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ASSESSMENT PROCEDURE

The Radboud dysarthria assessment: validity and reliability of the Arabic version

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ABSTRACT

Purpose: To cross-culturally adapt and validate the Radboud Dysarthria Assessment (RDA) and the speech component of the Radboud Oral Motor inventory for Parkinson's disease (ROMP-speech) into the Arabic language among Lebanese subjects with dysarthria.

Materials and methods: This study included 50 participants with dysarthria. The Arabic versions of the RDA (A-RDA) and the ROMP-speech (A-ROMP-speech) were administered in addition to the Arabic Speech Intelligibility test, the Lebanese Voice Handicap Index–10 (VHI-10lb) and semantic verbal fluency tasks. The maximum performance tasks were analyzed using the Praat software. The A-RDA qualitative recording form and the A-ROMP-speech were assessed for construct validity and internal consistency. The convergent validity of the maximum performance tasks, the severity scale, and the A-ROMP-speech were evaluated.

Results: Exploratory factor analysis of the qualitative recording form extracted 3 factors explaining 82.973% of the total variance, and it demonstrated high internal consistency ($\alpha = 0.912$). The maximum performance tasks of the RDA correlated significantly with the corresponding Praat scores. The severity scale and the A-ROMP-speech correlated fairly to strongly with the Arabic Speech Intelligibility test (r_s=-0.695 and −0.736, $p < 0.001$) and the VHI-10lb ($r = 0.539$ and 0.640, $p < 0.001$).

Conclusion: The A-RDA and the A-ROMP-speech are valid and reliable dysarthria tools among Lebanese subjects.

> IMPLICATIONS FOR REHABILITATION

- The present study cross-culturally adapts and validates a dysarthria assessment tool in the Arab culture.
- The Arabic Radboud Dysarthria Assessment (A-RDA) and the speech component of the Arabic Radboud Oral Motor inventory for Parkinson's disease-speech component (A-ROMP-speech) are valid and reliable measures to be used among Lebanese individuals with dysarthria.
- The use of the A-RDA and the A-ROMP-speech will contribute to better therapeutic outcomes and will lead to a common language among speech and language therapists.

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Dysarthria; validation; cross-cultural adaptation; Arabic; psychometrics; clinimetrics

Introduction

Dysarthria is defined as a cluster of motor speech disorders resulting from neurological impairments including cerebrovascular accidents, traumatic brain injuries

(TBIs), and neuromuscular and neurodegenerative diseases [1,2]. It influences the mechanism of speech execution as it may disrupt respiration, phonation, prosody, articulation, and/or resonance [3–6]. In all cases, dysarthria affects effective communication by imposing additional efforts on speakers due to reduced intelligibility, slurred speech, effortful respiration, and altered prosody [4,5,7,8]. Dysarthria is a common disorder, with its prevalence ranging between 20 and 42% in stroke survivors [9–11], 10 to 60% in patients following TBIs [2], and 50 to 90% in patients with Parkinson's disease [12]. Considering its high incidence following neurological disorders, it is crucial to assess its symptoms as early as possible to prevent associated negative sequelae and to provide suitable and timely treatment [13].

The clinical assessment of dysarthria is mainly conducted by experienced speech and language therapists (SLTs). It aims to identify the presence, type, and severity of the impairment to establish the appropriate therapeutic plan [14]. The assessment of dysarthria might be subjective and tricky to some extent as the mechanisms of speech production interact with one another; for instance, restricted breathing patterns affect phonation or vocal quality [15]. Despite its high incidence, literature reviews have shown that there is a limited number of published standardized diagnostic tools for dysarthria in adults [16–18]. Therefore, there is a great sense of urgency to develop standardized, reliable, and valid diagnostic tools for dysarthria. Importantly, as speech

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is highly intertwined with language and culture [19], the use of a scale for dysarthria in various cultures would require translation into languages other than the source language, cultural adaptation of the items, and evaluation of the clinimetric properties of the culturally equivalent version.

In response to this need, the Radboud Dysarthria Assessment (RDA) was chosen to be culturally adapted to the Lebanese culture. The RDA is a freely available measure for assessing dysarthria, originally developed and validated in the Netherlands [18]. It covers the five components of speech production (i.e., respiration, phonation, prosody, articulation, and resonance). When compared with other diagnostic tools, the RDA requires less time to be administered, as the evaluation of speech characteristics is less extensive than perceived to accurately assess dysarthria. Furthermore, the RDA is appropriate to characterize all the types of dysarthria as clinically required, and it allows the differentiation between the "mixed type" of dysarthria from different etiologies by specifying the combined types. The RDA is associated with a self-report questionnaire, the speech component of the Radboud Oral Motor inventory for Parkinson's disease (ROMP), which quantifies and evaluates one's perceived speech complaints and their influence on daily functioning. Critically, the RDA presents robust clinimetric properties, including highly reliable factors ($\alpha = 0.89 - 0.91$) and substantially to strongly convergent validity [18].

There are currently no standardized diagnostic tools for dysarthria in the Arab world. In fact, Lebanese SLTs who work with adults with dysarthria rely solely on informal assessments and checklists to assess dysarthria, as reported in a recently published study [20]. Further, Lebanese SLTs reported a critical need for the development of a culturally appropriate formal assessment in Arabic designed to evaluate dysarthria and determine its severity [20]. Importantly, as recommended by the World Health Organization's International Classification of Functioning, Disability and Health (ICF) [21], a holistic assessment of dysarthria goes beyond characterizing physiological impairment to include the influence of the disorder on one's daily activities [8,22]. As such, it is of great importance to cross-culturally adapt and validate the RDA for Lebanese adults with dysarthria as it evaluates the presence and severity of dysarthria and reflects the consequences of speech difficulties on daily functioning. Given this background, our aim is to (1) cross-culturally adapt the RDA and the speech component of the ROMP to the Lebanese culture and (2) assess their clinimetric properties in a sample of Lebanese subjects with dysarthria.

Materials and methods

The cross-cultural adaptation and validation of the RDA targeted the qualitative recording form, the severity scale, and the speech component of the ROMP questionnaire. The steps are as follows:

Cross-cultural adaptation of the Radboud dysarthria assessment (RDA)

The validation process of the RDA, including the qualitative recording form and a quantitative severity scale, focused on conceptual validation rather than linguistic adaptation.

Although the native language in Lebanon is Arabic, a previous study reported that Lebanese SLTs are either bilingual or trilingual, given that the formal education beyond elementary school is delivered in English and French languages [20]; with that in mind, they are more familiar with the scientific terminologies provided in these languages. Therefore, within this study, the English version of the RDA, proposed by Knuijt et al. (2017), was used [18]. Permission was granted from the initial authors to validate the English RDA. The cross-cultural adaptation of the RDA was performed according to the recommended guidelines for the cross-cultural adaptation of health status instruments [23].

Expert committee

An expert committee consisting of five SLTs reviewed the English RDA and determined the steps to cross-culturally adapt it. The steps involved: (1) assessing the clarity of the terminologies used within the RDA, (2) adapting the words used in the maximum phonation volume task, and (3) developing a standard Arabic reading text with specific criteria.

Using a Delphi method, twelve experienced SLTs were contacted and were asked to provide comments and feedback on the clarity of the English version of the RDA. They reported no problems in understanding the terminologies used. For the maximum phonation volume task, where participants are asked to produce words as loud as possible, Knuijt et al. (2017) used the words "hello" and "come here". Each SLT of the expert committee independently proposed several words that are similar in syllabic structure to these words. The committee met to discuss all the proposed words in terms of functionality and to reach a consensus on two chosen words. As such, the words "هاي" (Hi) and "أهلا وسهلا" (ahla wsahla) were chosen as they are familiar words used for greeting and are similar, in terms of syllabic structure, to the words used in the original RDA.

The reading text used within the original RDA did not undergo a standard translation due to the unique morphological, phonetic, and syntactic characteristics of the Arabic language. For that reason, a Modern Standard Arabic (MSA) reading text was developed. Initially, one linguist was contacted to develop an Arabic text that matches the following criteria: (1) the main topic of the text should be suitable and interesting for adults (2) the text should include several types of sentences ranging in complexity level (3) the text should include 1-, 2-, 3-, and 4-syllable words (4) the text should include words that contain all the Arabic consonants either in the initial, medial, or final word positions (5) the text should include a minimum of 500 words.

Following the first draft's development, each member of the expert committee was invited to independently evaluate and analyze the proposed text. Each SLT provided suggestions in case of disagreement. A meeting was held to discuss discrepancies and resolve disagreements. Great attention was paid to the morpho-syntactic features of the text. Some sentences were modified, and conditional sentences were added. To ensure clarity, Arabic diacritics and stress marks were added to the words. To ensure the appropriate quality of writing and to eliminate ambiguities and redundancies, two independent linguists, not involved in the initial development, evaluated the pre-final version of the text.

Pre-test

The pre-testing was conducted to assess the comprehensibility and suitability of the standard Arabic reading text. The pre-final version of the Arabic text underwent pre-testing with five subjects, three with dysarthria, and two healthy controls. The participants were asked to determine if they experienced any problems or

ambiguity while reading; they did not report any problems. Following this, a last version of the Arabic text entitled: رحلةٌ بحثٍ عن العالم (A journey in search of the world) was constructed; it included 526 words.

Cross-cultural adaptation of the speech component of the Radboud Oral motor inventory for parkinson's disease (ROMP-speech)

The translation and cross-cultural adaptation process of the ROMP-speech into MSA followed the recommended standard criteria for the cross-cultural adaptation of health status instruments [23]. It included the following stages:

Initial translation

The first step included the forward translation of the ROMP-speech from English into the modern standard Arabic language. Two independent Lebanese native speakers with good English proficiency, a sworn translator, and a healthcare professional, produced the first translation of the ROMP-speech. Translators were asked to translate in simple and plain language that can be understood by the equivalent of a 12-year-old.

Synthesis of the translations

The two translators and an SLT met to compare the two obtained versions and resolve discrepancies. The two produced versions were discussed, and a consensus Arabic version of the ROMP-speech was obtained.

Back-translation

Back-translation was conducted to ensure that the produced Arabic version of the ROMP-speech is equivalent to the English version. Two independent English speakers, who were blind to the original English version, performed the back-translation. The two produced versions were compared to the original version to ensure reproducibility. Again, two SLTs compared the back-translation to the original English version to make sure that the content was preserved.

Expert committee

The expert committee consisted of the forward and backward translators, a research methodologist, and two SLTs who were not involved in the previous stages. The committee met to discuss all translated versions and obtain a pre-final version of the ROMP-speech questionnaire. Each member was asked to provide feedback about the comprehensiveness and appropriateness of the translated items. Discrepancies found were resolved by consensus and a preliminary final Arabic version of the ROMP-speech (A-ROMP-speech) was developed for field testing.

Pre-test

The A-ROMP-speech was pre-tested in a sample of ten subjects with dysarthria for the aim of assessing the clarity and comprehensibility of the items. Following questionnaire completion, interviews with the participants were conducted to determine any ambiguity. Participants did not report any problem in understanding the items of the questionnaire.

Study design and participants

This is a cross-sectional study conducted in Lebanon from October 2021 to March 2023. Participants were recruited from different rehabilitation centers and private clinics across the different Lebanese districts. This study included a convenience sample of 50 Lebanese participants with dysarthria. Eligible subjects were: (1) diagnosed with dysarthria by a neurologist, (2) identified with appropriate oral language skills, (3) able to read well, and (4) aged 18 years and above. Subjects who met the inclusion criteria were enrolled in the current study regardless of their dysarthria type or severity. Dysarthria and aphasia can co-exist frequently. To accurately evaluate the validity of the RDA, participants with aphasia associated with dysarthria were excluded from the study. Participants diagnosed with alexia were also excluded. The design of the current study followed the recommendations proposed by the consensus-based standards for the selection of health measurement instruments (COSMIN) [24]. Moreover, to improve methodological quality, the Standards for Reporting Diagnostic Accuracy (STARD) were considered [25].

Procedure

A committee of five experienced SLTs participated in data collection. Participants were interviewed face-to-face, in a standardized manner, by an experienced SLT. After explaining the study objectives, participants were asked to sign the written informed consent before they participated in this study. The data collection process involved completing a socio-demographic questionnaire, along with performing a thorough speech therapy assessment including the RDA. The tasks of the RDA were audio-recorded for all the participants and video-recorded for twenty-three participants.

To assess the intra-rater reliability, the RDA and the ROMP-speech were re-administered within a 2-week interval for twenty-nine participants. To assess the inter-rater reliability of the RDA, another SLT scored the video-recorded RDA tasks independently for the twenty-three participants. The intra-rater reliability is a measure of consistency in assessment or rating performed by a single rater over a period of time, while the inter-rater reliability is a measure of consistency or agreement between two or more raters performing independently the same assessment. To assess the convergent validity of the maximum performance tasks of the RDA, they were analyzed using the Praat program [26] by an SLT who was blinded to the initial RDA scoring.

Measurements

Along with the measurement scales, a sociodemographic questionnaire was used. The sociodemographic questionnaire was administered in Arabic and covered two main sections: (1) the general personal information including the participant's age, gender, marital status, address, educational level, and employment status (2) the medical history including detailed information concerning pathology and date of onset. The measurement scales included:

The Arabic Radboud dysarthria assessment (A-RDA)

The RDA is a qualitative assessment tool that evaluates the general and sub-aspects of speech in subjects with dysarthria [18]. It was

initially developed and validated in Netherlands and Belgium [18]. The RDA involves two components composed of a qualitative recording form and a severity scale (Supplementary file I). The qualitative recording form includes five main sections, each reflecting a component of speech, which are articulation, resonance, phonation, respiration, and prosody. The different sections of the RDA are evaluated during three main different tasks:

1. Spontaneous speech (semi-structured interview): participants were encouraged to answer open-ended questions about friends, education, activities, and interests for 3-5 minutes.
2. Text reading: Participants were instructed to read aloud the developed Arabic text entitled: رحلةٌ بحثٍ عن العالم (A journey in search of the world) (Supplementary file II). The aim was to evaluate intelligibility and prosodic features. Unlike spontaneous speech, reading a long text requires an uninterrupted flow of speech, making this task more sensitive to fatigue effects.
3. The maximum performance tasks: included the maximum repetition rate (MRR), the fundamental frequency range (FFR), the maximum phonation volume (MPV), and the maximum phonation time (MPT). These tasks were performed three times and the best trial was scored.
4. The MRR (Diadochokinesis) was scored while the participant produced/pa/,/ta/,/ka/, and/pataka/on one breath for 4-5 seconds. The/pa/gives an impression about the lip function, the/ta/about the tip of the tongue, and the/ka/about the function of the tongue base. The diadochokine speed was calculated with a stopwatch and sound recording. The monosyllables are expected to be produced with an average of 6 syllables per second while the polysyllabic series with an average of 5-6 productions per second [27, 28].
5. The FFR was assessed by asking the participant to sustain a vowel/a/from the lowest to the highest possible pitch and vice versa.
6. The MPV was evaluated by encouraging the participant to produce the words "هاي"(Hi) and "أهلا وسهلا" (ahla wsahla) as loud as possible. The dynamic range of MPV was evaluated during this task, as it is difficult to note during spontaneous speech.
7. The MPT was implemented to evaluate the function of the phonatory-respiratory system by asking the participants to sustain the vowel/a/, measured in seconds.

However, several studies reported inconsistent results on the norms of MPT involving sustained/a/production [29]. The MPT is longer in males than in females and older people over 65 years [27]. Also, MPT appears to be influenced by age and height [27]. To differentiate between the phonatory and respiratory systems the s/z ratio was used (normally, the/z/might be more prolonged). A ratio above 1.4 will indicate a phonatory problem [30].

The scoring is based on a Likert scale of 4-points, ranging between 0 (normal) and 3 (severe problems). Based on the qualitative recording form of the RDA, the severity of dysarthria is rated. The severity score reflects the interpretation of the subject's performance on all the required tasks during the entire assessment. It is scored based on a 6-point Likert scale ranging between 0 (normal) and 5 (most severe). When the subject mostly scores 0 or 1 on the different items of the qualitative recording form, then the severity of dysarthria is judged as mild. In addition to that, the overall severity score represents the most affected aspect of speech production. As for the clinimetric properties of the original RDA, the qualitative recording form extracted four factors that explained 70.3% of the total variance. Its internal consistency (α) ranged between 0.89 and 0.91 for the individual factors. The inter-rater and intra-rater reliability (intra-class correlation coefficient) of the severity scale ranged between 0.85 and 0.86 [18].

As mentioned earlier, the English version of the RDA recording form was used, however, the different tasks were instructed and provided for the participants in the Arabic language including the standard Arabic reading text; thus, constituting the Arabic version of the Radboud Dysarthria Assessment (A-RDA). Throughout the administration of the RDA, the different tasks were audio-recorded; in case of doubt, the SLT can listen back. Furthermore, the RDA also includes a short self-evaluation questionnaire, ROMP-speech, which is used to evaluate and quantify the subject's speech complaints and its influence on daily functioning. As for the A-RDA, it includes the A-ROMP-speech, which is the Arabic cross-culturally adapted version of the ROMP-speech.

The speech component of the Arabic Radboud Oral motor inventory for parkinson's disease-speech component (A-ROMP-speech)

The ROMP is a self-evaluation questionnaire that rates speech, swallowing, and saliva control in patients with Parkinson's disease [31]. Within this study, the speech component of the ROMP questionnaire was used. The original authors of the RDA modified the ROMP-speech by replacing two items that were specific to hypokinetic dysarthria with items that suit all types of dysarthria; so that, it addresses all subjects with dysarthria despite the underlying medical condition [18]. It consists of seven questions scored on a 5-point response scale. The total score ranges between 7 and 35, with increasing scores indicating more severe complaints. The items of the ROMP-speech reflect the "function", "activity" and "participation" domains of the ICF [32]. Regarding its clinimetric properties, when validated among Dutch individuals with dysarthria, the ROMP-speech showed good construct validity and high internal consistency (α = 0.90) [18]. Within this study, the Arabic version of the ROMP-speech (A-ROMP-speech) was used (Supplementary file III).

The Arabic speech intelligibility test

The Arabic speech intelligibility test is an objective assessment tool used to estimate the degree of speech intelligibility in adults with communication disorders [33]. The test includes 250 cards of 125 words repeated twice. The words are categorized into five different sets, each consisting of 25 (x2) words. Within each set, the words include minimal pairs that might differ in one consonant or vowel. Set A includes red cards of monosyllabic words starting with the consonants/m/,/b/,/f/, and/w/. Set B consists of green cards of monosyllabic words initiated by the consonants/t/,/d/,/tˤ/,/dˤ/,/l/,/n/,/θ/, and/ð/. Set C involves yellow cards of monosyllabic words that start with the consonants/s/,/sˤ/,/ʃ/,/z/,/r/, and/ðˤ/. Set D includes white cards of monosyllabic words starting with the consonants/k/,/q/,/ʒ/,/x/, and/ɣ/. Finally, set E consists of blue cards of monosyllabic words initiated by the consonants/h/,/ħ/,/ʕ/, and/ʔ/.

For the test administration, the cards of each set (25 × 2) were scrambled face down on the table in front of the participant. The participant was asked to randomly pick cards and read them. The SLT listened to the participant's responses without observing lips or seeing the words. The SLT noted the responses for the different

cards "in order" for each set separately. The cards read by the participant were collected "in the same order" to be compared later with the responses perceived by the SLT.

For the scoring, the total score is expressed in percentage by computing the number of correct responses to the total number of cards (250 words). A categorical classification of the percentages is present as follows: 0-24 (unintelligible speech), 25-59 (poor intelligibility), 60-74 (fair intelligibility), 75-89 (good intelligibility), and 90-100 (excellent intelligibility). The Arabic speech intelligibility test exhibits good construct validity and inter-rater reliability (Kappa agreement coefficient) ranging between 0.87-0.94 [33].

The voice handicap index-10 (VHI-10)

The Voice Handicap Index-10 (VHI-10) is a self-administered questionnaire that quantifies the perception of vocal handicap in subjects with dysphonia and its effect on their quality of life [34]. VHI-10 includes 10 items that are scored based on a 5-point Likert scale fluctuating between 0 (never) and 4 (always), with the maximum total score of 40 signifying severe handicap. The Lebanese-adapted and validated version of the Voice Handicap Index–10 (VHI-10lb) was used in this study [35]. The VHI-10lb exhibits high internal consistency ($\alpha = 0.915$) and excellent test-retest reliability (intra-class correlation coefficient = 0.963) and it is proven to be clinically valid [35].

Semantic verbal fluency (SVF) task

The semantic verbal fluency (SVF) task was administered by asking the participants to generate orally, in one minute, as many words as possible under a given category. Four animate categories were chosen: animals, vegetables, fruits, and body parts. The chosen categories were found to induce the highest number of generated words in healthy Lebanese-speaking adults [36, 37]. As for the scoring, one point was given for each relevant exemplar. The SVF total score was calculated by summing up and averaging the scores obtained from the four categories. On average, healthy Lebanese-speaking adults generated 15.67 ± 3.38 words in the animate categories [37]. Results showed that performance on the SVF tasks was dependent on age and educational level. So, exemplar generation was reduced with age, while it increased with higher education [37].

Praat program

The Praat program (version 6.2.06) was used to analyze the maximum performance tasks of the RDA [26]. For the MRR, the number of monosyllables or polysyllables produced was divided by the exact duration of production, to obtain the average production per second. The intensity was calculated to evaluate MPV, expressed in decibels (dB). As for the MPT, the duration of the sustained vowel/a/was measured in seconds.

Ethical considerations

The current study was conducted based on the ethical guidelines laid down in the Declaration of Helsinki of the World Medical Association Assembly [38]. Approval to validate and use the RDA was requested from the initial author and was granted for academic and research purposes. Ethical approval was obtained from the Institutional Review Board of the Neuroscience Research Center at the Faculty of Medical Sciences-Lebanese University (Ref: 181/2/2021). All participants provided written consent for their voluntary participation in this study.

Statistical analysis

Data analyses were conducted using IBM SPSS statistical software version 26.0. For descriptive statistics, continuous variables were presented by means and standard deviations (SD), while categorical variables were presented by frequencies and percentages. The validity analysis consisted of construct, convergent, and divergent validity. To assess the construct validity of the qualitative recording form of the RDA and the A-ROMP-speech, exploratory factor analysis (EFA) was performed using the principal components analysis with Varimax rotation. Factors were selected depending on the eigenvalues (> 1); factor loadings and communalities ≥ 0.5 were considered representative [39]. To evaluate the adequacy of performing EFA, the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's test of sphericity were conducted. A KMO score ≥ 0.5 reflected suitability for factor analysis [40]. The convergent validity of the maximum performance tasks of the RDA was studied using Spearman's correlation with the corresponding Praat scores. The Spearman's correlation coefficient was also used to determine the convergent validity of the severity scale and the A-ROMP-speech with the VHI-10lb and the Arabic Speech Intelligibility test; correlation coefficients ≥ 0.7 were considered strong. The divergent validity of the severity scale was calculated using Spearman's correlation with the SVF total score.

The reliability analysis consisted of internal consistency, inter- and intra-rater reliability. The internal consistency of the qualitative recording form, the extracted factors, and the A-ROMP-speech was calculated using Cronbach's alpha (α), with coefficients greater than 0.7 representing good internal consistency [41,42]. The intra-class correlation coefficient with a 95% confidence interval (ICC, average measure) was used to measure the inter- and intra-rater reliability of the severity scale and the intra-rater reliability of the A-ROMP-speech. Reproducibility was considered representative with ICC > 0.75 [43]. All the statistical tests were two-sided and a $p < 0.05$ was considered significant.

Results

Sample characteristics

The sample included 30 males (60%) and 20 females (40%) with dysarthria with an average age of 47.800 ± 18.195. Almost half of the participants were married (56%), while 44% were single. Concerning their educational level, 70% received less than 12 years of education while 30% had at least 12 years of education. Most of the participants were unemployed (82%,). On the measurements, the participants' mean VHI-10lb score was 14.480 ± 10.610, their mean score on the Arabic Speech Intelligibility test was 72.598 ± 29.385 and their mean A-ROMP-speech score was 16.720 ± 7.315.

Table 1 depicts an overview of the type and severity of dysarthria and the medical diagnosis of participants. Dysarthria was induced by cerebrovascular accident and TBI in 26% and 20% of the participants, respectively. As for neurodegenerative diseases, 20% were diagnosed with multiple sclerosis, 16% had Parkinson's disease, 6% had amyotrophic lateral sclerosis, while multiple system atrophy and Huntington's disease had equal percentages of occurrence (2%). Furthermore, 6% of the participants had a

demyelinating disease and 2% were diagnosed with Guillain-Barre syndrome.

Clinimetric properties of the A-RDA

Construct validity

To assess the factor structure of the A-RDA qualitative recording form, EFA was performed over a sample of 50 participants. The KMO measure was 0.902 reflecting good sampling adequacy and suitability for factor analysis with a significant Bartlett's test of sphericity (X^2 = 1944.172, df = 300, $p < 0.001$). Factor analysis extracted a 3-factor model explaining 82.973% of the total variance (Table 2). Factor one included items of the articulation component as well as the resonance component and explained 34.410% of the variance. Factor two included items of the phonation, respiration, and prosody components and explained 24.704% of the variance. And, finally, factor three comprised the maximum repetition rate items and reflected 23.859% of the variance. Factor loadings were high for 16 items (0.716 – 0.855), and moderate for 9 items (0.538 – 0.698). Communalities were high for 23 items ranging between 0.732 and 0.953 and fair for 2 items (0.620-0.623), indicating that all the items of the A-RDA qualitative recording form are adequate.

Convergent and divergent validity

To evaluate the convergent validity of the maximum performance tasks of the A-RDA, correlation with the corresponding Praat scores was performed. Table 3 displays Spearman's correlation results. A strong negative correlation was determined between the MRRs and their corresponding scores (r ranged between −0.700 and −0.770, $p < 0.001$). A statistically significant correlation was demonstrated between the rating of the MPV and the maximum intensity calculated in Praat ($r = -0.507$, $p = 0.003$; $r = -0.524$, $p < 0.001$, respectively), as well as between the MPT and the duration of phonation ($r = -0.627$, $p < 0.001$).

Table 4 represents the convergent and divergent validity results of the A-RDA severity scale. The correlation of dysarthria severity with both the VHI-10lb ($r = 0.539$, $p < 0.001$) and the Arabic Speech Intelligibility test ($r = -0.695$, $p < 0.001$) was fair. On the other hand, the correlation of the severity scale with the SVF tasks was weak ($r = -0.220$, $p < 0.024$).

Reliability

To assess the internal consistency of the A-RDA qualitative recording form, Cronbach's alpha (α) was calculated. The 25 items of the qualitative recording form demonstrated a high-reliability coefficient of 0.912. The inter- and intra-rater reliability of the severity scale was also assessed. The inter-rater reliability was evaluated over a sample of 23 participants. It showed strong agreement across the two raters with ICC = 0.859 (0.768 – 0.940) and $p < 0.001$. As for the intra-rater reliability, it was evaluated in 29 participants and demonstrated high reproducibility of the severity scale (ICC = 0.876 (0.736 – 0.942), $p < 0.001$).

Clinimetric properties of the A-ROMP-speech

Construct validity

To make sure that the A-ROMP-speech is unidimensional, EFA was performed. The KMO measure (0.882) confirmed the adequacy of conducting a factor analysis, along with a significant Bartlett's test of sphericity (X2 = 211.632, df = 21, $p < 0.001$). Table 5 presents the results of the factor analysis. The EFA derived a one-factor model including the 7 items of the A-ROMP-speech and explaining 66.113% of the total variance. Factor loadings were high for 6 items (0.806 – 0.851) and fair for 1 item (0.692). Communalities were fair to high ranging between 0.579 and 0.724.

Convergent validity

To assess the convergent validity of the A-ROMP-speech, correlation with the VHI-10lb, the Arabic Speech Intelligibility test, and the A-RDA severity scale was conducted (Table 6). The Spearman's correlation of the A-ROMP-speech total score with the VHI-10lb ($r = 0.640$, $p < 0.001$) and the severity scale ($r = 0.631$, $p < 0.001$) was fair, and with the Arabic Speech Intelligibility test strong ($r = -0.736$, $p < 0.001$).

Reliability

Reliability evaluation of the A-ROMP-speech included assessing the internal consistency and the intra-rater reliability. The internal consistency of the 7 items of the A-ROMP-speech was demonstrated to be high (α = 0.913). The intra-rater reliability was evaluated in a sample of 29 participants, and it showed high

Table 1. The type and severity of dysarthria and the medical diagnosis of participants ($n = 50$).

Severity of dysarthria	Type of dysarthria					
	Flaccid	Spastic	Mixed	Hypokinetic	Hyperkinetic	Ataxic
1	CVA[a] ($n = 2$) GB[b] ($n = 1$)	CVA ($n = 1$) MS[d] ($n = 6$)		PD[h] ($n = 3$)		
2	CVA ($n = 3$) TBI[c] ($n = 2$)	CVA ($n = 1$) TBI ($n = 2$)	MS ($n = 1$)	PD ($n = 1$)		
3	TBI ($n = 1$)	CVA ($n = 1$) DD[e] ($n = 1$) MS ($n = 1$)	DD ($n = 1$) MS ($n = 1$) MSA[f] ($n = 1$)	PD ($n = 2$)	Huntington's disease ($n = 1$)	CVA ($n = 1$) DD ($n = 1$) MS ($n = 1$)
4	TBI ($n = 1$)	CVA ($n = 3$) TBI ($n = 2$)	ALS[g] ($n = 2$) CVA ($n = 1$)	PD ($n = 1$)		TBI ($n = 2$)
5			ALS ($n = 1$)	PD ($n = 1$)		

Severity of dysarthria: 1, minimal dysarthria; 2, mild dysarthria; 3, mild/severe dysarthria; 4, severe dysarthria; 5, very severe dysarthria.
[a]Cerebrovascular accident;
[b]Guillain-Barre syndrome;
[c]Traumatic brain injury;
[d]Multiple sclerosis;
[e]Demyelinating disease;
[f]Multiple system atrophy;
[g]Amyotrophic lateral sclerosis;
[h] Parkinson's disease.

Table 2. Exploratory factor analysis of the A-RDA qualitative recording form.

Items	Factor 1	Factor 2	Factor 3	Communalities
Lip movements	**0.774**		0.400	0.869
Jaw movements	**0.785**		0.423	0.865
Tongue movements	**0.698**		0.565	0.867
Vowels	**0.670**	0.404		0.750
Consonants	**0.760**		0.434	0.863
Clusters	**0.791**		0.400	0.898
Syllable structure	**0.761**		0.417	0.836
Maximum repetition rate /pa/			**0.833**	0.932
Maximum repetition rate /ta/			**0.855**	0.925
Maximum repetition rate /ka/			**0.849**	0.953
Maximum repetition rate /pataka/			**0.836**	0.896
Resonance	**0.741**			0.620
Vocal quality	0.513	**0.680**		0.827
Vocal use	0.453	**0.745**		0.885
Loudness	0.539	**0.716**		0.862
Pitch	0.493	**0.737**		0.842
Fundamental frequency range	0.483	**0.511**		0.623
Maximum phonation volume		**0.695**	0.408	0.732
Maximum phonation duration		**0.668**	0.520	0.809
Inhalation	0.431	**0.774**		0.868
Respiration during speech		**0.810**		0.845
Pattern of breathing		**0.835**		0.860
Melodic accent	0.524	**0.538**	0.446	0.764
Dynamic accent	0.450	**0.545**	0.503	0.752
Temporal accent	0.509	**0.554**	0.484	0.801
Eigenvalue	8.603	6.176	5.965	
Percentage of explained variance	34.410	24.704	23.859	
Cronbach's α	0.967	0.973	0.970	

Extraction Method: principal component analysis; Rotation Method: varimax with kaiser normalization.
Factor loadings < 0.4 were suppressed. Numbers in bold indicate the highest factor loading for each item.

Table 3. Convergent validity of the maximum performance tasks of the A-RDA.

	Praat variables						
	Average production per second				Maximum intensity		Phonation duration
A-RDA[a] items	/pa/	/ta/	/ka/	/pataka/	/hi/	/ahla wsahla/	Sustained /a/
Maximum repetition rate /pa/	−0.770 $p < 0.001$**						
Maximum repetition rate /ta/		−0.724 $p < 0.001$**					
Maximum repetition rate /ka/			−0.759 $p < 0.001$**				
Maximum repetition rate /pataka/				−0.700 $p < 0.001$**			
Maximum phonation volume					−0.524 $p < 0.001$**	−0.507 $p = 0.003$**	
Maximum phonation duration							−0.627 $p < 0.001$**

[a]The Arabic version of the Radboud dysarthria assessment.
Non-parametric Spearman correlation; **Correlation is significant at the 0.01 level.

reproducibility of the questionnaire's items (ICC = 0.987 (0.972 – 0.994), $p < 0.001$).

Discussion

The present study aimed to cross-culturally adapt the Arabic version of the RDA and the ROMP-speech questionnaire and to evaluate their clinimetric properties among Lebanese participants with dysarthria. The validation procedure was driven by the need to fill an existing gap in the assessment tools available to evaluate dysarthria in Lebanon [20]. The adaptation decision was based on the fact that the use of standardized assessment tools will contribute to better therapeutic outcomes and will lead to a common language among SLTs. Knowing that the Arabic language is the sixth most spoken language across the world [44], it is crucial to have standardized Arabic measures for the assessment of dysarthria which are still not available in Arab countries. In Jordan, researchers worked on the development and validation of the Arabic Frenchay dysarthria assessment; however, the adapted test and the corresponding results are not published, yet [45]. One of the advantages is that the RDA is not language-specific and can be easily adapted to different cultures [18]. It presents robust clinimetric properties and can be easily administered by a qualified SLT.

In the present study, the factor analysis extracted three clinimetrically strong factors that explained 82.973% of the total variance. Factor one included items of the articulation and resonance aspects, factor two included items of the phonation, respiration, and prosody components, and factor three included the maximum repetition rate items. When compared with the findings of the original RDA study, they presented 4 domains within the

Table 4. Convergent and divergent validity of the A-RDA severity scale.

	VHI-10lb[a]	The Arabic speech intelligibility test	SVF [b] total score
Severity scale	0.539 $p < 0.001$**	−0.695 $p < 0.001$**	−0.220 $p = 0.024$*

[a]The Lebanese version of the Voice Handicap Index–10;
[b]Semantic verbal fluency.
Non-parametric Spearman correlation; *Correlation is significant at the 0.05 level; **Correlation is significant at the 0.01 level.

Table 5. Exploratory factor analysis of the A-ROMP-speech.

Items	Factor 1	Communalities
Item 1	0.851	0.724
Item 2	0.851	0.723
Item 3	0.831	0.690
Item 4	0.836	0.698
Item 5	0.692	0.579
Item 6	0.806	0.650
Item 7	0.814	0.663
Eigenvalue	4.628	
Percentage of explained variance	66.113	
Cronbach's α	0.913	

Extraction method: principal component analysis.

Table 6. Convergent validity of the A-ROMP-speech.

	VHI-10lb [b]	The Arabic speech intelligibility test	Severity scale
A-ROMP-speech[a]	0.640 $p < 0.001$**	−0.736 $p < 0.001$**	0.631 $p < 0.001$**

[a]The Arabic Radboud Oral Motor inventory for Parkinson's disease-speech component; [b]The Lebanese version of the Voice Handicap Index–10.
Non-parametric Spearman correlation; **Correlation is significant at the 0.01 level.

qualitative recording form: (1) articulation, (2) resonance, (3) phonation, and (4) respiration and prosody. Such inconsistency in the factor structure might have different explanations. The phonation and respiration aspects involved in speech production jointly interact with the supra-segmental prosodic features which might explain why they constitute together one factor. The maximum repetition rate tasks might have stood alone as a single factor due to the fact that non-speech parameters differ from speech tasks and cannot solely reflect the motor speech profile of a subject with dysarthria [46]. Furthermore, non-speech tasks or maximum repetition rates are proven to require additional attentional and motor demands than articulation that is adapted to establishing intelligible, fluent, and natural production of speech [46]. The internal consistency of each dimension was good, so we can conclude that the items within each factor were representative.

This study delivered confirmation for the convergent validity of the A-RDA. For the maximum performance tasks, significant correlations were documented with the corresponding Praat scores. As for the convergent validity of the severity scale, it is important to mention that, to date, there is no standardized measures for assessing dysarthria in the Arab countries to compare the current results with. Dysarthria severity was proved to be correlated with the VHI-10lb ($r = 0.539$, $p < 0.001$). The participants' complaints regarding their voice and its impact on daily activities and the SLTs' rating of dysarthria severity somehow aligned emphasizing the importance of discussing the treatment goals with the patients and assigning shared ones [47]. Also, the correlation between the severity scale and the Arabic Speech Intelligibility test was fair ($r = -0.695$, $p < 0.001$), indicating that a lower severity score reflects better intelligibility in patients and vice versa. As for the divergent validity of the severity scale, Spearman's correlation with the SVF tasks was weak ($r = -0.220$, $p < 0.024$), supporting the fact that SVF relies heavily on linguistic abilities rather than motor speech capabilities. Consistent with the findings of the original RDA paper, the A-RDA qualitative recording form demonstrated high internal consistency ($\alpha = 0.912$). The inter- and intra-rater reliability of the severity scale presented strong reproducibility (ICC = 0.859 (0.768 – 0.940) and 0.876 (0.736 – 0.942), $p < 0.001$, respectively). Overall, the reported findings provided evidence about the clinimetric properties of the A-RDA among Lebanese subjects with dysarthria.

The A-ROMP-speech questionnaire was proven to be unidimensional, confirming the relevance of all its items to the same construct. For the convergent validity of the A-ROMP-speech, the correlation with the VHI-10lb ($r = 0.640$, $p < 0.001$) and the severity scale ($r = 0.631$, $p < 0.001$) was fair and strong with the Arabic Speech Intelligibility test ($r = -0.736$, $p < 0.001$). The findings support the fact that as the symptoms of dysarthria increase in severity and the more the intelligibility is reduced, the more the patient will present with complaints regarding his speech difficulties. Also, this emphasizes the significance of collecting patient-rated scores to assess the patient's perception of his/her speech difficulties [47]. The A-ROMP-speech demonstrated high internal consistency ($\alpha = 0.913$) and strong intra-rater reliability (ICC = 0.987 (0.972 – 0.994), $p < 0.001$). Such results indicate that the A-ROMP-speech is a valid and reliable self-report questionnaire to be used with Lebanese subjects with dysarthria.

It is important to mention the strengths and limitations of the present study. To the best of our knowledge, this study is the first to cross-culturally adapt a dysarthria assessment measure in the Arab culture and specifically Lebanon. Research on speech therapy-related topics is extremely limited in the Arab area and there is a lack of available standardized assessment tools. Future similar studies are needed on larger samples of subjects with dysarthria to assess the clinimetric properties of the A-RDA in different Arab countries and to ensure the reproducibility of the current findings. Further studies will emphasize the importance of administering standardized assessment measures in the evaluation of dysarthria which enhances speech therapy practices in the Arab world. The findings of the current study should be considered in light of some limitations. The sample size might be considered small ($n = 50$); however, when compared with the original study of the RDA validation in the Netherlands, it included 43 subjects with dysarthria [18]. The small sample size is mainly due to the restricted records of population-based data on dysarthria in Lebanon, which made it hard to find eligible participants and recruit a larger sample. This fact also affected the randomization in the selection of the participants and led to the recruitment of a convenience sample. On the other hand, the obtained results, including high communalities and strong internal consistency, can support the validity of the A-RDA and the reliability of factor recovery and thus reduce the effect of the sample size [48,49]. Moreover, several SLTs participated in data collection, which might constitute another flaw of this study and induce interviewer bias. However, the involved SLTs were well-trained and performed the assessment in a standardized manner.

In conclusion, the Arabic versions of the RDA and the ROMP-speech demonstrated robust clinimetric properties in a sample of Lebanese subjects with dysarthria. The construct validity of the A-RDA qualitative recording form and the convergent validity of the maximum performance tasks, the severity scale and the A-ROMP-speech showed statistically prominent results. Furthermore, the internal consistency of the qualitative recording form and the

A-ROMP-speech and the inter- and intra-rater reliability of the severity scale and the intra-rater reliability of the A-ROMP-speech were proved to be statistically high. Therefore, the A-RDA and the A-ROMP-speech are valid and reliable tools recommended to be used by SLTs to assess the symptoms and severity of dysarthria as well as patients' complaints regarding their speech problems. The results presented in this study are an important contribution to the clinical field as they encourage further studies to be conducted in other Arab countries to validate the A-RDA and thus improve speech therapy services and ensure that Arab SLTs follow the required professional standards.

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