Validation of app and phone versions of the Control of Allergic Rhinitis and Asthma Test (CARAT)

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Assessment of asthma control at every opportunity is recommended[1]. 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 ten questions answered in a 4-point Like rt scale that address upper and lower airway symptoms, sleep interference, limitation of activities, and the need to increase medication over a 4-week period[5]. CARAT is frequently administered on paper during medical visits, but digital versions through website[6] and mobile apps are available[7, 8].

With the COVID-19 pandemic, the European Respiratory Society recommends the use of phone screening to monitor patients with asthma[9] as face-to-face contacts are to be minimized. So, clinicians need to rely on CARAT versions (digital or phone) that can be used outside medical facilities to gain insight into patients’ health status and allow better strategic planning during the period between visits. So far, four apps integrate CARAT (implementing questions on ten consecutive screens with bullet-point responses)[7, 8] and their usefulness is being increasingly reported[10, 11]. An app version of CARAT with 1-week recall has been previously validated[7] and other was used in an interventional study with adolescents[12]. Yet, validation of the app version considering the 4-week recall period is still needed. A previous study applying CARAT by phone showed its feasibility, but not its validity[13].

CARAT collected 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 three CARAT versions (paper, phone and app) in patients with asthma.
We analyzed data collected between 03/2018 and 01/2020 from prospective observational studies conducted by the authors about the feasibility of Inspirer Mundi app[14]. Patients were recruited during a medical visit at 23 secondary care centres from Portugal and Spain. Patients were included if they had persistent asthma, were ≥13 years, were able to use apps, had access to a mobile device with Internet and were prescribed an inhaled controller medication. During medical visits, physicians reported patients’ asthma treatment, asthma control according to the Global Initiative for Asthma[1], number of exacerbations and of unscheduled medical visits. Patients filled in a sociodemographic and clinical questionnaire, including the CARAT paper version (pCARAT). Patients were invited to complete the CARAT in the following days using the Inspirer Mundi app[8](mCARAT). After approximately 1-week (3-10 days), CARAT was collected through a telephone interview (tCARAT) (Supplementary Figure S1). A total of 144 patients participated in the studies, but only those completing the three versions within 10 days were analyzed. CARAT total (CARAT-T, 0-30), upper airways (CARAT-UA, 0-12) and lower airways (CARAT-LA, 0-18) scores were calculated. Scores >24 on CARAT-T, >8 on CARAT-UA, and ≥16 on CARAT-LA defined good disease control. The internal consistency (Cronbach’s α), convergent validity (Spearman correlation-rs), reliability (intraclass correlation coefficient-ICC, Bland-Altman analysis), and agreement (% agreement, Cohen’s kappa-k) were determined.

Sixty-seven patients with a median[percentile 25-percentile 75]of 20[17-33]years were analyzed (Supplementary Table S1). mCARAT was completed in the same day of pCARATby 85% of patients (median 0[0-2]days), while tCARATwas completed after a median of6[5-7]days. The median pCARAT total score was 20[16-23], the mCARAT 20[18-24], and the tCARAT 22[18-26]. 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.

Internal consistency of the CARAT scores was good (pCARATα=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 (r_s=0.64-0.82)and tCARAT scores (r_s=0.55-0.64). The correlation between
mCARAT and tCARAT scores was also significant ($r_s=0.59-0.69$) (Supplementary Table S2). Differences in CARAT-T between methods were significantly correlated with time interval between the assessments ($r_s=0.22$, Supplementary Figure S2).

Test-retest relative reliability of CARAT scores was acceptable for all versions, although better for pCARAT-mCARAT ($ICC_{2,1}=0.65-0.85$) and mCARAT-tCARAT ($ICC_{2,1}=0.71-0.76$) in comparison with pCARAT-tCARAT ($ICC_{2,1}=0.59-0.71$). There was reasonable agreement between versions, with bias close to zero and reasonable limits of agreement. A slightly better agreement is seen between pCARAT-mCARAT in comparison with tCARAT-mCARAT and pCARAT-tCARAT (Figure 1, Supplementary Figure S3).

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

Comparison of paper and app versions obtained 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 with 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 one week later. During this period and considering the possible effect of the medical visit (and related interventions), patients may have changes in 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 the patient’s control than the initial weeks considering the 4-week recall period [7].

In an additional analysis

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(Supplementary Table S2) with patients answering the 3 versions within 7 days, slightly better results were found, compared to those answering with 10-day difference. Nevertheless, a better agreement between paper and app versions was noticeable for both time-lags. It is possible that the slightly larger differences observed between tCARAT and the other versions may also relate with the distinct nature of phone interview, involving an interviewer, in comparison with patients’ self-completion in paper and app versions. Future studies should collect the three methods during a shorter period (<48h) and in a random order to clarify this.

The internal consistency of the CARAT scores, regardless of the collection method, were above the 0.7 threshold [15]. Also, the correlation coefficients between CARAT scores obtained were found to be moderate [7]. Most ICCs were above 0.7 [15], so we can rely in the test-retest reliability of CARAT using the three methods. The only ICCs that were below this cut-off were CARAT-Tand CARAT-UA between paper and phone versions and CARAT-UA between paper and app versions. This may be linked to the high variability of UA symptoms in our sample.

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

Conflicts of interest
The authors have declared that they have no competing interests in relation to this study.

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References


Figure 1. Bland-Altman plots of Control of Allergic Rhinitis and Asthma Test (CARAT) total scores obtained through paper (pCARAT), app (mCARAT) and telephone (tCARAT)

* The dashed lines represent the bias and the dot-dashed lines the 95% limits of agreement