

Reliability of the breathing pattern assessment tool for in-person or remote assessment in people with asthma

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To the editor,

Breathing pattern disorders (BPD) are common in asthma and worsen patient outcomes.¹ Consequently, it is increasingly common in clinical practice to screen for BPD.^{2,3} However, previous tools to assess breathing patterns have required specialist training and equipment that is not widely available,⁴ and there has been no evidence for the reliability of assessing breathing pattern disorders in people with asthma. Recently, an observational assessment tool was developed to screen for BPD in asthma; the Brompton breathing pattern assessment tool (BPAT).⁵ Here, biomechanical breathing characteristics assessed with the patient at rest are chest wall movement, channels (oral versus nasal) and noise of inspiratory and expiratory flow, signs of air hunger, respiratory rate, and rhythm of breathing. Items are scored from 0-2, then summed to give an overall score out of 14. Higher scores indicate an abnormal breathing pattern. A BPAT score of ≥ 4 had a sensitivity of 0.92 and a specificity of 0.75 for detecting physiotherapist-diagnosed BPD,⁵ and these test characteristics have been reproduced in other asthma clinics.⁶ The BPAT is easy to administer, requires no manual assessment or equipment, and observations take only a minute to complete; however, its inter-rater reliability has not been determined. This tool has potential to be adapted for telehealth diagnosis, and to reduce the need for in-person consultations, especially pertinent in the context of COVID-19. In this study in people with asthma, we therefore determined the reliability of in-person and video assessments of breathing patterns using the BPAT.

We performed a prospective blinded inter-rater reliability study of the BPAT at our tertiary hospital between June 2019 and May 2020, recruiting adult participants with stable asthma from outpatient clinics. Individuals were excluded if they could not provide written informed consent or had been treated by a physiotherapist for BPD in the past 12 months. The study was approved by the Alfred Hospital Ethics Committee (Project 610/18).

Three respiratory physiotherapists and one exercise physiologist all with > 5 years of respiratory experience watched an instructional video of BPAT assessment produced by the developers of the tool.⁵ The BPAT was completed with the patient sitting comfortably in a supported seat, resting for at least five minutes prior to assessment.

Two in-person assessors independently completed BPAT assessments simultaneously whilst the participant was video recorded for subsequent scoring by a third assessor. The video was recorded using a smartphone positioned approximately one metre from the front of the participant and included their entire upper body in frame. All three assessors were blinded to each other's scores. The primary in-person assessor was a senior clinician physiotherapist whose ratings were compared both to the secondary in-person assessor

(senior physiotherapist [n = 14], or exercise physiologist [n= 16]), and the video assessor (senior physiotherapist).

Statistical analyses were conducted using IBM SPSS statistics (v.27). Categorical variables are presented as percentages and frequency, and continuous variables as mean or median values with standard deviation or interquartile range. Inter-rater reliability was assessed using a two-way mixed effect intraclass correlation coefficient (ICC) model based on single rating and absolute agreement for each rater. Mean estimations along with 95% confidence intervals were reported for each ICC. Coefficient values <0.50, between 0.50 and 0.75, between 0.75 and 0.90, and >0.90 were respectively interpreted as poor, fair, good and excellent.⁷ Bland-Altman plots were used to assess for any systematic differences in scores across the range of values between in-person and video scores, with limits of agreement (LOA) derived from the mean difference ± 1.96 of the standard deviation of the mean difference⁸. Sample size was determined by the methods of Walter et al.⁹

Inter-rater reliability analysis was performed on 30 participants with asthma [females 24 (80%), mean age 51 (SD 18), FEV₁ 79 (20) % predicted, BMI 30 (8) kg/m²]. Total BPAT scores ranged from 1-10 with a median score of 4 (IQR 3-7). The proportion of participants who demonstrated abnormal breathing patterns (BPAT ≥ 4) was 21 (70%) for the primary assessor, 20 (67%) for the secondary assessor, and 21 (70%) for the video assessor.

The reliability of the BPAT between two in-person assessors was excellent (Table 1), and review of the Bland-Altman plot revealed no systematic differences across the range of BPAT scores (mean difference 0.1, LOA -1.3 – 1.9) (Figure 1). Reliability was similar when the senior physiotherapist's scores were compared to a second senior physiotherapist [ICC (3,1) = 0.93 (0.74-0.98)] or to the exercise physiologist [ICC (3,1) = 0.97 (0.91-0.99)]. The raw scores across all BPAT domains for each participant by assessor are presented in the online supplement. Reliability was highest for subscores of channel of inspiration/expiratory and rhythm [ICC (3,1) = 0.98 and 0.91], and lowest for expiratory flow and respiratory rate [ICC (3,1) = 0.79 and 0.66] (supplement). Reliability between in-person and video assessment was good (Table 1). However, lower agreement was demonstrated than for in-person assessment (mean difference 0.5, LOA -2.4 – 3.4).

The variation in agreement between in-person and video assessments was attributable primarily to poor clarity of respiratory flow sounds over video. After excluding these data, the reliability remained good, with no systematic differences in scores but with a reduced mean difference and narrower LOA (mean difference 0.1, LOA -1.3 – 1.5). Bland Altman plots showing the differences in measurement between an in-person and video assessment are presented in the online supplement.

This study shows the BPAT has excellent reliability when conducted in-person and indicates that on 95% of occasions a second assessor will score within 1.4 points of the first. The BPAT has good reliability when conducted by video assessment, although less than in-person assessment due primarily, but not exclusively, to reduced clarity of sound recordings. On 95% of occasions the video score will be within 2.9 points of the in-person score. Exclusion of respiratory flow sounds improves reproducibility.

We note the following limitations. Our sample size was small and predominantly female. We found high rates (21/30, 70%) of positive BPAT scores (score ≥ 4), compared to previously published proportions in a similar population (29/117, 25%).¹⁰ Participants in this investigation were aware that their breathing pattern was being observed and video recorded. This may have influenced their total scores and overestimated the prevalence of BPD but is unlikely to alter reliability. The results in this study were achieved by experienced clinical physiotherapists and an exercise physiologist with extensive experience in respiratory care, using a tool that did not require extensive training, intensive calibration or specialised equipment.

Video recordings were not assessed in real time under 'real world' telehealth conditions, which may have implications for clinical settings. We ensured adequate picture quality and used the same recording device for all assessments, while patients using video-consultation may have different devices with variable quality.

This study demonstrated excellent in-person reliability for the BPAT. The reliability of BPAT assessment of video recording is lower than for in-person assessment but remains acceptable. When in-person consultations are limited due to COVID-19 or other reasons, it may be useful to administer the BPAT using videoconferencing technology, provided issues around sound recording are taken into consideration. Further research is needed to determine the validity of BPAT across normal populations and different health care professionals, and responsiveness to treatment including determination of the minimum important difference.

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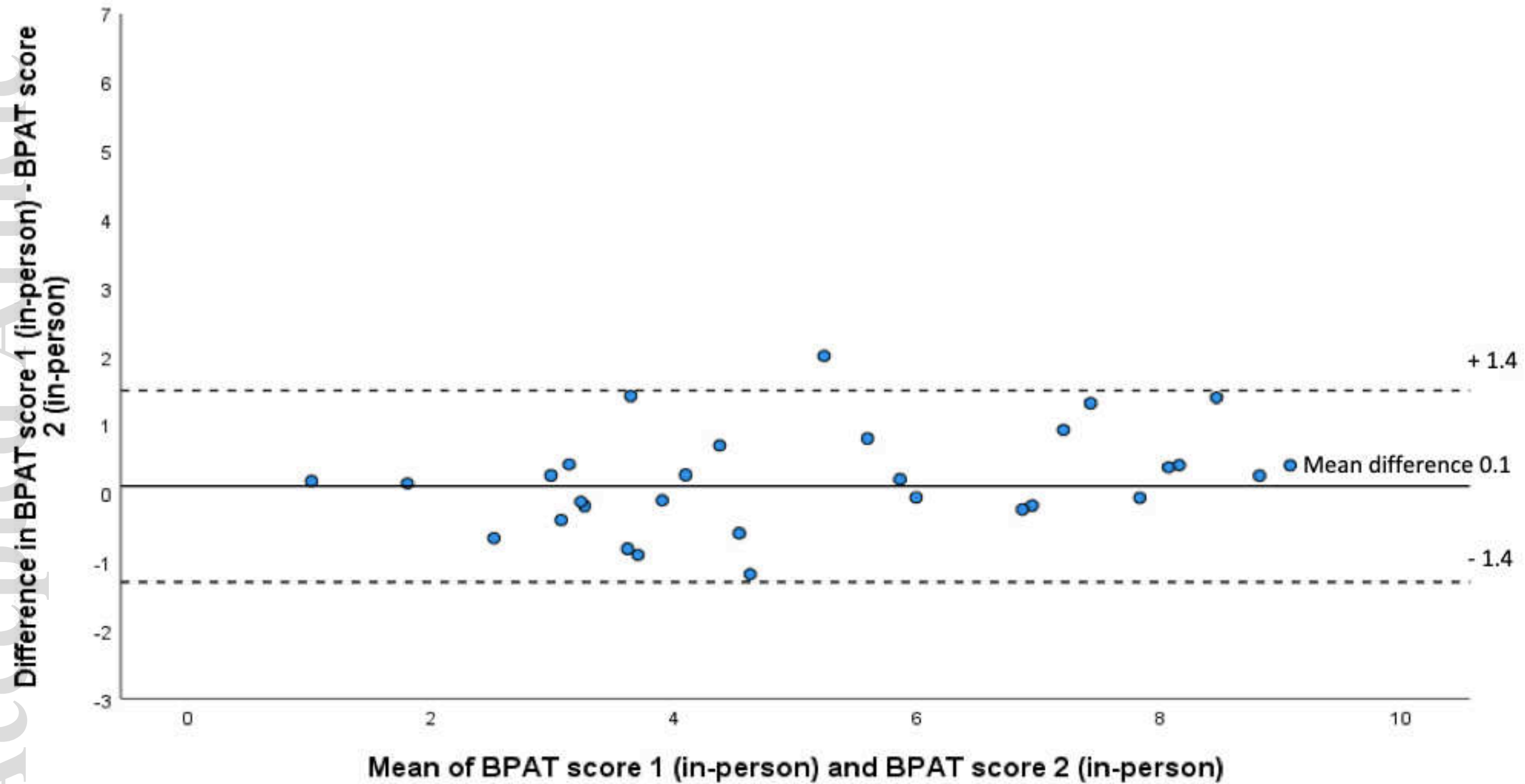
Table 1: Inter-rater reliability for in-person and video assessments using BPAT, n=30

	In-person assessment	In-person and video assessment	In-person and video assessment (no sound scores)
ICC (3,1)	0.95 (0.91-0.98)	0.76 (0.56-0.88)	0.76 (0.57-0.88)

Mean difference (score)	0.1	0.5	0.1
LOA (score)	± 1.4	± 2.9	± 2.3
Scores outside LOA	1 (3%)	2 (7%)	1 (3%)

ICC = intraclass correlation coefficient; data are mean estimation with 95% confidence interval; LOA = limits of agreement

Figure 1: Bland-Altman Plots showing reliability of the breathing pattern assessment tool (BPAT) between; A) two in-person assessors, B) an in-person assessor and a video assessor (supplementary), C) an in-person assessor and a video assessor, without the use of sound scores, (supplementary) n= 30



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Figure 1a. In-person assessment

Reliability of the BPAT across subscores – individual data and in-person intra-class correlation coefficients

Assessor 1 = Senior Physiotherapist (n=30)

Assessor 2 = Senior Physiotherapist (n=14) or Exercise Physiologist (n=16) shaded in grey

Video assessor = Senior Physiotherapist (n=30)

Subscore range (0-2)

Intra-class correlation and 95% confidence intervals presented for assessment between assessor 1 and 2

Abdominal or upper chest movement: ICC (3,1) =0.79 (0.61-0.89)

Assessor 1	2	1	2	2	2	1	2	2	2	2	2	1	1	1	2	2	2	1	1	1	2	2	1	1	2	0	2	1	1	1
Assessor 2	2	0	2	1	2	2	2	2	2	2	1	1	1	0	2	2	2	1	1	1	2	2	1	1	2	0	2	1	1	1
Video assessor	2	1	2	1	2	1	2	1	1	2	2	1	1	1	2	2	2	1	1	1	2	2	1	1	2	0	2	1	1	1

Inspiratory flow: ICC (3,1) = 0.86 (0.73-0.93)

Assessor 1	1	0	0	0	0	1	1	1	0	0	0	0	0	0	0	1	0	1	0	0	1	1	0	0	0	0	1	1	1	0
Assessor 2	1	0	0	0	0	1	1	1	0	0	0	1	0	0	0	1	0	1	0	0	1	0	0	0	0	0	1	1	1	0
Video Assessor	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0

Expiratory flow: ICC (3,1) = 0.79 (0.61-0.89)

Assessor 1	1	0	0	0	0	2	1	1	0	0	0	1	0	0	0	1	0	0	1	0	1	1	0	0	0	0	1	0	0	0
Assessor 2	1	1	0	0	0	1	1	1	0	0	0	2	0	0	0	1	0	0	1	1	1	1	0	0	0	0	1	0	0	0

Video Assessor	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0
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Supplemental Figure 1: Bland-Altman Plots showing reliability of the breathing pattern assessment tool (BPAT) between; B) an in-person assessor and a video assessor, C) an in-person assessor and a video assessor, without the use of sound scores, n= 30

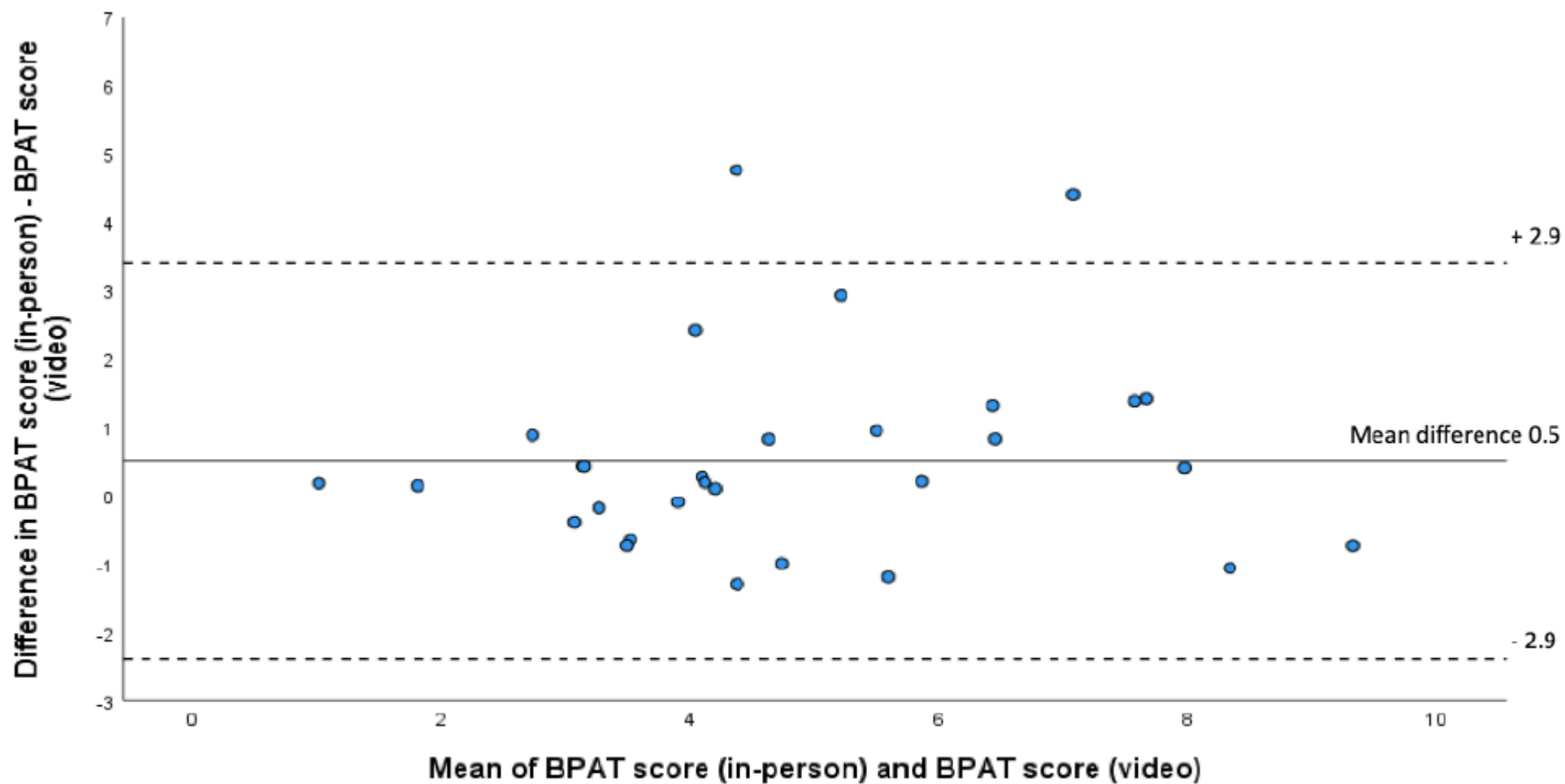


Figure 1b. In-person and video assessment

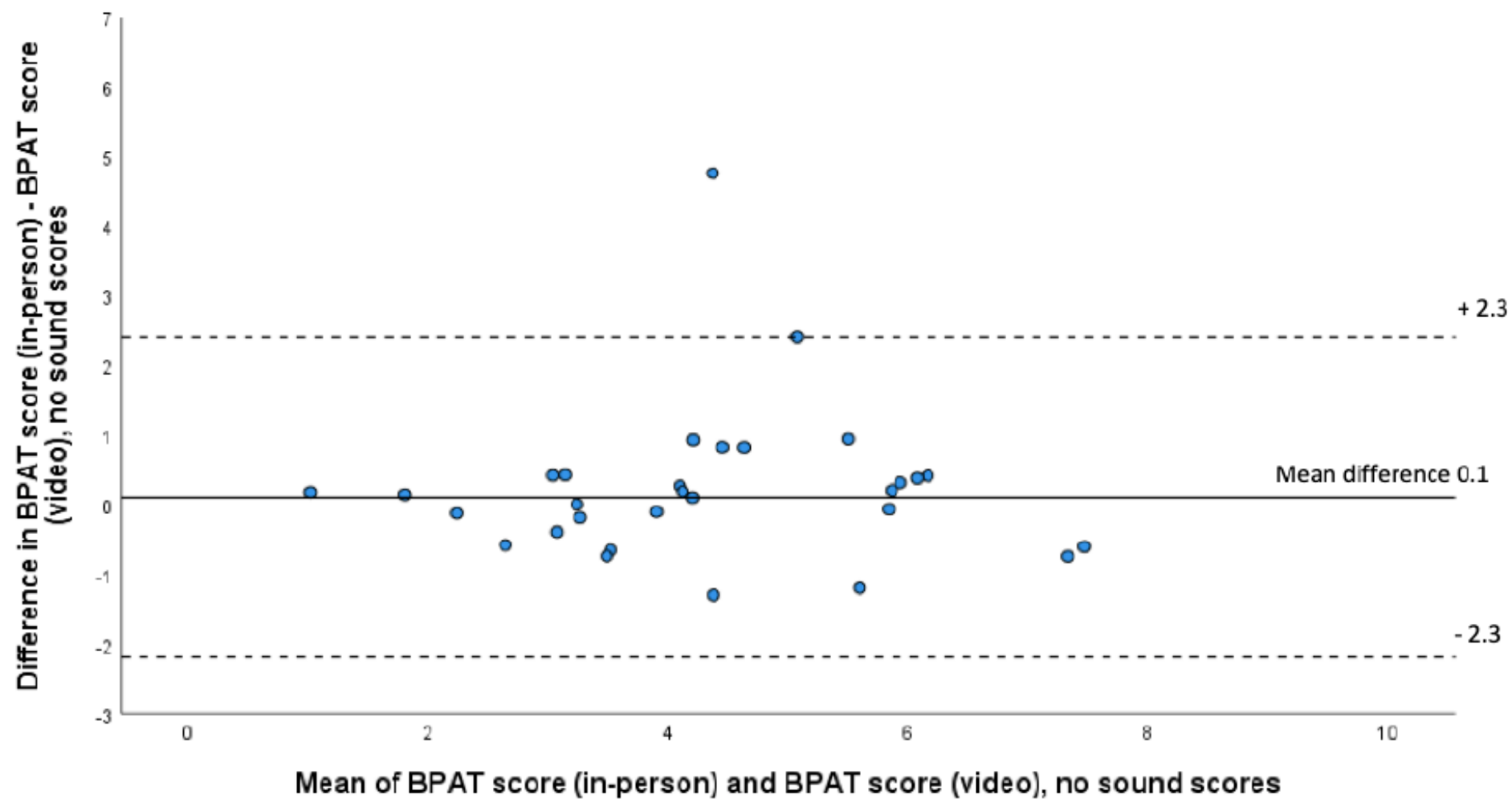


Fig 1c. In-person and video assessment (no sound)