Validation of App and Phone Versions of the Control of Allergic Rhinitis and Asthma Test (CARAT)

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Assessment of asthma control is recommended where possible [1]. The Control of Allergic Rhinitis and Asthma Test (CARAT) is a patient-reported outcome measure commonly used to assess asthma control in clinical practice [2-4]. It includes 10 questions answered on a 4-point Likert scale that address upper and lower airway symptoms, sleep disturbances, limitation of activities, and the need to increase medication over a 4-week period [5]. CARAT is frequently administered on paper during medical visits, although digital versions are available through website [6] and mobile apps [7,8].

The COVID-19 pandemic led the European Respiratory Society to recommend the use of phone screening to monitor patients with asthma [9] in order to minimize face-to-face contacts. Therefore, clinicians need to rely on CARAT (digital or phone versions), which can be used outside medical facilities to gain insight into patients' health status and enable better strategic planning during the period between visits. Currently, 4 apps include CARAT (questions on 10 consecutive screens with bullet-point responses) [7,8], and their usefulness is increasingly reported [10,11]. An app version of CARAT with 1-week recall has been validated [7], and another was used in an interventional study with adolescents [12]. However, the app version has yet to be validated taking into account the 4-week recall period. A previous study applying CARAT by phone showed its feasibility, but not its validity [13].

CARAT administered through a mobile app or phone interview is a convenient alternative to the paper version. Yet, before widespread implementation, we need to ensure these versions are equally reliable and valid. We compared the psychometric properties of 3 versions of CARAT (paper, phone, and app) in patients with asthma.

We analyzed data collected between March 2018 and January 2020 from prospective observational studies conducted by the authors about the feasibility of the InspirerMundi app [14]. Patients were recruited during a medical visit at 23 secondary care centers in Portugal and Spain. Patients were included if they had persistent asthma, were aged ≥13 years, were able to use apps, had access to a mobile device with Internet, and had been prescribed inhaled controller medication. During medical visits, physicians reported patients' asthma treatment, asthma control according to the Global Initiative for Asthma guidelines [1], number of exacerbations, and number of unscheduled medical visits. Patients filled in a sociodemographic and clinical questionnaire, including the paper version of CARAT (pCARAT) and were invited to complete CARAT in the following days using the InspirerMundi app[8] (mCARAT). After approximately 1 week (3-10 days), the responses for CARAT were collected through a telephone interview (tCARAT) (Supplementary Figure S1). A total of 144 patients participated in the studies, although the only patients analyzed were those who completed the 3 versions within 10 days. For each version of CARAT, the total score (CARAT-T, 0-30), upper airway score (CARAT-UA, 0-12), and lower airway score (CARAT-LA, 0-18) were calculated. Good disease control was defined as scores >24 on CARAT-T, >8 on CARAT-UA, and ≥16 on CARAT-LA. The internal consistency (Cronbach α), convergent validity (Spearman correlation, rs), reliability (intraclass correlation coefficient [ICC], Bland-Altman analysis), and agreement (% agreement, Cohen κ) were determined.

Sixty-seven patients with a median (IQR) of 20 (17-33) years were analyzed (Supplementary Table S1). mCARAT was completed on the same day as pCARAT by 85% of patients (median, 0 [0-2] days), while tCARAT was completed after a median of 6 (5-7) days. The median total score was 20 (16-23) for pCARAT, 20 (18-24) for mCARAT, and 22 (18-26) for tCARAT. The median CARAT-UA and CARAT-LA scores were 5 (4-8) and 15 (12-17) in pCARAT, 6 (4-8) and 15 (12-17) in mCARAT, and 7 (4-8) and 16 (13-17) in tCARAT, respectively.

The internal consistency of the CARAT scores was good (pCARAT, α=0.71-0.79; mCARAT, α=0.72-0.81; and tCARAT, α=0.71-0.80). The scores obtained with pCARAT were significantly correlated with the mCARAT scores (rs=0.64-0.82) and tCARAT scores (rs=0.55-0.64). The correlation between mCARAT and tCARAT scores was also significant (rs=0.59-0.69) (Supplementary Table S2). Differences in CARAT-T between methods were significantly correlated with the time interval between the assessments (rs=0.22, Supplementary Figure S2).

The relative test-retest reliability of the CARAT scores was acceptable for all versions, although better for pCARAT-mCARAT (ICC2.1=0.65-0.85) and mCARAT-tCARAT (ICC2.1=0.71-0.76) in comparison with pCARAT-tCARAT (ICC2.1=0.59-0.71). There was reasonable agreement between versions, with bias close to zero and reasonable limits of agreement. Slightly better agreement was seen for pCARAT-mCARAT than for tCARAT-mCARAT and pCARAT-tCARAT (Figure, Supplementary Figure S3).
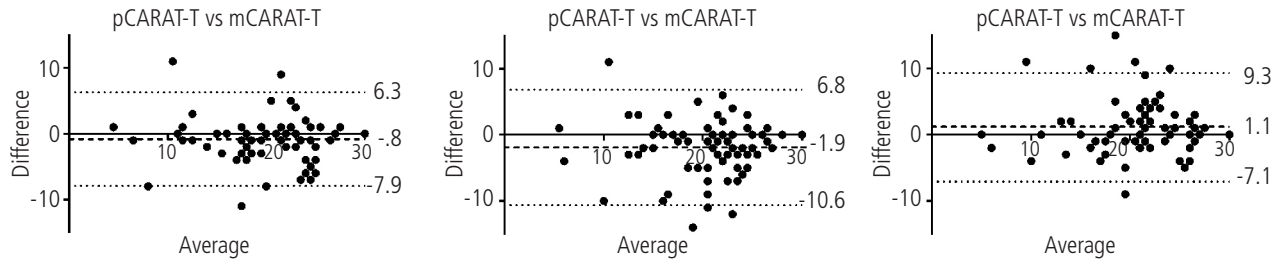
Figure. Bland-Altman plots of the total scores of Control of Allergic Rhinitis and Asthma Test (CARAT) obtained through paper (pCARAT), app (mCARAT), and phone (tCARAT). The dashed lines represent the bias and the dot-dashed lines the 95% limits of agreement.

Disease was not controlled in 81% of patients based on pCARAT, in 78% based on mCARAT, and in 67% based on tCARAT. Agreement in the CARAT-T control classification was higher for tCARAT and mCARAT (81%; κ=0.52 [95%CI, 0.30-0.74]) than for pCARAT and mCARAT (76%; κ=0.28 [95%CI, 0.01-0.55]) and for pCARAT and tCARAT (72%, κ=0.28 [95%CI, 0.04-0.52]). Uncontrolled UA and LA symptoms were present in 81% and 58% of patients based on pCARAT, in 76% and 36% based on mCARAT, and in 76% and 55% based on tCARAT. The agreement for classification of control according to CARAT-UA and CARAT-LA (75%-85%; κ=0.51-0.64) followed the same pattern as CARAT-T.

Comparison of paper and app versions yielded better results, followed by app and phone versions and, lastly, by paper and phone versions. This finding is likely related to the time interval between the assessments rather than to the collection method. Most patients answered the app version on the same day they filled in the paper version, while the phone version was collected 1 week later. During this period and considering the possible effect of the medical visit (and related interventions), patients may experience changes in their symptoms or in other CARAT-assessed domains or may perceive them differently. A previous study showed that recent weeks play a more prominent role in the assessment of control than the initial weeks, considering the 4-week recall period [7]. In an additional analysis (Supplementary Table S2) with patients answering the 3 versions within 7 days, slightly better results were found than for those answering with a 10-day interval. Nevertheless, agreement between the paper and app versions was noticeably better for both intervals. It is possible that the slightly larger differences observed between tCARAT and the other versions may also be associated with the distinct nature of the phone interview, which involves an interviewer, in comparison with patients' self-completion in the paper and app versions. Future studies should collect the 3 methods over a shorter period (<48 hours) and in a random order to clarify this possibility.

Regardless of the collection method, the internal consistency of the CARAT scores was above the 0.7 threshold [15]. In addition, the correlation coefficients between the CARAT scores obtained were found to be moderate [7]. Since most ICCs were above 0.7 [15], we can rely on the test-retest reliability of CARAT using all 3 methods. The only ICCs that were below this cut-off were CARAT-T and CARAT-UA between the paper and phone versions and CARAT-UA between the paper and app versions, probably because of the high variability of UA symptoms in our sample.

This study was based on a small sample, mostly of adolescents/young adults followed in secondary care. Future studies should include an adequately powered sample of patients with an extended age range also recruited from primary care. This study showed that both mHealth and phone versions of CARAT are acceptable tools for assessment of disease control in adolescents and young adults with persistent asthma.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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