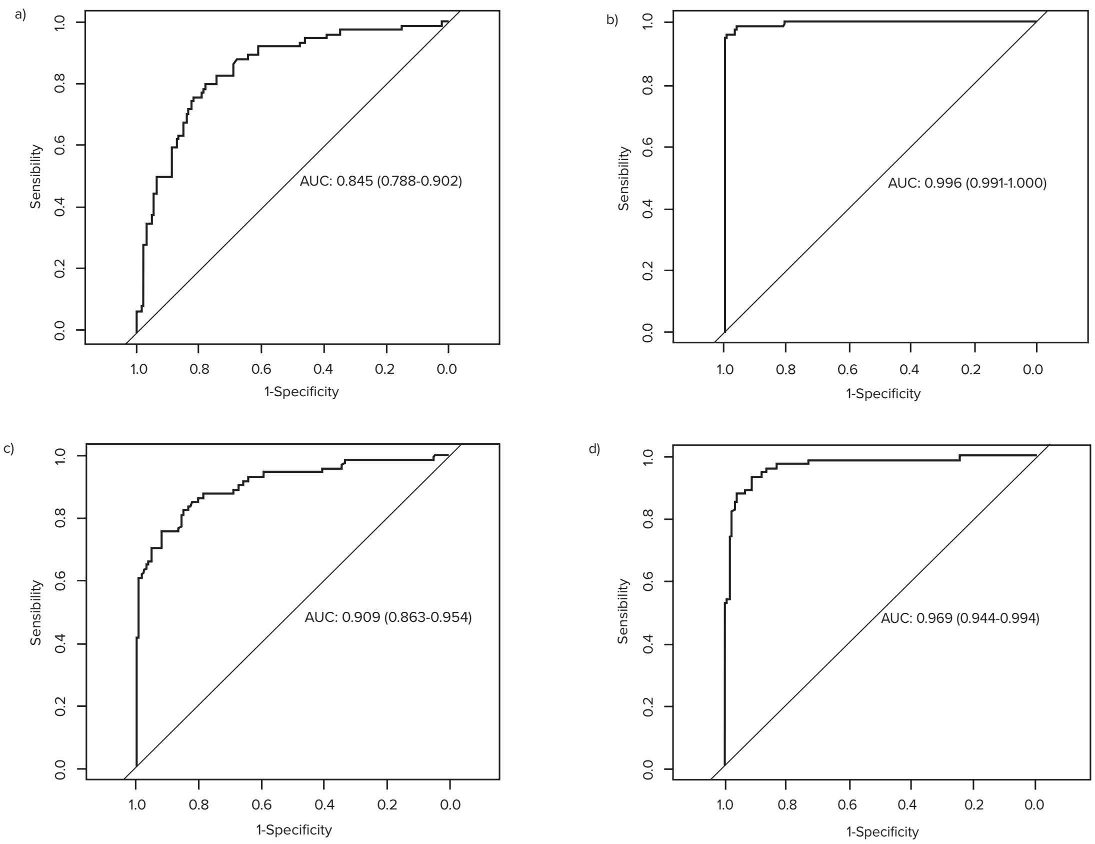

Figure 2. ROC Curve and AUCs of the four cognitive domains.
Note: a) ROC curve and AUC of the Executive functions; b) ROC curve and AUC of the Learning and Memory; c) ROC curve and AUC of the Language; d) ROC curve and AUC of the Speed Processing.

be consistent with literature that highlights verbal memory impairments in ID syndromes[7,31]educational, and social opportunities. Despite this, there is a paucity of research into effective treatments for this population. Notably, one of the most supported of psychological therapies, cognitive behaviour therapy (CBT, which limits the acquisition of other explicit cognitive-related skills.

In addition, other large effect sizes were seen on PPVT-III, SDMT, TMT A-B, a semantic fluency task (animals), Token Test, and Stroop Colors. Medium effect sizes were seen on the ROCF Copy and Memory, M-WCST Categories and Perseveration errors, Stroop Words and Word-Color, all letter fluency and fruits category measures. A small effect size was observed on the Stroop Interference.

The only test-score that was not significantly different between groups was the M-WCST total errors. Similarly, regarding cognitive domains, despite having all large effects, the executive function scores were the smallest relative difference when compared with the other cognitive domains. It seems some specific executive function measures are the ones that relatively discriminate the least. This could be due to the magnitude and type of executive skills that may differ between different ID syndromes, which at the same time result in heterogeneity of functioning within this disorder[32]. This inconsistency was also evaluated by Danielsson et al.[33], who suggested that switching abilities were not significantly different when compared with other executive function tasks, such as inhibition, working memory, and planning.

Therefore, memory and learning, speed processing, and language domain scores were the ones that provided the most distinct scores of the Norma-Latina battery in the ID profile. These results can provide the professionals with valid information on which are the best measures to be elected and differential diagnosis.

Analyses on the prevalence of low-scores give objective information about interpreting test performance, in order to reduce the likelihood of false positives in HC. According to the results, it was very unlikely for HC children to have a score ≤ 2 standard deviations from the mean level of performance on the Norma-Latina battery. However, regarding children with ID, a greater quantity of low-scores were seen at different threshold levels. For example, the HC group obtained a median of 1 low-score below the 10th and 5th percentiles, and no low-scores below the 2nd percentile. However, the ID group presented a median of 11 low-scores below the 10th percentile, a median of 9 low-scores below the 5th percentile, and a median of 7 low-scores below the 2nd percentile threshold. Even considering a less conservative threshold, such as the 25th percentile, children with ID had a median of 16.5 low-scores versus a median of 4 in HC children. Moreover, base rates at various cutoff-points and performance by domain were indicative that this Norma-Latina battery has a strong ability to discriminate between ID and HC. Optimal discrimination in terms of sensitivityand specificitycan be found having ≥5 scores below the 10th percentile or ≥3 scores below the 5th percentile. Therefore, these base rate analyses can also be used as an interpretation tool to reduce the risk to misinterpret low test-scores in HC, and assist in the differential diagnosis of ID profiles.

These results support the use and applicability of the Norma-Latina battery for Colombian children with ID. Neuropsychologists now count with many statistical measures to evaluate children with possible ID, describe their cognitive profile, and establish with high levels of specificity and sensitivity the likelihood of the diagnostic conclusions. The provided statistics offer a useful tool to validate cognitive profiles, in order to assist in intervention for practical skills in terms of the academic functioning, social development, and QoL of these individuals. Furthermore, this is the first study that evaluates the validity and applicability of a battery and the profile of children with ID in LA.

Strengths, Limitations, and Future Directions

One of the strengths of this study is that it matches the ID group and co-norms it with an HC sample. Also, descriptive and inferential statistical analyses were used to describe those references in terms of standard deviations from means and percentiles from individual subtests, effect sizes, base rates, and the optimal specificity and sensitivity for the better identification of the ID group.

In addition, because the ID sample did not differentiate between known genetic disorders and ID severity, this sample was representative of the broad ID Colombian population that may be encountered in clinical practice. Consequently, steps to match the groups on age, sex, and MPE were strictly established for comparative analyses.

However, this may also yield limitations. First, this study was conducted in Colombia. Because of the variability seen on Norma-Latina measures across other LA samples[15,34], it is likely that these results, particularly base rates, cannot be generalized to children from other countries. Finally, the ID group was established according to their performance on a specific intelligence battery, and not on the etiology. Therefore, different conditions associated with ID (i.e., Down and Williams Syndromes) may present distinct and unique profiles[32,35].

Therefore, future studies should focus on understanding whether distinctive neuropsychological profiles are seen in different ID groups. Moreover, this study should be replicated with other LA samples to better understand the use and generality of Norma-Latina tests with ID. Additionally, the use of an adaptive measure would also be recommended to explore the relation of these measures with functional daily living skills that are often impaired in ID. This recommendation would assist in measuring the efficacy of intervention programs targeting cognitive profiles with children with ID across development.

Clinical Implications

Norma-Latina battery discriminates between ID and HC groups. This study provides compelling support for its utility in the assessment of ID, in order to assist in diagnosis, and target cognitive skills for intervention. Norma-Latina battery provides feasible and accessible measures for clinical use in Colombia. The development of additional research protocols would be necessary to evaluate the differentiability of this battery in other clinical populations and across different countries.

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APPENDIX A

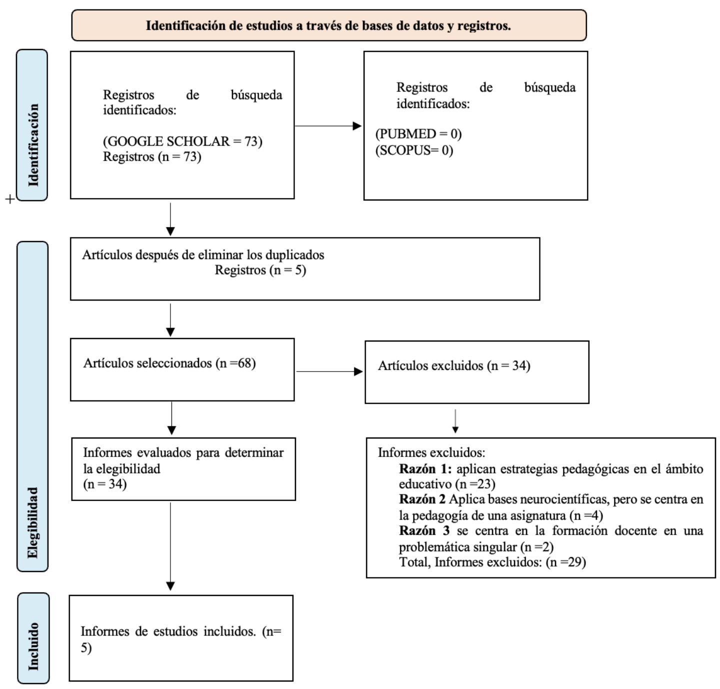
Relationship between the four cognitive domains and its neuropsychological tests.

Cognitive Domain	Number of test-score	Classification of the tests
Executive Function	n = 6	TMT-B Stroop Total words and colors Interference M-WCST Correct categories Perseverative errors Total errors
Learning and Memory	n = 5	ROCF Copy Immediate memory TAMV-I Free recall Memory delay Recognition
Language	n = 10	PPVT-III Token Test VFT f/a/s/m/r/p/animals/fruits
Speed Processing	n = 4	SDMT TMT-A Stroop Total Colors Total words

Note: Rey-Osterrieth Complex Figure (ROCF), Learning and Verbal Memory Test (TAMV-I), Modified Wisconsin Card Sorting Test (M-WCST), Shortened version of Token Test, Stroop Color and Word Test, Peabody Picture Vocabulary Test (PPVT-III), Verbal Fluency Test (VFT), Symbol Digit Modalities Test (SDMT), Trail Making Test.

Figura 1.

Diagrama de flujo PRISMA.



Fuente: propia.

en los que fueron aplicadas. También se analizaron las características de las poblaciones intervenidas, así como los retos y limitaciones enfrentadas durante su implementación (11).

Consideraciones Éticas:

Esta investigación se considera sin riesgo, ya que nos basamos en una investigación documental, por lo que no modificamos ni manipulamos variables, artículo 11 literal A de la Resolución 08430 de 1993 del Ministerio de Salud (18).

RESULTADOS

En el análisis de los datos, se revisó exhaustivamente la información recopilada para identificar variables y relaciones en el contexto de las estrategias neuropedagógicas aplicadas a docentes y su impacto en las habilidades escolares de estudiantes de básica primaria.

La búsqueda se enfocó en reconocer barreras y factores potenciadores en su implementación. La aplicación de los criterios de inclusión y exclusión permitió filtrar la información, descartando documentos no relevantes. Los resultados describen las estrategias más utilizadas y sus efectos, así como los inconvenientes y limitaciones en su ejecución.

Resultados y Análisis

Siguiendo los parámetros establecidos en el método PRISMA para la selección y depuración de información, se obtuvo un total de 73 documentos iniciales. Tras la identificación de duplicados, se eliminaron 5 registros, reduciendo la muestra a 68 documentos. Posteriormente, en el proceso de clasificación y evaluación de relevancia, se excluyeron 34 artículos por no cumplir con los criterios establecidos. Como resultado, 29 documentos fueron avalados para la fase de elegibilidad, de los cuales, tras un análisis más detallado, se incluye-