O1

Ventilatory efficiency in arm ergometry cardiopulmonary exercise testing (CPET).

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Introduction: Arm ergometry (AE) is an alternative modality for the performance of cardiopulmonary exercise testing. Due to a combination of decreased muscle mass, muscle fibre type differences, lower oxygen conductance and mechanical differences in the ergometers, peak V̇O2 is known to be lower when measured by arm ergometry(1).
However, parameters that assess ventilatory efficiency play an important role in diagnostics and little is known about the impact of AE exercise on these parameters. The aim of this study was to compare VE/VCO2 slopes obtained by both AE and cycle ergometry (CE).
Methods: Maximal CPET to volitional exhaustion was performed in a group of 116 (62 F) healthy volunteers of median age 38 (IQR 19) years, using both AE and CE with randomised testing order and a rest interval of at least 24 hours. Breath by breath gas analysis was performed using the Ultima CPX (Medical Graphics, UK) metabolic cart.
Statistical analysis, including Pearson correlation and paired t-test were undertaken using IBM SPSS Statistics 27.0.1.0 statistical software (IBM Corporation). Ethical approval was granted by the Health Research Authority, Wales REC 7 (REC Reference 17/WA/0284; IRAS Project ID 226248).
Results: The VE/VCO2 slope was significantly higher when obtained by AE and was >30 in 84/116 (72%) of healthy volunteers, despite a significant correlation (r=0.554; p<0.001), Table 1. Ventilation when exercising with the arms is influenced by a reduced breathing frequency and a reduced peak tidal volume. In addition, there is a significantly lower CO2 output when exercising with the arms.
Conclusions: Recognised normal ranges for ventilatory parameters may not be appropriate when exercising with the arms. The mechanical restraints of exercising with the upper body leads to a decrease in peak tidal volume and breathing frequency and a lower CO2 output altering the relationship between VE/VCO2.

Table 1: Ventilatory parameter data obtained from arm ergometry and cycle ergometry exercise testing.

	Arm Ergometry (SD)	Cycle Ergometry (SD)	Mean Difference	Z score
VE/VCO_2 slope *ml.min*$^{-1}$	32.56 (4.73)	28.43 (3.78)	4.12**	1.00
VT rest *L*	0.74 (0.24)	0.82 (0.28)	-0.08**	-0.38
VT peak *L*	1.98 (0.60)	2.40 (0.69)	-0.42**	-1.31
BF rest *bpm*	14.33 (4.23)	13.90 (4.02)	0.44	0.13
BF peak *bpm*	38.20 (10.21)	40.96 (8.56)	-2.76*	-0.28
VCO_2 peak *ml.min*$^{-1}$	2103.20 (4.73)	3055.29 (3.78)	-952.09**	-0.78

Data expressed as mean and standard deviation (SD). *p<0.01; **p<0.001; Z score = standardised test statistic

References:

1. Larsen, R. T., Christensen, J., Tang, L. H., et al. (2016) 'A SYSTEMATIC REVIEW AND META-ANALYSIS COMPARING CARDIOPULMONARY EXERCISE TEST VALUES OBTAINED FROM THE ARM CYCLE AND THE LEG CYCLE RESPECTIVELY IN HEALTHY ADULTS.' International Journal of Sports Physical Therapy, 11(7) pp. 1006–1039.

O2

Quality Assurance in a Respiratory Laboratory: How compliant are you?

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Introduction
This study attempts to scrutinize the real-world adherence to a biological control and linearity program within an operational respiratory laboratory, where weekly designated time is allocated. The aim was to establish a local benchmark for performance monitoring and audit, taking account of reasonable workplace considerations. that was both reasonable and attainable, thereby providing a comparative reference for future assessments of compliance.

Method
The records encompassing 3 years (July 2020 to June 2023) of QA examinations were extracted from the Pulmonary Function Testing software. Subsequently, these records underwent comparison with their respective predetermined dates for both Biological Control and Linearity checks. A permissible variance of ±7 days was employed in relation to the scheduled dates for the completion of both checks. Non-compliance dates were tallied and scrutinized to identify reasons (clinical duties, training, staffing, bank holidays etc).
Absolute compliance was calculated and defined as the ratio of all executed examinations compared to the predetermined dates for QA checks. Adjusted compliance was similarly calculated, although the predetermined dates were corrected for reasonable causes of non-compliance. These were classified as; staffing, bank holidays, clinical duties, equipment maintenance, conference attendance.

Results
When adjusted for reasonable circumstances, biological control checks demonstrated rates of 72% (2020-21), 78% (2021-22), and 87% (2022-23). In contrast, linearity checks exhibited higher rates of 86%, 97%, and 99% during the corresponding years. Dates of non-compliance with no articulable reason were 9.6%, 1.92% and 0% in respective years. The results indicate ana improvement in compliance and the execution of QA procedures over the three-year period.

Discussion
This study highlights that designated time for QA activities within a working department result in a relatively high compliance rate. Staffing emerged as a primary factor influencing non-compliance, suggesting potential mitigation in centres with increased personnel. Notably, the study does not delve into the intangible aspect of the department's culture regarding the perceived significance of QA. Recording QA execution and establishing a shared understanding of the importance and rationale behind QA among all staff members is posited as a strategy likely to foster a sense of collective responsibility, potentially enhancing overall compliance within the team.

O3

Optimising initial therapeutic strategy for obstructive sleep apnoea patients with nocturnal hypoventilation

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Background: Obstructive sleep apnoea (OSA) is locally diagnosed via domiciliary limited multi-channel sleep study and treated with fixed-pressure continuous positive airway pressure (CPAP) determined via Oxford algorithm (Stradling et al., Respir Med 2004; 98(2): 152-154). Some comorbidities induce nocturnal hypoventilation alongside OSA, significantly increasing morbidity. CPAP indirectly alleviates hypoventilation, but severe cases may require higher treatment pressures (Soghier et al., Ann Am Thorac Soc 2019; 16(10): 1295-1303). Though initial efficacy facilitates long-term CPAP success, clinical cutoffs for this indication are poorly defined. Previous studies have attempted predictive models using baseline study parameters (Slouka et al., J Appl Biomed 2019; 17(1): 81), but not specifically within hypoventilators on fixed-pressure devices. This study aimed to define thresholds within routinely collected diagnostic variables indicating significant probability of CPAP failure in normocapnic OSA patients with nocturnal hypoventilation.

Methods: A retrospective audit was performed on OSA patients with hypoventilation (locally defined as ≥ 10 minutes of continuous SpO_2 < 90%) and a non-hypoventilation control group commencing CPAP between September 2021 and September 2022 (n = 90/group). Assessed variables were age, body mass index, neck circumference, apnoea/hypopnoea index (AHI), oxygen desaturation index, Epworth Sleepiness Score, time spent < 90%, < 85% and < 80% SpO_2 (T90, T85 and T80), mean SpO_2 and SpO_2 nadir. Within both phenotypes, median comparisons were made between compliant (≥ 4 hours usage for 70% of nights in the third month) and noncompliant patients, controlled (average AHI < 5 events/hr in the third month) and non-controlled patients and resolved (T90 < 10%) and persistent hypoventilation via Mann Whitney U tests. Receiver operating characteristic (ROC) curve analysis was performed on statistically significant variables to identify viable predictors of CPAP failure.

Results: No assessed variables predicted CPAP non-compliance or suboptimal OSA control in either phenotype. However, baseline T90, mean SpO_2, T85 and neck circumference were significant predictors of persistent hypoventilation on CPAP, with T90 and mean SpO_2 demonstrating clinical viability (Youden index ≥ 0.5; Table 1).

Conclusions: Hypoventilators with severe nocturnal hypoxia may benefit from increased starting pressure relative to the Oxford algorithm (Table 1), to be further characterised in follow-up studies.

Table 1 – Baseline T90 and mean SpO_2 are clinically viable predictors of persistent hypoventilation on fixed CPAP with treatment pressure derived from the Oxford algorithm. Comparison table of statistically significant predictors of persistent hypoventilation on CPAP following ROC analysis including P value, AUC and optimal predictive threshold value indicated by the maximal Youden index within that variable. Patients meeting these threshold values had significantly increased risk of persistent hypoventilation on CPAP. Resolved hypoventilation *n* = 23, persistent hypoventilation *n* = 22.

Rank and variable	P value	Area under curve	Optimal threshold	Sensitivity (95% CI) (%)	Specificity (95% CI) (%)	Youden Index
1. T90 (%)	< 0.0001	0.87	> 63.8%	**81.82** (61.48 – 92.69)	**86.96** (67.87 – 95.46)	**0.687**
2. Mean SpO_2 (%)	0.0012	0.782	< 88.5%	**86.36** (66.67 – 95.25)	**69.57** (49.13 – 84.4)	**0.559**
3. T85 (%)	0.0045	0.747	> 14.45%	**68.18** (47.32 – 83.64)	**73.91** (53.53 – 87.45)	**0.421**
4. Neck circumference (inches)	0.0126	0.723	> 17.75 inches	**65** (43.29 – 81.88)	**73.91** (53.53 – 87.45)	**0.3891**

O4

Could the 6-Minute-Walk-Test be shortened in duration and still capture significant oxygen desaturations in patients with interstitial lung disease?

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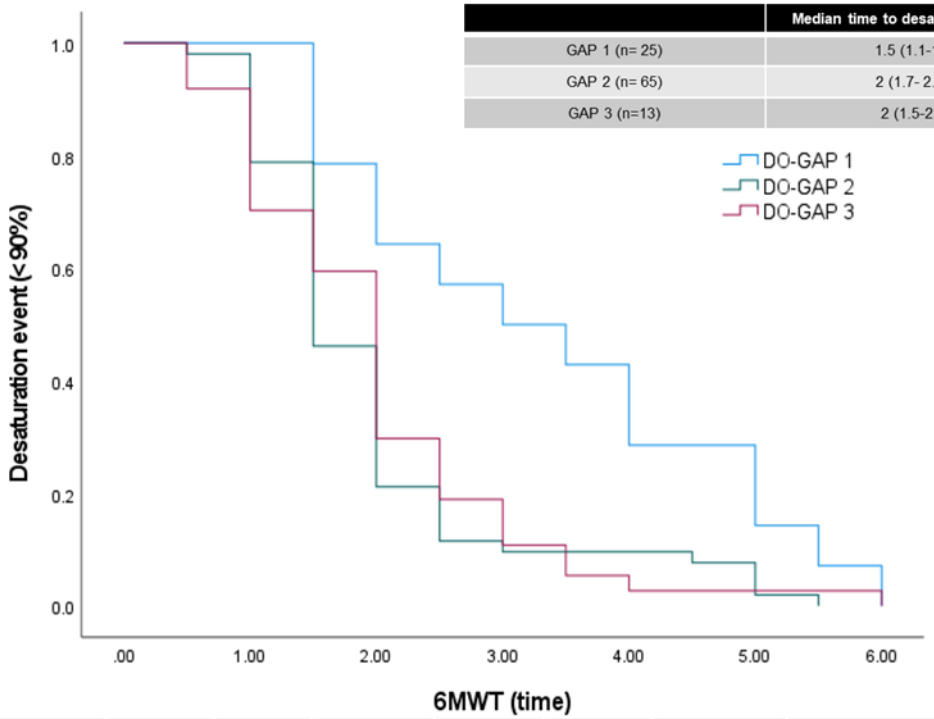
Background: The 6-Minute-Walk Test (6MWT) is clinically used to detect oxygen desaturation on exertion. Peripheral oxygen saturation (SpO2%) dropping below 90% during the 6MWT is an eligibility criterion for ambulatory oxygen therapy according to British Thoracic Society guideline (2015). Shorter walk test durations could be advantageous in patients with more severe interstitial lung disease (ILD) unable to meaningfully complete a 6MWT and in remote monitoring settings (Robertson et al. 2024).
Aims: 1) To compare SpO2% recorded during different time periods of the 6MWT and the prognostic implications. 2) To determine the median time to desaturation event (SpO2% < 90%) and whether severity of ILD affects this.
Methods: Retrospective routine clinical 6MWT and lung function data were collected from patients with ILD. Median lowest SpO2% recorded in the first time period (0-2 mins), middle time period (2-4 mins) and last time period (4-6 mins) of the 6MWT were statistically and prognostically compared. Patients were classified according to the Distance-Oxygen-Gender-Age-Physiology (DO-GAP) index (Chandel et al. 2023)
Results: 258 patient records were analysed. Median (IQR) SpO2% recorded at 0-2, 2-4 and 4-6 minutes of 6MWT were 93% (8), 92% (8) and 91% (10) respectively and were significantly different between time periods($p<0.001$). Prognostically, areas under the curve (AUC) for predicting 3 year mortality were significant ($p<0.001$) and similar for the lowest SpO2% recorded between 0-2, 2-4 and 4-6 minutes of the 6MWT (AUC = 0.71, 0.72 and 0.71, respectively). 107 patients had significant desaturation (SpO2% <90%) during the 6MWT, of whom 14 were already walking with ambulatory oxygen therapy. Kaplan Meier analysis demonstrated the median time for SpO2% to fall below 90% ranged from 1.5–3 minutes between the DO-GAP groups ($p=0.01$ figure 1).
Conclusion: For patients with ambulatory oxygen desaturation during a 6MWT, the SpO2% generally falls below 90% early in the test. For example, a 3MWT has over 80% sensitivity for identifying ambulatory oxygen desaturation in more severe ILD (DO-GAP groups 2 and 3). Shorter walk test durations could be used to detect oxygen desaturation in patients with ILD which would be more efficient, more patient-centred and more compatible with remote exercise testing.



No at risk	0 mins	1 mins	2 mins	3 mins	4 mins	5 mins	6 mins
DO-GAP 1	14	14	11	8	6	4	1
DO-GAP 2	52	51	24	6	5	4	0
DO-GAP 3	37	34	22	7	2	1	1

Figure 1: Kaplan Meier analysis of time to desaturation event for n=103 patients with ILD who all desaturated to <90% by the end of a 6MWT. Patients are categorised into the three strata of the DO-GAP severity index

P2

The Assessment of Respiratory Entropy in Chronic Obstructive Pulmonary Disease Using Structured Light Plethysmography

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Introduction:
Spirometry is the gold standard for diagnosing COPD. However, its insensitivity to small airways and early disease, and demanding volitional manoeuvres have resulted in ongoing interest into alternative methods of assessment that only require tidal breathing. We sought to determine if measures of respiratory entropy ("regularity" of breathing) from structured light plethysmography (SLP) could be useful in the diagnosis of COPD.

Method:
18 participants with varying severities of COPD were recruited. SLP (PneumaCare, Cambridge, UK) was performed before and after 2.5mg of salbutamol, followed by spirometry if not previously completed within 6 months. Entropy data were calculated using LabChart 8 (AD Instruments Ltd, 8.1.24) in four ways; as root mean squared of successive difference (RMSSD; variability from one breath to the next) and standard deviation (SD; overall variability) for both breath-to-breath interval (BB) and tidal volume (VT). Entropy was compared to spirometry (FEV1/FVC, FEV1 z-score, FEV1 %pred) using Spearman's Rank Correlation. Pre- and post-salbutamol entropy in COPD was compared using a Wilcoxon Signed-Rank test. COPD data was compared to data from 13 healthy participants (previously tested in a separate study) using a Mann Whitney-U test. All analyses were undertaken using IMB SPSS (version 24) with $p<0.05$ as the threshold for statistical significance. The study was sponsored by PneumaCare® (REC Reference 21/YH/0004).

Results:
No correlations were found between any SLP entropy and spirometry parameters in COPD. There were no significant differences observed in any entropy parameter following bronchodilation. However, there were significant differences between entropy post-bronchodilation in COPD and health; SDBB ($p=0.011$), RMSSDBB ($p=0.025$), SDVT ($p=0.001$), and RMSSDVT ($p=0.011$). Some differences were also observed pre-bronchodilation in COPD compared to health; RMSSDVT ($p=0.042$) and SDVT ($p=0.010$), although RMSSDRATE was not different ($p=0.106$) nor was SDBB ($p=0.051$), although a power calculation for the latter suggested it was underpowered by only 5 participants.

Conclusion:
Although SLP entropy does not correlate with spirometry in this pilot study, it appears greater (hence, less regular) in COPD post-bronchodilator compared to health and could, therefore, prove useful diagnostic tool with more data. However, it does not appear to be useful in bronchodilator reversibility testing.

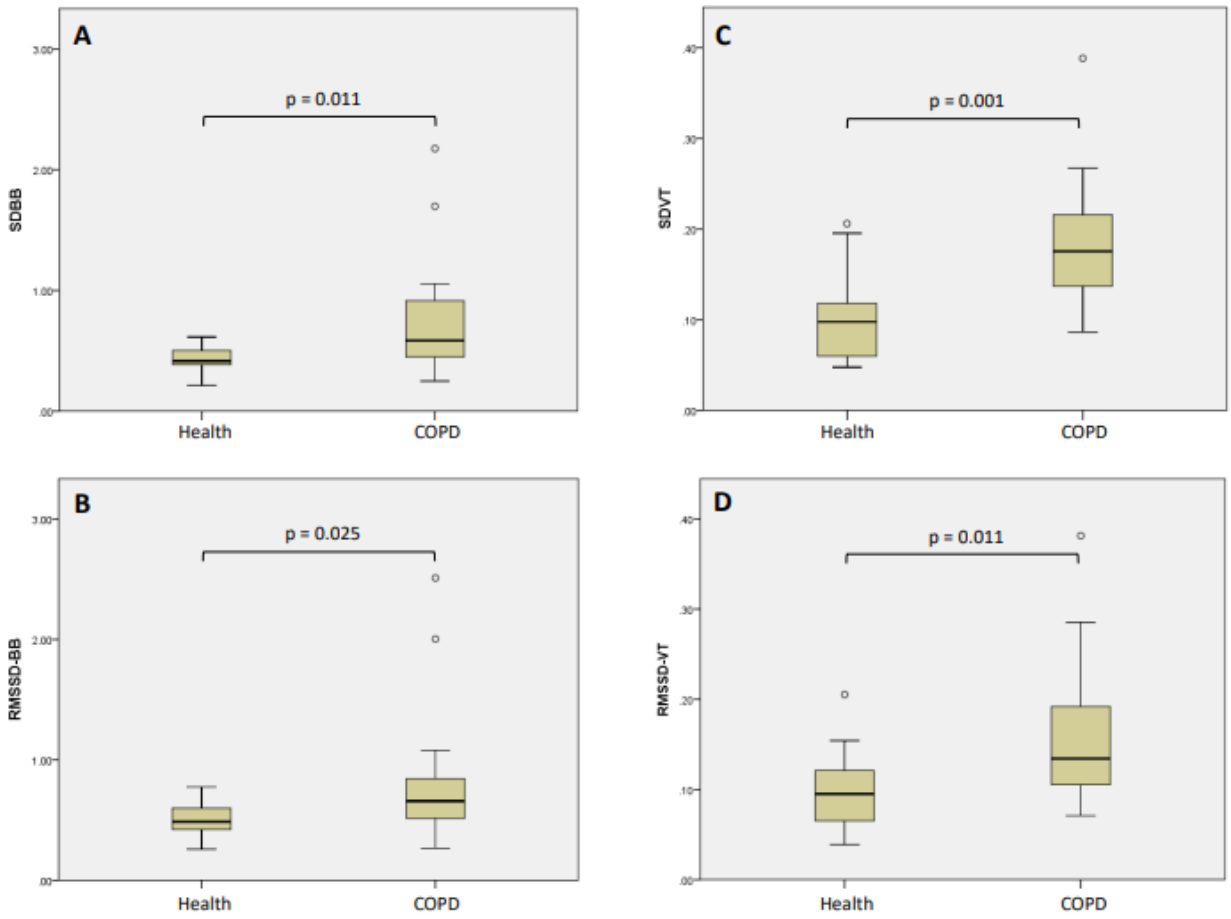

Figure 1: Box & Whisker plots of entropy in health (n = 13) versus COPD post-bronchodilator (n = 18), derived by 4 methods; **A.** SD_{BB} (p = 0.011), **B.** $RMSSD_{BB}$ (p = 0.025), **C.** SD_{VT} (p = 0.001), **D.** $RMSSD_{VT}$ (p = 0.011). Boxes are median +/- interquartile range (IQR) with whiskers set at 1.5 x IQR.

P4

OSCILLOMETRY IN ROUTINE LUNG FUNCTION TESTING: A UK-BASED SURVEY

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INTRODUCTION: Oscillometry is used to assess lung function during normal tidal breathing. Although it offers potential advantages over spirometry and has been available for many years, adoption into clinical practice anecdotally seems slow. This online survey aimed to investigate 1) the prevalence of oscillometry within respiratory services in the UK, 2) understand the reasons for utilisation and 3) the barriers to adoption of the technique.

METHODS: This survey formed part of a larger project supported by the National Institute for Health and Care Research Applied Research Collaboration Wessex, and was approved by the University of Portsmouth ethics committee. It was disseminated electronically to all Association for Respiratory Technology and Physiology (ARTP) members and further distributed via LinkedIn and X. Quantitative data was analysed and presented as frequency statistics. For qualitative data, free-text comments were analysed for common themes.

RESULTS: 42 NHS respiratory services completed the survey. 17 (41%) services indicated they own an oscillometry device; eight with a forced oscillation technique device (ResMon Pro), eight with an impulse oscillometry device (Vyntus IOS), one with both. Of the 14 services currently using oscillometry for clinical testing, eight (57%) test on adults, three (21%) on paediatrics, and three on both. All 14 services reported using oscillometry for patients with asthma, and eight (57%) for chronic obstructive pulmonary disease. 12 (86%) services use it for patients who cannot perform technically acceptable spirometry. Of the 24 services currently without a device, 12 (50%) indicated they would consider purchasing one within the next five years, with lack of funding being the main barrier in eight of the remaining 12 (67%). Four (10%) and 36 (86%) services perceived respiratory consultants' understanding of oscillometry to be 'none' or 'little', respectively. 40 (95%) reported a publication from the ARTP, outlining the benefits/limitations and/or guidance on reporting, would be beneficial.

CONCLUSIONS: Oscillometry is being used within some respiratory services across the UK, predominately for patients with asthma and those who cannot perform technically acceptable spirometry. The next step is to liaise with the ARTP and discuss supporting the potential development of national standards of oscillometry and a guidance publication.

P5

It’s not all about Asthma! The prevalence of alternative diagnosis in patients with confirmed or suspected asthma.

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Introduction

Asthma can be over or under diagnosed in patients reporting respiratory symptoms (Aaron et al. AJRCCM 2018; 198: 1012-20). Alternative diagnoses such as inducible laryngeal obstruction (ILO) or breathing pattern disorder (BPD) mimic asthma symptoms and can be challenging to identify (Williams et al. ERJ Open Res 2023; 9: 00635-2023). The aim was to review the prevalence of alternative diagnoses in patients with confirmed or suspected asthma who completed the NuvoAir home assessment.

Methods

Outcome and engagement data was collected and analysed from patients referred to the 12 week NuvoAir home assessment service from December 2021 to November 2023. Patients were onboarded by respiratory physiologists who coached them to perform quality assured spirometry four times weekly and when symptomatic. Symptom history was recorded and Nijmegen and/or VCD questionnaires completed if BPD or ILO were suspected. Post assessment a report was generated with results, interpretations and recommendations. NHS clinicians facilitated onward referral and outcomes were gathered. An experience questionnaire was sent to patients.

Results

Of 75 patients referred, 21 individuals (28%, age 43.7 (±11.7) years; 4 Male, 17 Female) had a concurrent diagnosis suspected at referral. Average engagement to 4 times weekly spirometry was 84% with 73% of sessions graded A-C (ATS 2005). Overall 25% of patients were diagnosed with ILO and 55% diagnosed with BPD (Figure).
Two subgroups emerged; group 1 asthma uncertain with no previous evidence of obstruction (n=7) and group 2 uncontrolled asthma with uncertain cause (n=14). In group 1 asthma was disproven for all. In group 2; asthma was disproven in one individual, asthma was solely responsible for symptoms in two and 11 individuals received an additional diagnosis (Figure). When surveyed, 75% of patients thought the NuvoAir assessment was useful in detecting drops or improvements in their lung function, understanding patterns of their health and providing them with reassurance.

Conclusions

In this cohort of patients with uncontrolled or unconfirmed asthma, a physiologist-led home assessment utilising serial spirometry measures, validated questionnaires and detailed history taking has enabled an accurate diagnosis of asthma and facilitated the timely identification of BPD and ILO.

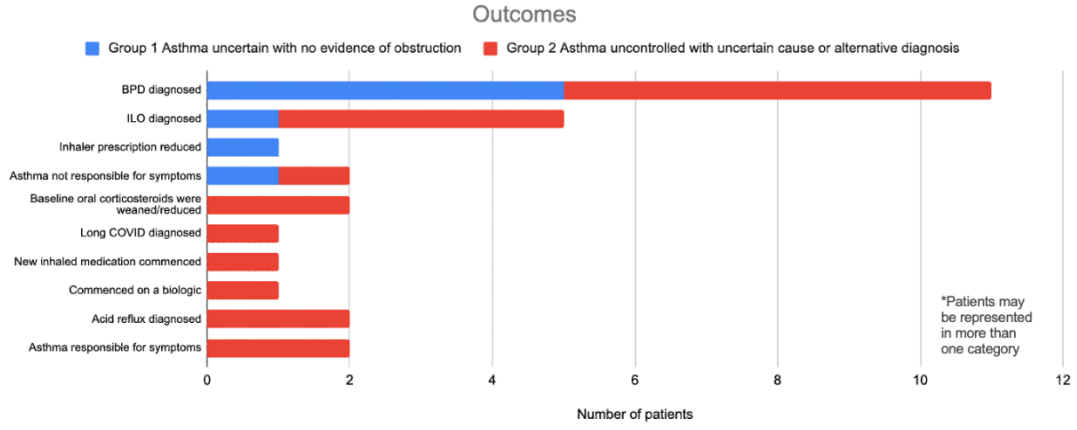

Figure: Clinical outcomes of home spirometry assessment

P7

Immediate and 3-month tolerance of nebulised Sodium Colistimethate to treat pseudomonas infection/colonisation in patients with non-CF bronchiectasis.

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Introduction: Nebulised Sodium Colistimethate (SCM) is recommended as an off licence treatment in the British thoracic society guidance to manage Pseudomonas Aeruginosa (PA) colonisation in patients with non-cystic fibrosis (CF) bronchiectasis. In non-CF bronchiectasis, PA colonisation is associated with increased mortality, risk of hospital admission and exacerbation. Despite the evidence, use of nebulised antibiotics is not without risk with bronchospasm a known side effect, occurring in approximately 7-10% of patients undergoing nebulised antibiotic therapy.

Aim: Nebulised SCM is offered in the local service, but tolerance has not been previously assessed in this cohort. The aim of this study is to review patients undergoing trials of nebulised SCM to identify potential risk factors and mitigating strategies to reduce the incidence of intolerance.
Methods: Patients who underwent SCM challenge test between January 2019 and June 2023 were included. Spirometry data was obtained and the pre-and post (nebulised SCM) was reviewed for the incidence of bronchospasm (defined as a fall ≥15% FEV1). In subjects who did not show initial adverses reaction, tolerance and PA clearance was assessed at 3 months.

Results: 60 patients were included (F=43 (72%), mean: 71). 7 (13%) had an adverse reaction during SCM challenge test. 53 proceeded to a 3-month trial of nebulised SCM; 33 (55% of the total cohort; 62% of the remainders) successfully completed the course, 16 (27% of the cohort, or 30% of the remainders) ceased due to intolerance, 1 patient was unable to comply due to dementia associated cognitive decline and 3 patients were lost to follow up.

Discussion: 38% were unable to tolerate the 3-month SCM treatment course either due to initial bronchoconstriction or later suspected treatment-related adverse effect. The frequency of adverse effects was lower than that identified in a recent RCT but many of the side effects in the clinical trial were attributable to other cause and fewer patients stopped the treatment than in our cohort (7% vs. 45%). It was difficult to determine the time point at which the treatment was ceased and the exact reasons why in this study as almost all patients had ceased treatment before their clinic review.

P8

Comparison of dead space estimates using Fowler and Cotes sampling methods during gas transfer.

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Background: Anatomical dead space can be calculated using different methods. Cotes method estimates dead space utilising bodyweight (2.2 ml x kg). The Fowler technique measures dead space utilising the tracer gas washout curve.
Aims: To compare TLCO between dead space calculation methods (Fowler and Cotes) using the set discard and sample volume option.

Methods: TLCO was measured using the Master Screen (Vyaire) rapidly responding gas analyser and the single breath method. Settings were changed retrospectively to compare the impact of dead space calculation methods on past TLCO results. Discard and sample volumes were set at 900 ml and 600ml respectively for both methods. Gas transfer parameters and dead space values between methods were compared statistically using paired t-tests or Wilcoxon rank sum tests. Z-score classifications were also compared between methods. Difference in agreement between dead space methods was compared using Bland-Altman method to calculate the bias (Fowler dead space – Cotes dead space). Linear regression was used to test for any change in the bias with change in dead space scale range.

Results: TLCO results are presented in table 1 from 53 patients comparing methods. TLCO and VA values were significantly different between methods. Several patients changed z-score severity class depending on method used. Anatomical dead space was significantly higher using the Fowler method compared with Cotes ($p<0.001$). The calculated bias between dead space methods was -100.5 ml ±64.9(26.8 to – 227.8 ml). There was a significant systematic change in bias with change in scale with dead space ($r = 0.69$ $p<0.001$) which indicates the difference in values between dead space methods was higher in the higher ranges of dead space.

Table 1: Comparison of Fowler and Coates method values. *** p<0.001 data presented as mean (± SD) or median (IQR)

[1](n=53)	Fowler	Cotes	Significance
TLCO (mmol/min/kpa)	4.77 (2.85)	4.90 (2.86)	***
TLCO pred. (%)	66 ± 24	69 ± 24	***
TLCO z score	-2.47 ± 1.85	-2.27 ± 1.78	***
VA (litres)	4.05 ± 1.33	4.23 ± 1.31	***
VA pred. (%)	77 ± 19	80 ± 18	***
VA z score	-2.11 ± 1.67	-1.78 ± 1.56	***
KCO	1.22 ± 0.36	1.22 ± 0.36	
KCO pred (%)	85 ± 0.60	85 ± 0.60	
KCO z score	-0.89 ±1.51	-0.89 ±1.51	
TLCO Z score classification	Normal (n=27) mild (n=5) moderate (n=9) severe (n=15)	Normal (n=23) mild (n=6) moderate (n=16) severe (n=9)	***
Discard volume (litres)	0.91(0.02)	0.91 (0.02)	
Sample volume (litres)	0.59 (0.02)	0.59 (0.02)	
Anatomical dead space (ml)	244(104)	150(34.7)	***

Table 1: Comparison of Fowler and Coates method values. *** p<0.001 data presented as mean (± SD) or median (IQR)

Conclusion: Calculation of TLCO using Cotes and Fowler methods with set option for discard and sample volume produce significantly different outcomes resulting in a difference in classifications of abnormality. Anatomical dead space was significantly higher using the Fowler method. Future investigations should investigate the impact of automatic discard volume determination setting when using different anatomical dead space methods.

P9

The suitability of obtaining a single acceptable gas transfer result

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Introduction

The single-breath gas transfer test assesses the lung transfer factor of carbon monoxide (TLCO) and is routinely used in clinical practice for monitoring chronic respiratory conditions. The ARTP recommend achieving two acceptable and reproducible results, with the mean being reported (Sylvester et al., 2020). It is unknown whether obtaining one acceptable manoeuvre is sufficient.

Methods

200 patients from June 2023, who performed gas transfer testing from the following clinical specialities were reviewed: Interstitial Lung Disease, Pulmonary Vascular Disease, Oncology and Lung Defence. Testing was conducted using Vyaire equipment in accordance with ARTP 2020 guidelines, and GLI 2017 reference values were utilised (Stanojevic et al., 2017). ARTP 2020 z-score thresholds were used to classify the severity of abnormalities. A one-way ANOVA was used to assess for differences between manoeuvres, and sub-analyses were conducted to account for clinical specialities and spirometry patterns.

Results

25 patients (12.5%) achieved one acceptable result and 14 (7.0%) achieved no acceptable results. Of those 39 patients, 23 declined further testing, 10 performed maximal attempts, 5 did not meet VIN criteria and 1 patients' testing was stopped prematurely due to safety concerns. In the remainder of the cohort, it took a median 3 attempts to obtain 2 acceptable and reproducible results. Of the 161 patients who performed a minimum of two acceptable manoeuvres, 138 (85.7%) met ARTP reproducibility criteria within the first two manoeuvres, while 4 patients (2.5%) failed to meet reproducibility criteria. There was no statistical difference between acceptable manoeuvres for TLCO, KCO or VA ($p<0.05$). When accounting for clinical specialities or spirometry pattern, all results were comparable and non-significant ($p<0.05$). Changes in TLCO, KCO and VA, and the proportion of patients whose grading severity changed between manoeuvres are seen in Table 1.

Conclusion

In 86% of cases, one acceptable manoeuvre provided the clinical information required. There were negligible differences in results between acceptable manoeuvres and few patients changed gas transfer grading. These results highlight the suitability of using the first acceptable gas transfer result, questioning the requirement for routinely obtaining two acceptable and reproducible gas transfer results.

		Absolute difference	% Predicted difference	Z-Scores difference	Change between Normal and Abnormal Classification	Change in Grading Severity
1^{st} vs 2^{nd} acceptable manoeuvre	TL_{CO} (mmol/min/kPa)	0.04 (0.32)	0.61% (4.37%)	0.06 (0.36)	4 (2.5%)	18 (11.2%)
	K_{CO} (mmol/min/kPa/L)	0.01 (0.06)	0.78% (4.09%)	0.05 (0.29)	3 (1.9%)	14 (8.7%)
	VA (L)	0.00 (0.20)	0.00% (3.59%)	0.00 (0.33)	4 (2.5%)	18 (11.2%)
1^{st} acceptable manoeuvre vs reported value	TL_{CO} (mmol/min/kPa)	0.04 (0.17)	0.48% (2.36%)	0.06 (0.20)	3 (1.9%)	11 (6.8%)
	K_{CO} (mmol/min/kPa/L)	0.01 (0.03)	0.51% (2.31%)	0.04 (0.16)	1 (0.6%)	11 (6.8%)
	VA (L)	0.00 (0.09)	-0.02 (1.75%)	0.00 (0.16)	0 (0.0%)	26 (16.1%)
Data reported as median (Interquartile range)						

P10

Retrospective audit analysing the effects of applying the Global Lung Initiative (2021) reference ranges on static volumes for Non-Caucasian population

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Introduction
The introduction of the Global Lung Initiative (GLI (2021) reference values for static volumes has allowed for a more statistically valid and representative interpretation of lung volumes.
Recent guidance encourages the use of more up to date reference ranges, although there is limited research on the impact of adopting the current GLI equations in a Non-Caucasian subjects.
The aim of this study was to assess the impact of adopting the GLI equations for static volumes in an adult Non-Caucasian population of Berkshire.

Method
An retrospective audit was performed using data from Non-Caucasian (NC) and Caucasian (C) patients (as a control), which were changed from ECSC (1993) to GLI reference values.
The NC group (n=100) consisted of 50% male/female with a mean age 56.4 years (range 21-79 years), height 166cm (142-187cm) and BMI of 28 kg/m2 (18-45 kg/m2). The C group (n=100) were matched accordingly.
Changes in predicted values and z scores for TLC, FRC, RV, and VC MAX were tested for statistical significance with the appropriate difference test. Changes in severity of clinical abnormality was assessed with interrater agreement testing.

Results
VC MAX, TLC, RV and FRC for the NC group, had statistically significant mean differences for predicted values and z-score ($p<0.001$) when moving from ECSC to GLI datasets.
Significant differences were found between the NC and C group for changes in z-score when using GLI for VC Max ($p<0.01$), FRC ($p<0.01$) and RV ($p<0.05$).
There was an increase in severity score for NC patients for VC Max, with the frequency of patients who were classified as normal reducing from 81 to 33. TLC also showed a change, the frequency of normal classification reducing from 68 to 40. The C group showed a similar pattern of severity shift but with less statistical significance

Conclusions
The adoption of the GLI reference equations for a non-Caucasian population of Berkshire result in significant changes when interpreting static lung volume results compared to a Caucasian control group. This data would suggest non-Caucasian populations are potentially more affected by implementation of new prediction models.

P12

Exploring physiological discordance between spirometry and gas transfer in idiopathic pulmonary fibrosis (IPF)

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Introduction
FVC is used as the index for monitoring, commencing anti-fibrotic treatment and as an outcome measure in IPF but may not reflect the full physiological impact of disease. Gas transfer measures the alveolar/capillary changes however, these values can be discordant to spirometry values. The reason for these discordant values in IPF is not currently understood and this may have an impact on clinical management.

Method
Retrospective analysis of full PFTs in 207 IPF patients were conducted and indices were compared by Pearson correlation. Of these, 32 patients were identified with discordant FVC and KCO values. These were further categorised as being either volume impaired (VI) with an FVC:kCO ratio ≤1.3 or Diffusion Impaired (DI) with an FVC:KCO ratio of ≥4.
HRCT of these discordant patients were visually assessed, and quantifications made for the level of honeycombing and reticulation/ground glass changes1. The presence of emphysema and pulmonary hypertension were also assessed. Comparison of groups was made by independent t-test.

Results
In the full cohort, the mean (SD) age was 75.15 (8.30) years, smoking exposure 19.00 (34.30) pack years, BMI 28.29 (4.69) kg/m2 and male:female 155:52.
Spirometry demonstrated restriction with reduced FVC (77.56% predicted), preserved FEV1/FVC ratio (0.83) and impaired gas transfer (TLCO 56%, VA 67% and kCO 82% predicted). Statistically significant relationships were evident between FEV1 and FVC, and all gas transfer parameters ($p<0.01$).
Data of the 32 discordant patients are summarised in Table 1 with no significant difference in demographics between groups. CT scans did not show any significant differences in interstitial abnormalities or presence of pulmonary hypertension however, emphysema was only present in DI group.

Conclusions
Whilst VA closely correlates with FVC and reflects restriction severity, kCO reflects the diffusion impairment and therefore, this provides more specific information about alveolar/capillary impairment than TLCO.
Whilst there were 2 distinct discordant groups with physiological differences seen, the extent of interstitial abnormalities were similar in both groups. Coexisting emphysema rather than pulmonary hypertension may account for DI phenotype.

1Sverzellati N et al. Visual score and quantitative CT indices in pulmonary fibrosis: relationship with physiologic impairment. Radiol med. 2007:112:1160-1172

Table 1: Comparison of VI and DI groups

	Group VI (n=16) Mean (SD)	Group DI (n=16) Mean (SD)	Significance
Age (years)	76.44 (8.89)	77.94 (8.80)	NS
BMI (kg/m²)	27.88 (5.64)	30.81 (17.24)	NS
Sex (M:F)	5:11	16:0	
Smoking history (pack years)	11.06 (25.86)	24.97 (20.33)	NS
Presence of Emphysema (%)	0	50%	0.001
Mean score for honeycombing			
Upper zone	1.06 (0.44)	1.19 (0.54)	
Middle zone	1.31 (0.48)	1.56 (0.81)	
Lower zone	1.75 (0.68)	1.88 (1.15)	
Mean score for reticulation/ ground glass changes			
Upper zone	1.06 (0.68)	0.69 (0.70)	
Middle zone	1.19 (0.54)	0.88 (0.62)	
Lower zone	1.25 (0.58)	1.50 (0.73)	

P13

Evaluation of pre-bronchodilator FEV1/VCMax z-score in the context of significant bronchodilator response in patients with an FEV1/VCMax z > -1.645

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Introduction
Bronchodilator responsiveness (BDR) during reversibility may be possible even without the presence of airflow obstruction (AFO). Over two decades the definition of AFO and what constitutes a 'significant' BDR has led to some differences in practice. This study aims to reaffirm the importance of considering reversibility in normality and considers borderline AFO as being distinct to normal based on FEV1/VCMax. This distinction is anticipated to reopen debates regarding the implementation of guidelines, and the performance of reversibility, which is often limited to patients with defined AFO.

Methods
A retrospective analysis of reversibility was taken in an 18 month 'post-COVID-19' cohort, where BDR was seen despite normal baseline FEV1/VCmax ratio (n=78, Male=28, Female=50, Adults=69, Paediatric=9, Caucasian = 76, Black = 1, Other/Mixed = 1). Patients were categorised into a 'Borderline' and 'Normal' group (determined by an FEV1/VCMax Z-score of -1.645<Z<-1.282 and Z>-1.282 respectively), and analysed against ARTP, ATS/ERS and NICE reversibility guidelines. T-tests were performed to assess degree of BDR between borderline and normal groups.

Results
BDR was most identified in patients by ARTP (2020) guidance (n=78); of these, 31 were positive according to ATS/ERS (2021), 28 by NICE/BTS (2019) and 27 by ATS/ERS (2005). Twenty-four of the 78 ARTP-identified positive responses were in the 'borderline' group (31%), 45% were in 'borderline' when using ATS/ERS (2021), 35% when using NICE/BTS (2019) and 29% when using ATS/ERS (2005). Independent sample t-tests yielded no statistically significant difference in the mean for FEV1 %improvement, raw improvement (ml), nor FEV1 %predicted improvement.

Conclusion
The results indicate the ATS/ERS (2005) guidance to be the most conservative while ARTP (2020) the least, when determining a significant BDR. Irrespective of the guidance applied, most patients showing significant BDR were not 'borderline'. However, 45% of patients belonging to the 'borderline' group when applying the ATS/ERS (2021) guidance may suggest an important Z-score window, that yields a high number of positive responses from a relatively small range of Z-scores. Using Z>-1.282 could prove an efficient compromise, aiming to minimise missing significant responses whilst avoiding over-administrating bronchodilators, were the threshold of -1.645 to be applied when indicating BDR studies.

P14

Is the Forced Oscillation Technique a suitable surrogate for more volitional lung function testing in COPD?

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Background: The forced oscillation technique (FOT) has been intensively researched for use in patients with respiratory disease. However, since then the technology has progressed and its uses within respiratory testing have increased. This study aims to identify if FOT measurements can be used to identify pathology associated with chronic obstructive pulmonary disease (COPD) in comparison to more volitional lung function assessments.

Methods: FOT was performed using Resmon Pro (Restech Milano, Italy), spirometry and body plethysmography were performed using Jaeger Masterscreen (Vyaire Medical, Germany) in 6 patients (2 female, age 67.1years ± 5.7, height 170cm ± 12.7 and weight 74.3kg ± 14.4) with a known diagnosis of COPD as part of a clinic visit in November 2023. Results have been analysed using Pearson's correlation to determine the relationships between measurements.

Results: Analysis identified a strong (R= 0.9473) significant (P=0.004093) correlation between RV/TLC ratio standard residual (SR) and AX inspiration SR (Figure 1). Other correlations were identified but none were significant.

Conclusion: When analysing the relationship between AX (area under the reactance curve) during inspiration and the RV/TLC ratio, a strong and significant correlation can be found identifying its potential use for identifying and severity grading lung gas trapping in patients with COPD. Additional further research to greater identify the specificity and sensitivity of these tests against already established markers of pathophysiology in a larger cohort is warranted.

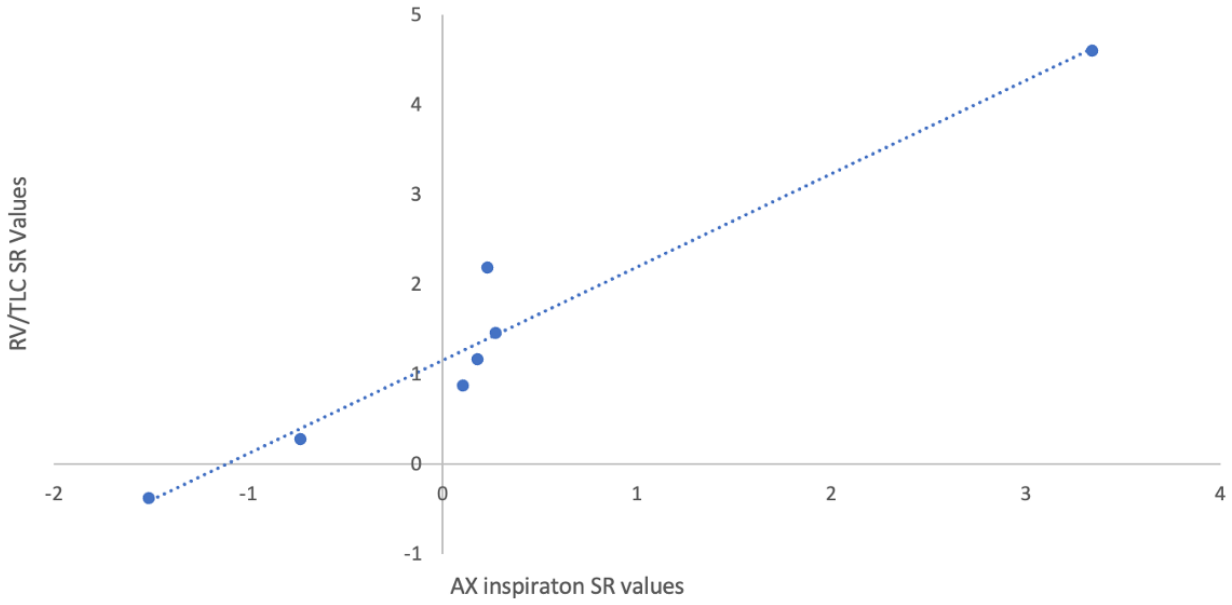

Figure 1: Comparison of lung function and FOT measurements from 6 patients with a confirmed diagnosis of COPD. AX inspiratory measuring the elastic properties of the lung and increases in conditions impacting the lung periphery.

P15

A retrospective review of home-based spirometry quality in an adult lung transplant cohort

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Introduction
Lifelong surveillance of lung transplant (LTx) recipients is essential for the detection of allograft complication and early detection may improve patient outcomes (Odisho et al, 2023). Regular home and hospital spirometry are part of routine monitoring, with home spirometry highly correlated with hospital spirometry (Wijbenga et al, 2020).
The introduction of artificial intelligence-based software (ArtiQ.QC) to a remote monitoring program (patient-facing app & Bluetooth-connected spirometer) allowed spirometry efforts to be assessed against international standards (Graham et al, 2019) and provided automated feedback to patients. Home spirometry, of sufficient quality, could support the identification of complications, clinical decision making, and reduce the patient burden. An understanding of the data quality, ensuring results are useful and reproducible is required.

Methods
Lung transplant recipients, consenting to a remote monitoring program, were asked to perform spirometry measurements daily in year 1, reducing to twice weekly and weekly when deemed clinically appropriate.
65 patients provided home spirometry data from 1/10/2022 to 30/09/2023. From 1/4/2023 patients received automated feedback and spirometry was graded according to 2019 ATS/ERS criteria (Graham et al, 2019) via ArtiQ.QC. Data collected prior to 1/4/2023 was retrospectively graded using ArtiQ.QC.
We retrospectively analysed the quality of spirometry sessions pre- and post- the introduction of ArtiQ.QC.

Results
There was no change in the percentage of A graded sessions in the 6 months post introduction of ArtiQ.QC, and an increase in the percentage of E and F graded sessions. Additional analysis highlighted 49% (352) of post ArtiQ.QC E and F graded sessions were recorded by only 2 patients.

Conclusions
Good quality standards can be achieved through home-spirometry, with and without automated feedback, with appropriate support from trained respiratory physiologists. Automated quality control is useful for identifying patients struggling with home spirometry, who may benefit from intervention (e.g., video conferencing). This automated selection of patients requiring support reduces the burden of reviewing every patient unnecessarily. The impact of additional coaching for patients identified as producing a high percentage of poor-quality readings requires further investigation.

Number of Spirometry Sessions	6-months prior to introduction of quality feedback	6-months post introduction of quality feedback
Total Sessions	1,773 (6409 blows)	1,536 (7659 blows)
A Graded (≥3 Acceptable within 0.150L*)	681 (38%)	586 (38%)
B Graded (2 Acceptable within 0.150L*)	476 (27%)	153 (10%)
C Graded (≥2 Acceptable within 0.200L*)	35 (2%)	53 (4%)
D Graded (≥2 Acceptable within 0.250L*)	16 (1%)	33 (2%)
E Graded (≥2 Acceptable > 0.250L or 1 acceptable)	351 (20%)	370 (24%)
F Graded (0 Acceptable or ≥0 usable)	213 (12%)	341 (22%)
U Graded (0 Acceptable or ≥1 usable)	1 (0.05%)	0 (0%)

Table 1: Sessions graded to ATS/ERS standards by ArtiQ.QC

P16

Home-based spirometry: is one effort enough?

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Introduction

Regular home and hospital spirometry are part of routine post lung transplant (LTx) monitoring. The goal is to facilitate the early detection of complications and home spirometry is highly correlated with hospital spirometry (Wijbenga et al, 2020).
The recommended goal of all testing sets is ≥3 acceptable forced expiratory volume in 1 second (FEV1) and forced vital capacity (FVC) measurements, with the difference between the largest and the next largest measurement ≤0.150L (Graham et al, 2019). These recommendations were developed for diagnostic spirometry and may increase patient burden and impact adherence when using spirometry for monitoring purposes only. There are no official guidelines for home spirometry and further research is required to establish the optimal schedule for home spirometry (Maher et al, 2022).
This retrospective study assessed the quality of home spirometry sessions from post LTx patients, focussing on determining whether fewer spirometry manoeuvres would impact test session outcomes.

Methods

Lung transplant recipients, consenting to a remote monitoring program, were asked to perform spirometry measurements daily in year 1, reducing to twice weekly and weekly when deemed clinically appropriate.
In a 60-month period, 50 of 108 patients achieved 642 FEV1 A grade sessions, as determined by artificial intelligence-based software (ArtiQ.QC). These sessions were analysed to determine the number of blows performed and the number of blows taken to achieve an effort meeting A grade acceptability and repeatability criteria.

Results

Of the 642 FEV1 grade A sessions, 74.5% required ≤ 4 efforts, 18.5% required 5-6 efforts, and 7% required ≥ 7 efforts.
93% of FEV1 grade A sessions have an acceptable FEV1 in the first effort; 79% of these first efforts were within 0.150L of the highest FEV1 reading for the session.

Conclusions

When good technique has been established, one spirometry effort can produce good quality FEV1 results, potentially reducing patient burden. These findings could support guidance on the optimal schedule of home spirometry for monitoring purpose. This research would not support changes to established guidelines when performing diagnostic spirometry. Further intervention would be required for those patients not achieving spirometry with a high-quality level.

Effort with the first accepted FEV_1 in a session	**1**	**2**	**3**	**4**	**5**	**6**
Session count	596	32	9	4	1	0

Table 1. Effort producing first accepted FEV_1 in a session, as graded using ArtiQ.QC.

P17

A case study on the effect of keeping an African Grey Parrot: Hypersensitivity Pneumonitis.

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Pathophysiology: Hypersensitivity pneumonitis (HP) is inflammation of lung parenchyma caused by inhaling small particles of an allergen, provoking type III and type IV hypersensitivity reactions. A subtype of HP is caused by animal exposure to the proteins within the waxy powder coating found in avian serum, faeces, and feathers. Acutely this can cause fevers, shortness of breath as well as chest discomfort for the patient.

Case Presentation: Patient (45-year-old, female, fitness instructor) presented to the emergency department with a 3-month history of worsening breathlessness and cough, oxygen saturations declining to 87% on room air. Upon initial investigation the only remarkable findings where increase inflammatory markers (mild neutrophilia and mildly raised CRP) and the patient was discharged with antibiotics. Symptoms did not improve; therefore, a respiratory referral was made. Further history taking and investigations revealed the patient owned a pet parrot, which due to traveling limited contact had been made with until the COVID19 lockdown. Patient was found to have reduced gas transfer results (TLCOc SR -3.24, VA SR -0.39 and KCOc SR -2.93) and CT-thorax revealed widespread mosaic attenuation, air trapping and patchy areas of ground glass changes.

Conclusion: A diagnosis of hypersensitivity pneumonitis (HP) was made, and the patient was recommended to re-home the bird. The patient's lung function then returned to within expected values and symptoms subsisted within 5 months of the antigen being removed. This recovery was swift and unpredicted, but without the quick identification and removal of the antigen, long term exposure can lead to irreversible fibrotic changes. This case study highlights the importance of identifying antigens which may be causing patient symptoms as well as the lack of awareness of the recovery time of acute hypersensitivity pneumonitis.

References - Usman N, Annamaraju P. Type III Hypersensitivity Reaction. [Updated 2022 May 30]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK559122/

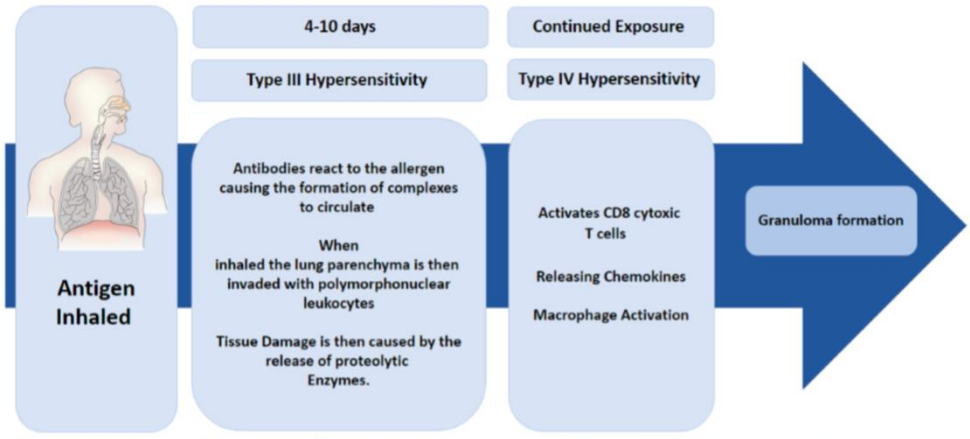

Figure 1: Pathophysiological pathway of inflammation causing hyposensitivity pneumonitis adapted from Usman and Annamaraju (2022)

P18

Impact of applying adult and paediatric scoring criteria on sleep disordered breathing grading severity in a cohort of adolescents

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Introduction:
Different criteria apply when scoring respiratory events during sleep in adults and children (AASM scoring manual, 2023). In addition, severity classifications of sleep disordered breathing (SDB) also differ between adult and paediatric populations with higher thresholds applied for adults. There are no explicit guidelines for scoring adolescents; the AASM states that patients aged ≥13 years old can be scored using adult criteria if they have an adult habitus (AASM scoring manual, 2023). We aimed to assess if there is any significant effect on number or duration of respiratory events, and grading SDB severity when scoring sleep studies using paediatric compared to adult criteria in our patient cohort of adolescents.

Methods:
Adolescents aged between 13-17 years (n = 25) attending for an inpatient cardiorespiratory polygraphy sleep study from January 2022-December 2023 were included. Exclusion criteria were: patients with neurodisability and studies performed using non-invasive ventilation or supplemental oxygen. Median age (range) was 14 years old (13-17). Apnoea-hypopnoea index (AHI) categories were defined using the scoring criteria defined by the AASM scoring manual (2023). Studies were retrospectively double-scored using paediatric and adult scoring criteria by the same physiologist.

Results:
The mean (standard deviation) estimated total sleep time was 07:10:29 (01:19:47). Mean AHI using paediatric scoring criteria was 4.41 (6.56); mean AHI using adult scoring criteria was 4.20 (5.94). There was no significant difference in AHI between adult and paediatric scoring (p = .364), mean apnoea duration (p = .690) or mean hypopnoea duration (p = .078). There was no significant difference in the absolute number of events scored between adult and paediatric scoring (p = .379). Grading severity was lower when using adult criteria compared to paediatric criteria in 14/21 studies.

Conclusions:
This study shows that applying different scoring criteria in adolescents does not significantly affect number or duration of respiratory events, or overall AHI. However, the severity of SDB changes for the majority of patients. This could influence patients' diagnoses and subsequent treatment. A larger patient cohort is required to further understand the implications of specific age thresholds in severity grading of SDB.

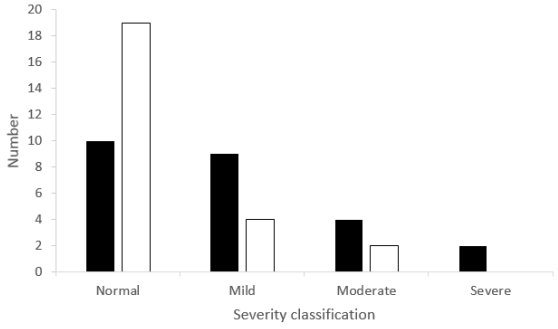

Figure 1: Grading severity classifications when using paediatric scoring criteria vs adult scoring criteria in adolescents aged 13-17 years old. Black bars = paediatric scoring criteria; white bars = adult scoring criteria.

P19

Fast Track Pre-operative OSA Screening Pathway - Don't sleep on it!

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Introduction:
Obstructive sleep apnoea (OSA) is a risk factor for anaesthetic morbidity and mortality. ERS 2017 guidelines suggest that patients who are high risk of OSA should undergo a sleep study.

Methods:
A new pathway was established in December 2022 to ensure patients were screened for OSA and established on treatment pre-surgery. Pre-operative nurses were taught: to complete a STOP-Bang questionnaire, Epworth sleepiness score, and issue multi-night oximetry. Figure 1 demonstrates the flow of the fast-track (green) and the normal pathway via the sleep service (cream).
Exclusion criteria: not seen via fast-track; did not return equipment.

Results:
Eighty-six patients met criteria for OSA screening, 24 patients excluded, 62 followed the fast-track pathway. Figure 1 shows patient characteristics, pathway and sleep disordered breathing (SDB) severity. Thirty patients (48%) started CPAP therapy. Referral-to-treatment-time (RTT) was 6 days compared to 42 days if a monitor was not issued by the pre-operative team.
The number of patient contacts with the department was also lower with the fast-track pathway compared to the urgent sleep pathway, 2 contacts versus 6 contacts.
Thirty-two patients were discharged, 13 had no evidence of SDB and a STOP-Bang <5. STOP-Bang was miscalculated 42% of the time, errors occurred on history collection of witnessed apnoeas and measurement of collar size.

Conclusions:
There is merit in establishing a pathway of this nature. Clear benefits can be seen on the RTT averages and number of patient contacts.
The STOP-Bang miscalculation has been addressed with the pre-operative nurses, disposable tapes provided for accurate collar size measurement; it is predicted that this will reduce inappropriate referrals. The ODI cut-off will be changed to 3% to comply with newest guidance. Patient satisfaction and compliance post-surgery will also be assessed. These changes will be audited in the next cycle.

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Verbraecken, J. et al. (2017). Pre-operative screening for obstructive sleep apnoea. European Respiratory Review, 26(143).
Cheng, M., & Steier, J. (2022). Pre-operative screening for sleep disordered breathing: obstructive sleep apnoea and beyond. Breathe, 18(3)
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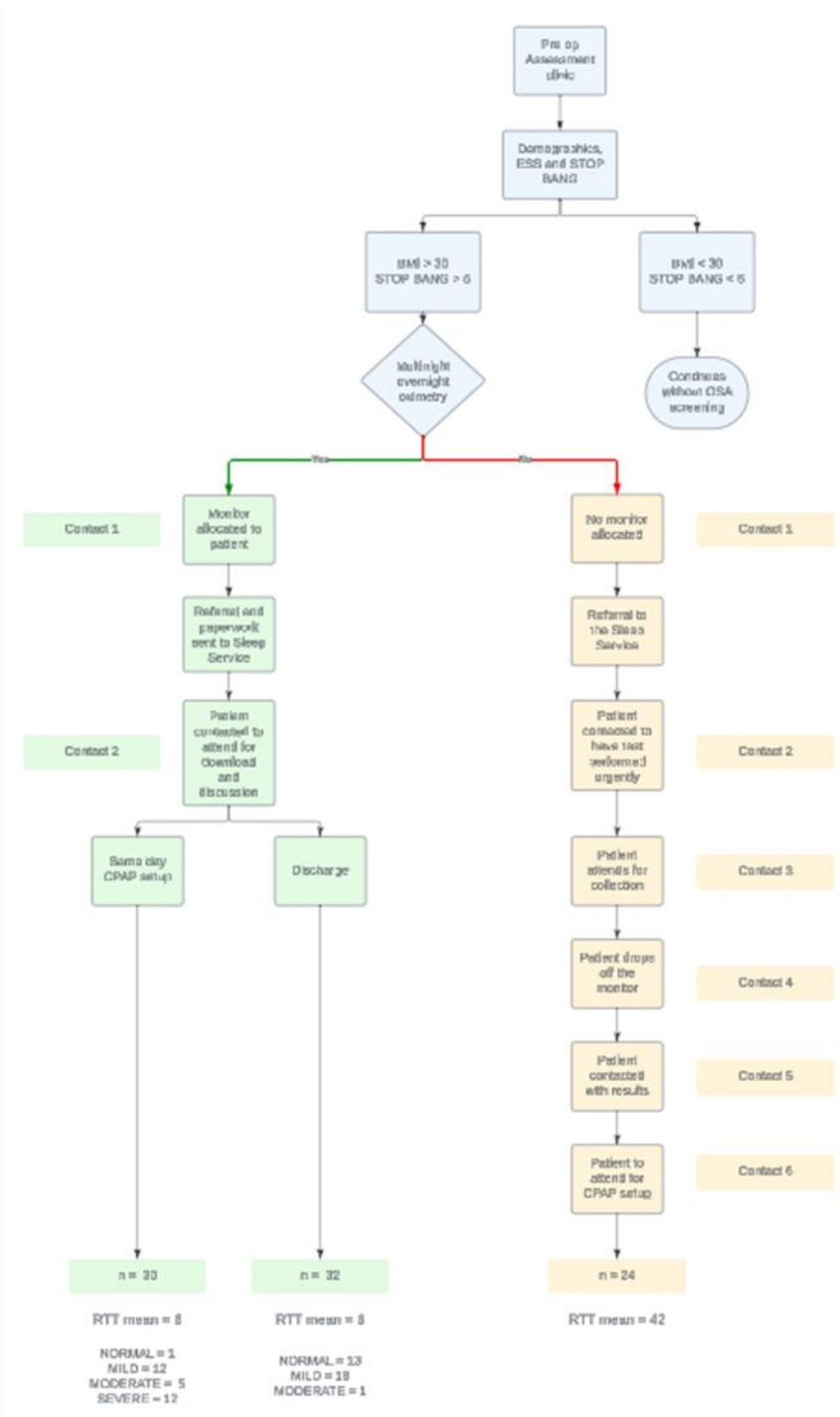

	Treatment started (*n* =30)	Discharged (*n*= 32)
Age, years (mean, SD)	65 ± 12.6	66 ± 11.3
Body mass index, kg/m2 (mean, SD)	35.0 ± 6.8	33.1 ± 6.4
Male sex, *n* (%)	22 (73)	27 (84)
Epworth sleepiness score (mean, SD)	9.7 ± 5.1	4.2 ± 2.0

P20

Are We Prescribing CPAP Appropriately?

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Introduction:
CPAP is the first line therapy for moderate and severe obstructive sleep apnoea (OSA). It is generally recommended in mild sleep apnoea only if the symptomatic burden affects quality of life (NICE, 2008). We sought to determine if CPAP was being prescribed in accordance with the recommended guidelines, with a focus on mild OSA.

Methods:
The study was a retrospective audit of all new CPAP issues (following 1-week trial) within a 6-month period (n=142). Patients were grouped into “compliers” and “non-compliers” based on CPAP data at 12 months (>70% nights, >4 hours/night). Demographics, sleep apnoea severity (based on AHI or ODI for 19 patients with only oximetry), baseline Epworth, and features of CPAP set-up were compared between compliers and non-compliers. Categorical data were compared using a Fisher’s Exact test (or Chi-Squared for the 3 severity groups) and continuous data were compared using a Mann Whitney-U test. All comparisons were undertaken with IBM SPSS (version 4) with $p<0.05$ as the threshold for significance.

Results:
86 patients (61%) were compliant with CPAP at 12 months and 56 (39%) were not. There were no differences in age, sex, or BMI between the two groups, nor were there any differences in disease severity. However, the proportion of patients with a positive Epworth (>11) pre-CPAP was higher in compliers ($p=0.012$). The proportion of preliminary CPAP trial extensions was higher in the long-term non-compliers ($p=0.008$). There were no differences in humidifier issue, expiratory pressure relief (EPR) activation, or number of masks tried on CPAP. However, mask leak was significantly but modestly higher on average in non-compliers ($p=0.003$).

Conclusions:
In accordance with recommended guidelines, CPAP is primarily prescribed for those with moderate or severe OSA. Long-term compliance is perhaps low considering all patients had a successful preliminary trial but OSA severity does not influence this. Trial extension may be a red flag, particularly for those with a negative baseline Epworth and may instigate a franker discussion with patients before considering long-term CPAP issue. Mask leak may not be a major factor but it could warrant greater consideration to improve compliance in some.

	Compliant at 12 months	Non-Compliant at 12 months	p =
N=	86	56	ns
M : F	56 M : 30 F	34 M : 22 F	ns
Age (years)	50 (19 - 76)	51 (22 - 85)	ns
BMI (kg/m2)	35.0 (29.9 - 42.2)	36.9 (30.14 - 41.7)	ns
AHI / ODI	34.9 (18.9 - 67.1)	30.4 (17.2 - 49.6)	ns
Severity	17 Mild : 18 Mod : 52 Sev	9 Mild : 19 Mod : 28 Sev	ns
ESS $\geq$ 11	63 Y : 23 N	25 Y : 31 N	0.012
CPAP Trial Extended	13 Y : 73 N	19 Y : 37 N	0.013
Humidifier	32 Y : 54 N	21 Y : 35 N	ns
EPR	23 Y : 63 N	21 Y : 35 N	ns
$\geq$ 2 masks	43 Y : 43 N	26 Y : 30 N	ns
AHI on CPAP	1.8 (1.1 - 3.3)	1.8 (0.8 - 3.1)	ns
Mask Leak	2.7 (0.7 - 6.7)	4.7 (1.9 - 17.4)	0.003

Table 1: A summary of demographics, baseline diagnostic data, and long-term CPAP data between patients still compliant with CPAP 12 months after issue and those no longer compliant at 12 months. The proportion of patients with a positive baseline Epworth Sleepiness Score (ESS), those who had their initial 1-week trial extended, and mask leak was significantly higher in long-term non-compliers. Data are presented as ratios or median (interquartile range), except for age which is median (range).

P21

A retrospective service evaluation looking into the efficacy of Watchpat referrals for the diagnosis of sleep disordered breathing

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Introduction: Patients with suspected obstructive sleep apnoea (OSA) often have negative overnight oximetry (ONO) despite presenting with daytime sleepiness. Watch peripheral arterial tonometry (WatchPat) is a more accurate alternative to measuring respiratory events during sleep using an algorithm-based approach. However, who best to refer for testing using WP needs more insight.

Aims: To find clinical indicators in groups of patients who have positive and negative WatchPats (WP) and to suggest methods to streamline referral pathways.

Methods: This is a retrospective service evaluation across a 1-year period (March 2021 – March 2022). Patients with suspected OSA completed overnight oximetry. If the results of overnight oximetry were negative, WatchPat was performed 4 weeks later to further investigate symptoms.

Results: 119 patients (43.7% female) were included in this study. Of these, 62 individuals were placed onto treatment for OSA. From these, 25 (40.3%) had both negative WP apnoea hypopnea index (AHI) and ONO ODI. Bland Altman analysis showed high levels of agreement between WP AHI and ONO ODI with only 7.56% of WP patients differing based on 95% confidence intervals. ROC curve analysis found the area under the curve for ESS was 0.44% and had poor ability to discriminate patients for positive WP referrals. Males who went onto treatment had a mean body mass index (BMI) with standard deviation of 44.4 ± 10.71. For males who didn't have treatment this was 28.44 ± 3.62. In the female population the BMI was 36.81 ± 10.69 and 32.44 ± 8.99 for those who were treated and untreated respectively. This shows patients who are obese are more likely to have positive WP studies.

Conclusion: Overall, the study demonstrated a strong relationship between WP AHI and ONO ODI. Results indicated that the clinical importance of WP is based on its capacity to diagnose REM OSA, which may be overstated if autoscoring is not particularly precise. In addition, there is a high association between individuals with an obese BMI and positive WP test results. Lastly, the ESS is incapable of discriminating based on the need for WP, and there is no gender-related variation in WP results.

P22

A Quality Assurance Review Model for Pulmonary Function – The Royal Papworth Method

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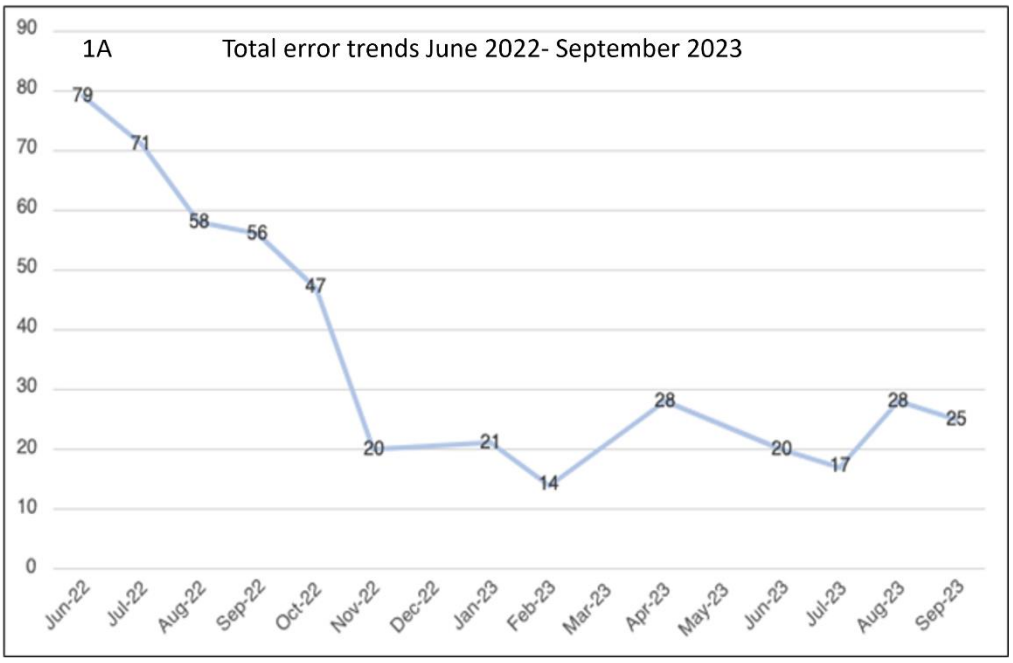
Introduction:
Prior to the COVID-19 pandemic, pulmonary function test (PFT) quality control procedures were undertaken monthly in the Respiratory Physiology department at Royal Papworth Hospital. Due to COVID-19, quality control procedures were temporarily postponed. In June 2022 the department re-introduced quality assurance systems, to re-assess the quality of PFT's (spirometry, gas transfer and static lung volumes), ensuring PFT's were performed in accordance with guidance (Sylvester et al 2020: Graham et al 2017: Graham et al 2019). These statements provided recommendations on quality assurance systems to ensure that pulmonary function testing is as accurate and precise as possible and are reliable for clinical decision-making.

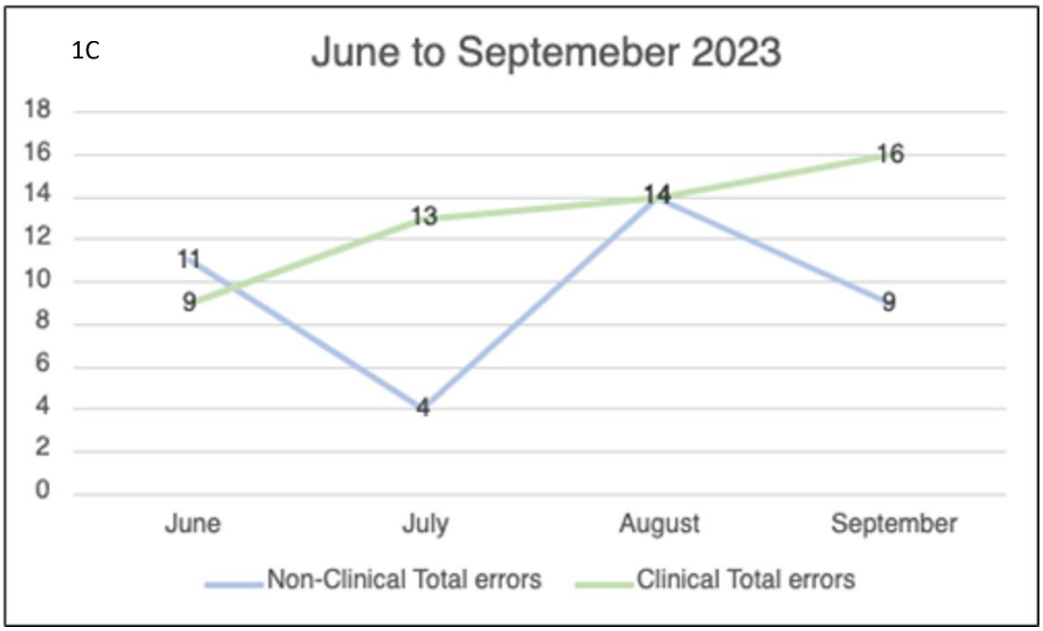
Methods:
A monthly quality control programme was developed involving both a senior respiratory physiologist (Band 6 or above) and a respiratory physiologist (Band 5). 20 PFT's were randomly selected from the previous month, with 1-3 PFT's per respiratory physiologist being reviewed. Errors were fed back to individuals with support provided to prevent re-occurrence. Common errors across individuals were addressed anonymously in our weekly department meeting, where there was opportunity for questions and re-training. As part of continuous improvement of the quality control procedures in June 2023, errors were sub-categorised into clinical and non-clinical, to help identify those with the greatest potential to impact on clinical decision-making.

Results:
Figure 1a displays the number of errors, while figure 1b shows the clinical and admin errors assessed, figure 1c then shows the trends.

Conclusion:
This quality improvement project has highlighted the importance and impact of undertaking regular quality assurance procedures. The procedure has helped demonstrate the department's compliance with national standards, acting as a service improvement tool to highlight areas for further development, aiding staff to meet expected standards, whilst supporting the department's plan of obtaining Improving Quality in Physiological Services (IQIPS) accreditation.



1B Clinical errors	Percent occurance	Non-Clinical errors	Percent occurance
Appropriate comments for any errors	15%	Grading for spirometry	25%
Gas Acceptability/reproducibility	9%	Grading for Gas transfer	18%
Spiro Acceptability/reproducibility	15%	Consent comments	0%
Box Acceptablity/reproducibility	1%	Haemoglobin comments	3%
VC max correctly reported and ratios updated	8%		
More manoeuvres than necessary	5%		
Less manoeuvres than necessary without comment	7%		



P23

A Cross Sectional Survey of Documentation of Terminology: Adult Service Users receiving NIV & CPAP outside of Critical Care

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Introduction:
There is local evidence that positive pressure support (Non-Invasive Ventilation (NIV) and Continuous Positive Airway Pressure (CPAP)) are conflated, leading to incorrect documentation. Inaccurate documentation breaches HCPC, NMC and GMC standards of conduct (Health Education England, 2017); more importantly it may be dangerous and life threatening for acutely unwell individuals or those requiring long term support (Smith M, et al BMJ 2014; 14:3). Incorrect documentation and confusion may be due to Health Care Professionals (HCPs) having insufficient visual cues of device type or a lack of understanding to differentiate between the two. The aim is to establish if other Trusts delivering positive pressure support to adults, outside of critical care, experience similar issues.

Methods:
An 8 question survey was disseminated via social media as part of a local Quality Improvement Project (QIP) to identify if documentation errors occur at a national level. The survey asked about frequency of documentation errors, format of documentation and staff groups involved.

Results:
A total of 63 responses from Respiratory HCPs across the world were received. 60 (95%) respondents have experienced incorrect documentation, with 33 (52%) stating this often happens. This does not appear to be associated with a single profession. Exploring this further 39 (66%) have observed NIV and CPAP being written in the same entry but referring to the same modality. Respondents were asked if they acted about incorrect documentation and 39 (66%) of HCPs checked yes, with varied expanded answers.

Conclusion:
This short survey suggests that NIV and CPAP are poorly differentiated, which leads to documentation errors not just at a single hospital but much more widely. This may lead to confusion with regard to correct settings and potentially ineffective ventilation, patient deterioration, increased length of stay and higher financial costs.
Further exploration of the reasons for this are required to allow improvements to be made. Within the local QIP, data is being collected before and after implementation of the Home Mechanical Ventilation in Partnership (HMViP) sticker (figure 1) to identify if this improves documentation.

Reference:
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2. Smith M, et al. BMJ 2014;14:3.

P24

When should patients referred for sleep apnoea screening have capillary blood gases?

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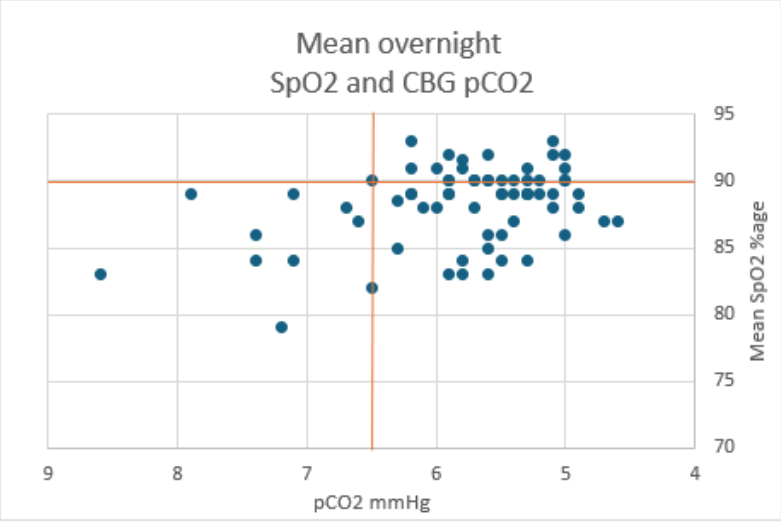
Aims
Patients referred for sleep apnoea screening may have a degree of respiratory failure and require a capillary blood gas (CBG) to measure partial pressure of carbon dioxide (pCO2). Our current practice is to use a threshold of a mean overnight saturation (SpO2) of ≤92% to prompt measurement of capillary pCO2. The aim of the study was to review this practice and audit capillary pCO2 levels in patients with low mean overnight SpO2.

Method
75 patients who were referred for sleep apnoea screening between Aug 2022 and July 2023 with a Body Mass Index (BMI) >30kg.m2 were reviewed.
An overnight sleep study was performed. All the patients with a mean overnight SpO2 of less than 92% on the overnight study went on to have a CBG to measure pCO2 levels before treatment was initiated. A negative correlation scatter plot of the results was created.

Results
The data showed than no patient with a mean overnight SpO2 of 90% or more had a capillary pCO2 of more than 6.5 kPa.

Conclusion
Obstructive Sleep Apnoea (OSA) and Obesity Hypoventilation Syndrome (OHS) frequently co- exist, with 70% of patients with OHS also having OSA. OHS is defined by the combination of obesity, with BMI over 30kg.m2 and increased daytime PaCO2 levels. While CPAP is the treatment of choice for these patients, it is important to identify those who may require a post treatment capillary pCO2 measurement to ensure they are adequately treated. In the acute setting an arterial pCO2 measurement of >6.5 kPa would indicate a degree of respiratory failure and indicate initiation of PAP treatment. While this study was based on patients with chronic OSA/OHS rather than acute, a capillary pCO2 of 6.5 kPa was chosen as a reasonable marker of risk of significant OHS. The results indicate that when reviewing patients referred to the sleep clinic for sleep apnoea screening, patients with possible OHS do not require an assessment of capillary pCO2 levels unless the mean overnight saturation is less than 90%.



P25

UHNM Respiratory Physiology service improvement initiative: A review of the departmental new clinic structure; How has this benefited the department/service?

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Introduction: Prior to the COVID-19 pandemic, the respiratory physiology clinic structure had been in place since 2012. The service had grown organically to meet the rising service demands; however, this had evolved into a convoluted structure with frequent force bookings and little time for staff enrichment. COVID-19 highlighted that the NHS had to adapt and look at new ways of working. One of the priorities was to revise the departments clinic structure.

Aim: The aim of this audit was to assess the impact and viability of a service improvement initiative which involved an overhaul of the departments working ethos and the implementation of a new clinic structure.

Method: A retrospective service audit was performed on pulmonary function data acquired during routine clinical practice. The timeframe selected was the same 27-week period in 2022/2023. This timeframe was selected to compare the improvement initiative, while reducing the possible impact of seasonal variation. A process capability index (Cpk) was used as a statistical measure of service performance. An arbitrary value of two was assigned to the Cpk, based on previous business models. Values greater than two indicated a robust service with little unnecessary variation.

Results: Prior to the service improvement initiative, the respiratory service showed significant non-centralised variation (Cpk 0.77). The average number of PFTs performed daily was 10.0. Run chart analysis highlighted significant trends around the mean, alluding to an unstable process that was influenced by external factors. In comparison, the new clinic structure demonstrates an improvement in the process's capability (Cpk 1.06) with an increase in the average number of daily tests (11.4 PFTs). Though there is still daily variation, it is now common cause variation. Special cause variation has been eradicated.

Conclusion: This audit has identified that the changes in clinic structure have elicited service improvements, such as creating a surge capacity allowing the department to adequately adapt to external factors without significant adverse impact on daily performance. Additionally, we have increased capacity to meet future demands and provided staff with more time/opportunities for further training/development. Therefore, increasing the departments efficiency and improving staff welfare and workplace enthusiasm.

P26

The Impact of Weight Loss on Moderate to Severe Obstructive Sleep Apnoea

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Introduction
Obesity is a common risk factor for obstructive sleep apnoea (OSA) due to increased pressure on upper airway soft tissues. Left untreated, moderate to severe OSA may contribute to cardiovascular disease including hypertension, stroke and heart failure (Drager et al. JACC 2013; 62(7), 569-576). Although treatment of mild OSA does not seem to impact overall cardiovascular health (Guimarães et al. JCSM 2021; 17(2), 149-158), weight loss and continuous positive airway pressure (CPAP) therapy is recommended for OSA and overall cardiovascular health (Epstein et al. JCSM 2009; 5(3), 263–276).

Objectives
• Identify any correlation between confirmed weight loss and overall OSA severity.
• Consider the amount of weight loss most beneficial to improve OSA severity.

Methods
As part of a service audit, data from adult patients who have undergone at least two limited sleep studies (LSS) between September 2020-2022 was extracted from the electronic database within the sleep department at UHNM NHS Trust. The first LSS identified their apnoea-hypopnoea index (AHI) as moderate (≥15 ≤30) or severe (>30) OSA, with the second LSS being conducted due to confirmed weight loss. CPAP was not used during either LSS. The pre and post weight loss LSS results were then compared to identify if any changes had occurred, including via a paired t-test.

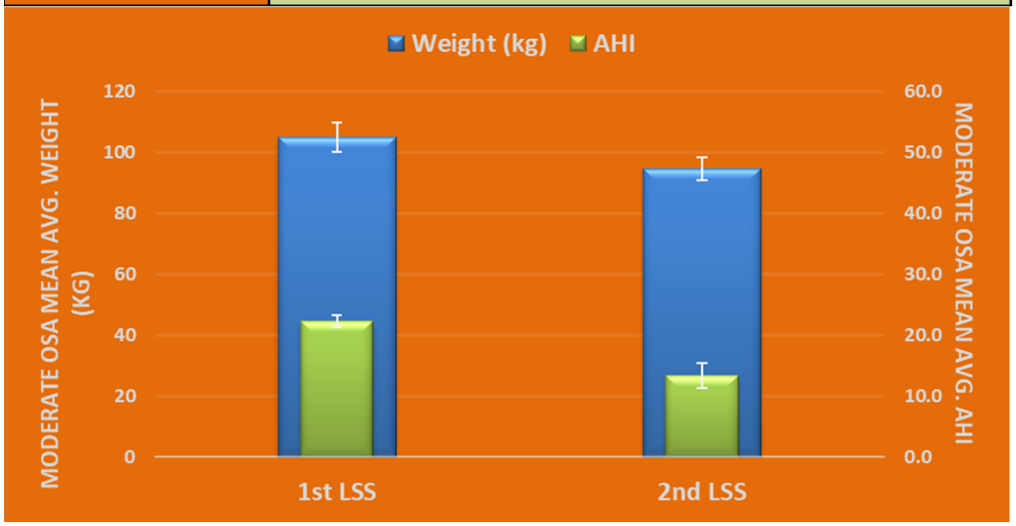
Results (see Figure1)
On average, patients dropped into a lower category of OSA severity from severe to moderate and moderate to mild respectively. To achieve this there was a 12.8kg drop in weight in the severe category and a 10.2kg drop in weight in the moderate category. This was associated with a 0.8in and 0.5in reduction in collar size respectively, potentially reducing pressure on upper airway soft tissues. The results were statistically significant ($p<0.05$).

Conclusion
Results suggest that weight loss with collar size reduction in moderate to severe OSA can decrease OSA severity to a milder form, potentially having a positive impact on long-term cardiovascular health. The findings could possibly assist as a service improvement reference, both for local sleep services and their moderate to severe OSA patients who are considering weight loss intervention to supplement their CPAP treatment.

Figure 1. Change in the mean average weight and AHI pre and post weight loss in severe and moderate OSA patients.

Severe OSA (n=23)	Mean avg.	Weight (kg)	BMI	Collar (in)	AHI
no AHI improvement (n=3)	1st LSS	114.3	36.67	17.8	48.3
	2nd LSS	101.5	32.52	17.0	24.9
no collar reduction (n=8)	difference	12.8	4.2	0.8	23.4
	% difference	11.20%	11.32%	4.49%	48.45%
	t-test (*p*)	0.0001	0.0439	0.0022	0.0002

Moderate OSA (n=23)	Mean avg.	Weight (kg)	BMI	Collar (in)	AHI
no AHI improvement (n=2)	1st LSS	105.0	35.69	16.3	22.3
	2nd LSS	94.8	32.13	15.8	13.4
no collar reduction (n=9)	difference	10.2	3.6	0.5	8.9
	% difference	9.71%	9.97%	3.07%	39.91%
	t-test (*p*)	0.0018	0.2130	0.0225	0.0005



P27

Occupational asthma due to mild steel?

Mr Samuel Wallbanks[1,3], Dr Kimberley Nettleton[1,3], Mr Christopher Huntley[1,3], Dr Vicky Moore[2,3], Professor Sherwood Burge[3], Mr Gareth Walters[1,3]
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INTRODUCTION
Mild steel is not traditionally thought to represent a cause of sensitisation-induced occupational asthma (OA). Following the inciting case in October 2015, 28 cases from a large heavy machinery manufacturer presented with symptoms consistent with OA in the period from 2015 to 2024. This study documents the initial 16 cases diagnosed with OA at this workplace.

METHODS
As part of the OA pathway, new patients have a full occupational history, spirometry with FeNO, chest X-ray and a methacholine challenge test with skin prick and allergy testing. The most sensitive and specific test for OA is serial peak expiratory flow (PEF) measurements performed over 4 weeks, analysed with OASYS; a computational software which analyses work and rest PEF data (1). Data are presented as frequencies and proportions.

RESULTS
Of the 16 cases of OA reported in this analysis, 10 are welders, 1 robot welder, 2 are CNC operators, 1 paint sprayer, 1 short blaster and 1 plasma cutter. 14 of 16 (88%) had spirometry within the "normal range" for their age, sex, ethnicity and height. Three of 16 (14.7%) showed longitudinal declines in FEV1 of >400 mL over 4 years. Of the 9 who had methacholine challenge testing, 4 were reactive (44.4%). All were diagnosed with serial PEFs, with a median OASYS score of 3.43 (2.8-3.8).

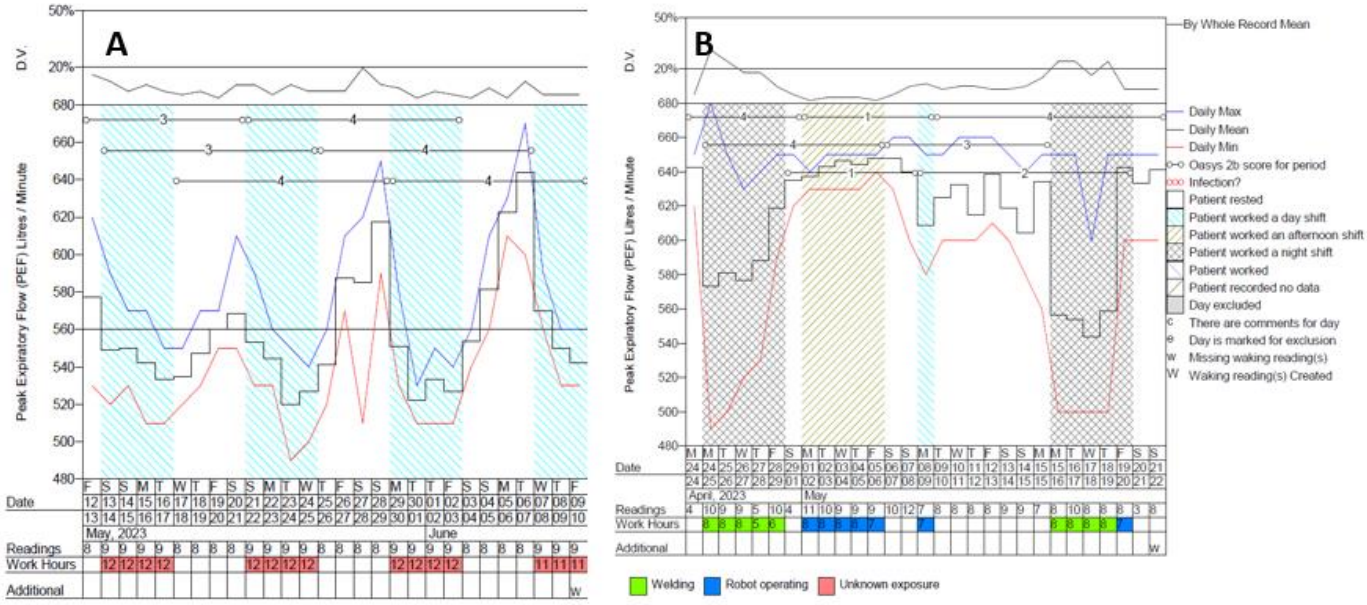

Figure 1. two cases of OA with delayed (A) and immediate (B) deteriorations in PEF related to work.

CONCLUSIONS
The exact cause of OA in this group is unclear. Whilst welding fume appears to be the most likely explanation, the divergence in clinical presentation, types of reaction, and components within the mild steel make it trick to specify the exact cause at present. A workplace challenge test will be performed in collaboration with the workplace to better identify a cause for this outbreak.

REFERENCES

1. Burge et al, (1999). Development of an expert system for the interpretation of serial peak expiratory flow measurements in the diagnosis of occupational asthma. Occupational and environmental medicine, 56(11), 758.

P28

Concordance of COPD diagnosis when comparing NICE criteria with SRs following introduction of GLI predicted equations and new SR indexes?

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Introduction
A previous study determined that 9% of patients attending for reversibility testing via primary care referral had results that would fulfil the GOLD criteria (same categorisation as NICE) for mild COPD but were normal using SRs (McArthur et al, ERJ Sep 2019, 54 (supp 63) PA1115; DOI: 10.1183/13993003.congress-2019.PA1115) (using ECCS predicted equations), which resulted in a ratifying comment being added to primary care reports (Although patient results would fulfil the criteria for mild COPD using NICE guidelines, please note that a ratio <70 is normal for this patient). With the introduction of new predicted equations (GLI 2012/2017) and SR indexing (Sylvester et al, BMJ Open Respiratory Research 2020;7:e000575. doi: 10.1136/bmjresp-2020-000575) in current commenting practices the effect this has on prevalence and severity of abnormality should be investigated.

Aim
To determine if concordance of COPD diagnosis has changed when comparing NICE criteria with SRs following the introduction of GLI predicted equations and new SR indexing ranges.

Methods
A retrospective analysis of data collected over a 1 year period in patients with suspected COPD were compared with previously collected data, and prevalence of COPD and severity of diagnosis investigated.

Results
See Table 1.

Conclusion
There is greater concordance between NICE and the new SR indexing in patients with suspected COPD primary care referrals after the transition to GLI predicted equation (increase by 4%). However two percent more patients now fulfil the criteria for NICE mild COPD when they are normal based on SRs, therefore the use of the ratifying statement is currently justified.

	Total number of patients included	Normal ventilatory capacity, above predicted (number and percentage)	Post-bronchodilator showing normal SR although fulfils criteria for mild COPD (number and percentage)	Different post-bronchodilator Classification to NICE (number and percentage)	Post-bronchodilator SRs Concur with NICE (number and percentage)
2018/ 2019	782	126 16%	71 9%	164 21%	421 54%
2022/ 2023	1094	152 14%	115 11%	188 17%	639 58%
Since change in guidelines (%)		**Decrease 2%**	**Increase 2%**	**Decrease 4%**	**Increase 4%**

P30

Discussing neuromuscular electrical stimulation therapy (NMES) as a Novel Treatment for OSA: Case Study

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Background
Obstructive sleep apnoea (OSA) is a type of sleep disordered breathing caused by reoccurring oropharyngeal collapse. Patients with untreated OSA are at increased risk of hypertension, stroke, heart failure, diabetes, depression, road traffic accidents and cognitive dysfunction. A new novel OSA treatment using neuromuscular electrical stimulation therapy (NMES) called eXciteOSA® is being trialled at St Georges University Hospitals NHS Foundation Trust for patients with mild OSA, to expand potential treatment options for patients. Prospective benefits of NEMS include treating the cause of sleep apnoea instead of a device which treats the symptoms, reducing adherence problems with nighttime appliances such as CPAP.

Case presentation
BD, a 42-year-old computing office worker was referred to the trust from Kingston hospital. He was referred to the Kingston sleep service for nighttime snoring, described by the patient as a 'gasping snore'. He sleeps seven to eight hours per night and has a midday hour nap five days a week. His sleep schedule is regular and he has cut out all caffeine. Kingston hospital conducted an overnight pulse oximetry study which showed an oxygen desaturation index (ODI) of 13 dips per hour. St Georges Hospital then took over care and treatment of the patient and the patient was started on an eXiteOSA® trial. Adherence was optimal for the first months but dropped 4% below recommended use in the final month of phase 1. In June a repeat sleep study was conducted after phase 1, showing an ODI of 22 dips per hour. The patient was reviewed and placed on the CPAP waiting list, with the device to be returned once CPAP treatment is started.

Conclusion
Lifestyle factors are likely the cause of worsening symptoms and ODI, leading to the recategorization of his condition to moderate OSA rather than mild. There is inadequate evidence on the safety and effectiveness of the device. Current research is limited in its evidence. Further research is needed to establish the effectiveness of NEMS on patients with OSA.

Key words: neuromuscular electrical stimulation, mild obstructive sleep apnoea, Intraoral device, Sleep disordered breathing.

P31

The diagnostic pathway for narcolepsy type 1: a case study

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Introduction: A 36-year-old female presented to their GP with EDS and was referred to the sleep service. They had a BMI of 26 kg/m2 and an ESS of 15. Following a HSAT they were diagnosed with OSAHS. They were referred onto a dietician, offered sleep hygiene advice and discharged back to the care of the GP.

Case History: Two years following this, the patient made the appropriate lifestyle changes, however their symptoms worsened. They now had a BMI of 23 kg/m2 and an ESS of 22. They were experiencing increased daytime sleepiness, cataplexy and sleep paralysis. They were referred for an MSLT which revealed 4 napping opportunities, all with SOREMPs and a mean sleep latency of 3.6 minutes. This patient was diagnosed with narcolepsy type 1 and initiated a treatment plan of modafinil and fluoxetine.

Discussion: Although there was a delay in diagnosing this patient with NT1, a diagnosis of 2-years following an onset of symptoms is greatly improved from the literature reported average levels. This patient was initiated on the appropriate first-line treatment. This patient should maintain annual follow-ups with the sleep consultant to ensure continuous effective and relevant treatment is offered and adhered to.

P32

Noisy Breathing during exercise in a Cystic Fibrosis patient - What's the cause?

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Introduction: A cystic fibrosis (CF) patient with co-existing Crohn's disease had previously had a spell in intensive care and was intubated due to bowel surgery complications. He later presented with exercise intolerance and what the PE teacher described as wheeze on exercise. It had been noted that he had a flattened inspiratory loop on spirometry potentially indicating an upper airway obstruction. There was no expiratory airflow limitation and no response to bronchodilator. A cardio-pulmonary exercise test (CPET) was performed to investigate the cause of the symptoms.

Methods: CPET was performed on a cycle ergometer with an incremental ramp protocol. Following this a continuous laryngoscopy during exercise (CLE) was performed. The patient was treated surgically by ENT using a web excision of posterior laryngeal web. They were followed up for CPET and spirometry post-surgery.

Results: Primary CPET performed showed ventilatory limitation and stridor in keeping with an upper airway obstruction. CLE revealed a laryngeal web. Surgery was performed and CPET showed a normal ventilatory response with no stridor. Ventilatory analysis of the CPET is shown in the table below. Tidal volume and breathing frequency response was improved. The spirometry had a normal inspiratory loop.

Conclusion: This case shows the valuable use of CPET and CLE in the diagnosis of upper airway obstruction when symptoms are only present during exercise. CPET findings were indicative of several abnormalities that indicated an upper airway ventilatory abnormality. The improvements seen in ventilatory responses indicate the successful surgical intervention.

Peak Parameters	Pre	Post	% Change
Ventilation (L/min)	37	79	114
Tidal Volume (L)	1.164	1.250	7
Resp Rate (min^{-1})	32	63	97
$ETCO_2$ (kPa)	5.90	3.98	-33
$VeVCO_2$ slope	22.1	27.0	26

P33

Deriving the optimal VO2atAT/PredPeakVO2 threshold for predicting low Peak VO2

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Introduction: A VO_2 at anaerobic threshold as a percentage of peak predicted VO_2 (VO_2atAT/PredPeakVO_2) less than 40% has been considered an indicator of disease, despite little evidence. We aimed to determine the optimal threshold for VO_2atAT/PredPeakVO_2 which can predict a low peak VO_2, using data from cardiopulmonary exercise tests (CPET).

Methods: Data was retrospectively collected from patients referred to Cambridge University Hospitals NHS FT for CPET between 2016 and 2021. Data was included if the CPET was physiologically maximal. Multivariable logistic regression was used to investigate the association between VO_2atAT/PredPeakVO_2 and low peak VO_2 defined as a peak $VO2_2$ less than the lower limit of normal (LLN). We adjusted for age, sex, BMI, referral reason, and smoking history. Post-estimation commands were used to generate the Youden index, representing the VO_2atAT/PredPeakVO_2 threshold with the highest sensitivity and specificity for predicting low Peak VO_2. We then used linear regression to assess the association of the new threshold with CPET parameters.

Results: Data from 217 patients were included. Mean age was 51 years (±15.6), with 51% being female. Mean BMI was 28.3 (±5.7). 63% were referred for shortness of breath of unknown cause. Mean Peak VO_2 was 2.1L/min (±0.7) with 24% having a low Peak VO_2. The results of the regression analysis showed that for a 1% increment in VO_2atAT/PredPeakVO_2, odds of having a low Peak VO_2 decreased by approximately 14% (OR: 0.86, 95%CI 0.81-0.91, p<0.0001). The optimal VO_2atAT/PredPeakVO_2 threshold for predicting a low Peak VO_2 was 44%, with a sensitivity of 83.3%, specificity of 84.7%, area under the receiver operating curve of 0.88, and a Youden index of 0.68. 20% of patients were below the 44% threshold, which was associated with having a significantly lower Peak VO_2 (β: -0.48L/min, 95%CI -0.64, -0.31, p<0.0001), oxygen pulse (β: -2.51ml/beat, 95%CI -3.50, -1.54, p<0.0001), and steeper cardiovascular slope (β: 10.07, 95%CI 5.10-15.04, p<0.0001).

Conclusion: A VO_2atAT/PredPeakVO_2 less than 44% has the highest sensitivity and specificity for predicting a low Peak VO_2 and is associated with an impaired cardiovascular response to exercise. Further validation of this threshold is required in a range of different patient populations.

P34

Is the oxygen uptake efficiency slope (OUES) a good surrogate for VO2 peak in patients with unexplained breathlessness?

Mr Chris Harding[1], Dr Chara Alexiou[1], Dr Ben Knox-Brown[2], Dr Karl Sylvester[1,2]
[1]Cambridge University Hospitals NHS Trust, Cambridge, United Kingdom, [2]Royal Papworth Hospital NHS Trust, Cambridge, United Kingdom

Introduction: Evidence (Akkerman M et al, Pediatric Exercise Science, 22(3)2010 & Gavotto A et al, Archives of Disease in Childhood,2020) suggests that the oxygen uptake efficiency slope(OUES) could be used as a surrogate for VO2 peak in the presence of a sub-maximal test. We, therefore, wished to determine the relationship between OUES and peak VO2 to confirm this claim.

Method: OUES and VO2 peak values were compared in 227 physiologically maximal tests performed to ARTP standards (Pritchard A et al, BMJ Open Respiratory Research, 2021) over 2022/2023. Patients were sub-classified by BMI and breathing pattern response for comparisons across subject groups. We also compared how many patients were classified as having normal aerobic capacity using both values.

Results: Median(IQR) values demonstrate significant difference between OUES 1719(1373-2191) and VO2 peak 1635(1247-2121) in all patients when assessed by Wilcoxon Signed-rank test $p<0.001$. When sub-categorised, analysis that was restricted to those that had a BMI classified as obese and then those with a dysfunctional breathing pattern also had significantly different OUES ((1847(1477-2303) and 1586(1343-1826)) and VO2 peak((1715(1368-2151) and 1473 (1175-1788)) $p>0.01$. There was no significant difference between median(IQR) OUES and VO2 peak when analysis was restricted to those with no breathing pattern disorder ((1828(1393-2268) and 1693(1328-2163), hyperventilation ((1742(1293-2271) and 1442(1165-2122), normal BMI((1493(1306-1963) and 1424(1191-1933)) and overweight ((1727(1423-2211) and 1670(1279-2181)) $p< 0.001$. The underweight sub-category could not be analysed due to its small sample size. When compared to the measured peak VO2, 179 of 227 patients(79%) were correctly classified as normal or abnormal by OUES, with a positive predictive value(PPV) of 82% and a negative predictive value (NPV) of 86%.

Conclusions: OUES could be used to estimate VO2 peak in sub-maximal CPETS in the majority of patients reporting unexplained breathlessness. However, in obese patients with a BMI > 30kg/m2 and in those with a dysfunctional breathing pattern, OUES compared to VO2 peak suggested significant differences. OUES also provided a good positive and negative predicted value for normal or abnormal aerobic capacity. This could be particularly useful in providing a more accurate calculation of aerobic capacity and functional limitation during CPETS in the clinical setting.

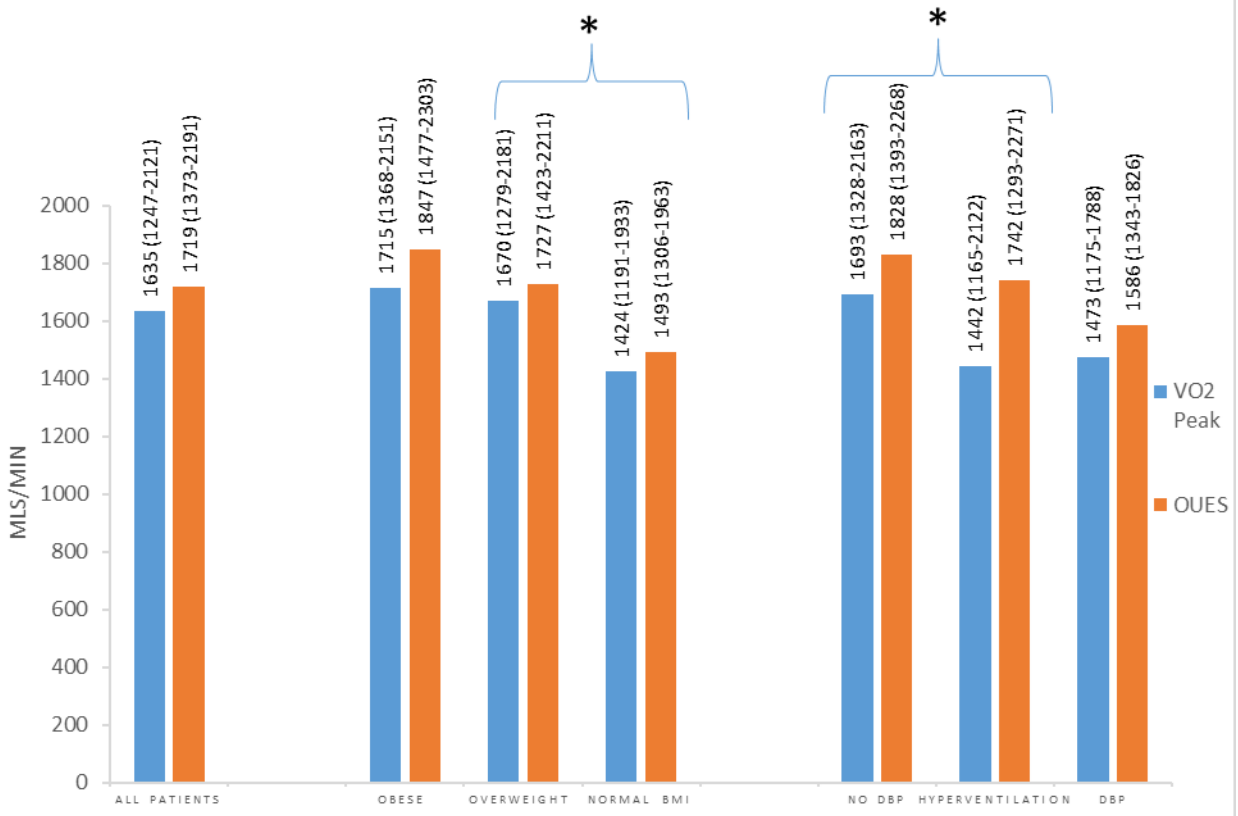

Figure 1 Comparison of Median (IQR) VO2 peak and OUES in all patients and then restricted analysis of each sub-group, * No significant difference observed p<0.001

P35

Evaluation of a physiologist-led paediatric home spirometry assessment

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INTRODUCTION: Spirometry is required for diagnosis and can provide evidence for treatment optimisation in asthma. The feasibility and validity of home spirometry is unclear with recent data, in adults with asthma, demonstrating poor engagement and data quality (Williams, 2023, ERJ Open Research). Home spirometry may be even more challenging in children.
The aim of this analysis was to assess the feasibility and effectiveness of the NuvoAir paediatric home spirometry asthma assessment.

METHODS: Children and young people aged 5 to 17 years referred to specialist teams (primary, secondary and tertiary care) with confirmed or suspected asthma were also offered the NuvoAir 4-12 week physiologist-led home spirometry assessment.
Patients or their parents installed the NuvoAir Home app on their own devices and were given spirometry coaching with a physiologist via videocall. Patients used an Air Next Bluetooth spirometer to record regular spirometry (frequency personalised, mean 4 days a week) and when symptomatic. A report was produced at the end of the assessment period with results and recommendations.

RESULTS: Data is presented from the first 30 children referred for the home spirometry assessment, 37% were spirometry naïve. The main reason for referral was either an unclear diagnosis of asthma (12) or for treatment optimisation (18). Patients were aged mean (SD) 10.2y (3.6y), 13 were female 17 male.
The median adherence to the home spirometry personalised protocol was 61% (IQR 35 to 101%). In total 553 spirometry tests were recorded (mean 20 per patient), with 60% good quality tests (computer interpretation A-C, ATS/ERS 2005). Overreading identified a higher proportion where data was usable using ATS/ERS 2019 interpretation, reanalysis is planned. Reports were provided inclusive of serial spirometry to support diagnosis and/or treatment decisions in all 30 patients.

CONCLUSIONS: The home spirometry assessment was feasible and provided good quality data and engagement to support diagnosis and treatment optimisation. Further analysis is planned to determine the impact on speed, accuracy and respiratory diagnosis outcomes
In contrast to other studies, this cohort received personalised coaching and carried out multiple consecutive tests (including when symptomatic) which enabled the capture of rich data insights for diagnosis and treatment optimisation.

P36

The association between socioeconomic status and asthma diagnosis in children and young people referred to the Leicester asthma diagnostic pathway

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Introduction: Symptoms of asthma in children and young people (CYP) include a wheeze, cough and breathlessness. However, symptoms are often non-specific and objective tests are recommended to confirm the diagnosis from age 5 (NICE, 2017).
Socioeconomic deprivation is associated with poor outcomes in asthma. Factors such as air pollution and second-hand smoke may play an important role (Alsallakh et al., 2021). However, it is unclear how socioeconomic status and likelihood of confirming an asthma diagnosis in CYP referred for objective testing is associated.

Aims: To evaluate the association between socioeconomic status and confirmed asthma diagnosis in CYP referred by the GP for diagnostic testing.

Method: GP practices referred 5–18 year-olds with suspected asthma to the Leicester paediatric community asthma diagnostic pathway (LPAP). Where 1st line tests (spirometry, BDR and FeNO) were inconclusive, patients progressed to second line bronchoprovocation challenge tests (treadmill and/or provocholine challenge test) as per the LPAP. Data was analysed to assess outcomes in relation to the patient's socioeconomic status. Socioeconomic status was determined by the patient's postcode using the Index of Multiple Deprivation Decile (IMD10) (1 = most deprived, 10 = least deprived decile) (Ministry of Housing, Communities and Local Government, 2019).

Results: 88 CYP successfully completed the diagnostic pathway. Patients were categorised by IMD10 and LPAP testing outcome (Table 1). 55 CYP had asthma confirmed based on test results. The median IMD10 of those who had asthma confirmed was 3 (IQR 4); the median IMD10 for those where asthma was not confirmed was 7 (IQR 4). Overall, 74% of children from more deprived backgrounds could have asthma confirmed compared with only 49% of children from less deprived backgrounds (chi2 test, p = 0.0172).

Conclusion: A greater proportion of CYP from more deprived socioeconomic backgrounds referred to LPAP had objective evidence to confirm asthma compared with children from more affluent backgrounds. The reasons for this finding merit further exploration. Hypotheses to be tested are that the referral threshold for testing may be higher in children from more deprived backgrounds, more affluent families may present children with symptoms to the GP earlier and/or referral thresholds may be lower.

Table 1: LPAP outcomes stratified by IMD10

IMD Deciles Grouped	**Tests Positive (Asthma Confirmed)** *N (%)*	**Tests Inconclusive (Asthma not Confirmed)** *N (%)*
1-to-5	36 (73.5)	13 (26.5)
6-to-10	19 (48.8)	20 (51.2)

P37

Post COVID Persistent Exercise Induced Dyspnoea in Children and Young People: Is CPET the key test?

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Introduction
There is a limited understanding about post COVID dyspnoea in children and young people (CYP) although breathing pattern disorders have been identified as a cause of post COVID dyspnoea in adults (Frésard et al. BMJ Open Respiratory Research 2022; Mar 9(1)). Reduced pulmonary function has been noted in adults following SARS-CoV-2 infection (Sanchez-Ramirez et al. Biomedicines 2021 9(8)). We aimed to determine the cause of post COVID persist dyspnoea in CYP through pulmonary function testing and cardiopulmonary exercise testing (CPET).

Methods
Data was retrospectively analysed on CYP with post COVID syndrome referred for respiratory workup at Royal Brompton Hospital with post COVID dyspnoea, all had mild COVID-19 infection and not hospitalised with acute infection. Pulmonary function tests (pre and post exercise spirometry, lung volumes, gas transfer) and CPET were performed.

Results
Data is presented from 41 CYP referred for evaluation of persistent post COVID dyspnoea. 32 of 41 (78%) completed a maximal effort CPET. Among these, 15 (47%) exhibited a normal peak oxygen consumption (VO2max), while 17 (56%) showed a reduced VO2max, primarily due to physical deconditioning. Plethysmographic lung volume and transfer factor for carbon monoxide (TLCO) measurements were measured in 25 and 28 out of 41 CYP respectively. All CYP were noted to have normal gas transfers and breathing pattern disorders as identified on CPET. Almost half (19/41) CYP exhibited erratic tidal volume (VT) and breathing frequency (BF), while 13 almost a third (13/41) displayed high and erratic VT above physiological capacity.

Conclusions
The CPET results demonstrate that in CYP experiencing post COVID persistent dyspnoea there was no underlying pulmonary abnormality as demonstrated by there being no cardiac or pulmonary limitation to exercise and normal gas transfer (also indirectly noted on CPET). All patients were noted to have a breathing pattern disorder, which is likely to be the main cause of post COVID persistent dyspnoea in CYP. CPET provided the most useful information in elucidating the cause of post COVID persistent dyspnoea in CYP.

Table 1: Demographic, CPET, Lung function and Breathing Pattern Characteristics of children with Post COVID syndrome. Data are shown as number (%) or median (IQR).

Demographics		Lung Function	
Sex, male: female	14:27	FEV_1 (% pred)	91.6 (89-102)
Height (cm)	166 (162.3-173.1)	FVC (% pred)	90.5 (86-102.7)
Weight (kg)	56.9 (47-67.3)	TLCO (%)	89.1 (81.5-100.4)
BMI (kg/m^2)	19.7 (17.8-23)	RV (%)	138.8 (111.2-176.1)
Weight: under/normal/over	6/28/5/2	TLC (%)	101.5 (91.9-105.9)
Hospitalised	0	RV/TLC (% pred)	135 (115.3-172.9)
Age at CPET	16 (14-17)	Post exercise bronchoconstriction	1
CPET Parameters			
VO_{2max} (ml/min/kg)	34.8 (28-42.3)	Peak Heart rate (bpm)	187 (174.5-193)
VO_{2max} (% pred)	82 (65-98)	Peak Heart rate (% pred)	98 (90.5-102.5)
Workload (Watts)	190 (147.5-227.5)	Peak O_2 pulse (% pred)	83 (68-101)
Anaerobic threshold (% of predicted VO_{2max})	64.5 (53.3-77.9)	VE/VCO_2 Slope	29.2 (26-33.3)
Ventilatory reserve (100-VEpeak%)	35 (27-48.5)	$P_{et}CO_2$ Rest (kPa)	4.2 (4-4.4)
Peak breathing frequency (bpm)	45 (38-54)	$P_{et}CO_2$ Peak (kPa)	4.9 (4.6-5.3)
Peak breathing frequency (%pred)	101 (85-122.5)	$P_{et}CO_2$ Recovery (kPa)	4.9 (4.6-5.3)
Breathing Pattern Disorder	41 (100%)	Hyperventilation (PCO_2 <4.2 kPa)	8/41 (19.5%)
		Anticipatory Hyperventilation	20/41 (48.8%)
Type of Breathing Pattern:			
Erratic VT and BF	19/41	Stunted BF (± high/erratic VT)	7/41
High erratic VT and erratic BF	13/41	Stunted VT and high erratic BF	2/41

BMI: body mass index; FEV_1: forced expiratory volume in 1 s; FVC: forced vital capacity; TLCO: transfer capacity for carbon monoxide; RV: residual volume; TLC: total lung capacity; VO_{2max}: maximal oxygen uptake; VE: minute ventilation; VT: tidal volume; BF: breathing frequency

P38

Determining the inter-rater agreement of the VO2 at AT between CPET practitioners within a large tertiary CPET service

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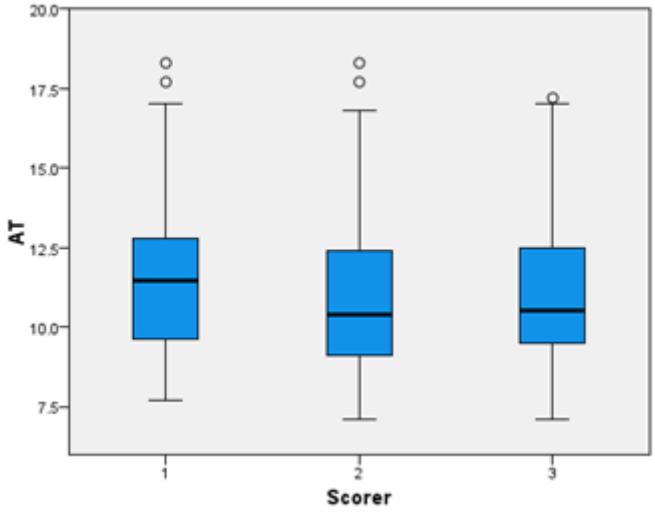
Introduction: Cardiopulmonary exercise testing (CPET) measures the oxygen uptake at the anaerobic threshold (VO2 at AT) to predict post-operative complications including mortality, morbidity, and length of stay (LOS). VO2 at AT is determined using the gold standard v-slope methodology (Beaver et al. J. Appl. Physiol 1986: 60(6); 2020-2027) and dual methods criteria (Cooper and Storer et al. J Sports Sci Med 2017: 16(3); 396-406). There is subjective interpretation of the angle of deflection between S1 and S2 slopes (Abbott et al. British journal of anaesthesia 2018: 120(3); 475-483) and therefore ensuring a high degree of inter-rater agreement is essential.

Methods: AT data was collected from 30 consecutive patients who performed pre-operative CPET. VO2 at AT (mL/kg/min) was measured using the v-slope methodology followed by the dual criteria method. CPET practitioners were blinded to the AT which was measured as part of clinical practice. CPET practitioner experience was estimated to range between 500 – 1500 tests performed. Data was analysed using SPSS. An evidenced based VO2 at AT of 11.0 mL/kg/min was used to discern between low (<11.0) and high surgical risk (≥11.0) patients. Intraclass correlation coefficient (ICC) and Fleiss's kappa (k) were used to assess inter-rater variability.

Results: Results demonstrated all 3 practitioners agreed that an AT was detected (100%). Intraclass correlation for 'single' VO2 at AT measures were ICC = 0.867 (95% CI, 0.770 – 0.930) demonstrating 'good' inter-rater agreement. Intraclass correlation for 'average' VO2 at AT measures were ICC = 0.952 (95% CI, 0.910 – 0.976) demonstrating 'excellent' inter-rater agreement. Fleiss's kappa demonstrated a 'good' strength of agreement between CPET practitioners k = .686 (95% CI, 0.480 – 0.893).

Conclusions: Our study suggests a good level of inter-rater agreement between CPET practitioners within a large tertiary CPET service when scoring VO2 at AT. This study highlights the importance of performing robust quality assurance processes within diagnostic exercise services to ensure consistent high-quality and clinically reproducible results which may impact upon surgical stratification for patient's clinical care.



P39

Abnormal oxygen pulse response in paediatric cystic fibrosis cardiopulmonary exercise tests - an update.

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Introduction:
Children with Cystic Fibrosis (CF) undergo annual cardiopulmonary exercise testing (CPET) as part of their routine assessment. It had previously been reported that several were showing an abnormal oxygen pulse response (O2pulse) with a flattening and/or fall at higher intensity exercise. Our primary aim was to look at follow up CPETs to evaluate for the repeatability of an abnormal O2pulse. Our secondary aim was to look at a subset of patients who had CPETs pre and post initiation of Kaftrio and evaluate the O2pulse response.

Methods:
This was a retrospective analysis of clinical data obtained over a 3 year period. Spirometry and CPET using an incremental maximal ramp protocol on a cycle ergometer were performed. A paired sample student T-Test was used to look for a significant difference pre and post Kaftrio treatment.

Results:
There were 32 patients who had sequential CPET measurements. 21 had a normal initial O2pulse response and 11 were abnormal. On subsequent CPET, 17 of the patients with normal baseline O2pulse responses, remained normal and 4 became abnormal. Of the 11 with an abnormal initial response, 9 normalised on subsequent testing.
10 patients had CPET pre and post Kaftrio. 7 had an abnormal baseline O2pulse response. Of these, 2 showed a normal response on CPET post Kaftrio. The 3 that had a normal baseline all showed an abnormal response post Kaftrio. There was no significant difference in any CPET parameters pre and post Kaftrio. There was a significant difference in the FEV1 and FEV1/FVC z-score. Data is shown in the table below.

Conclusions:
We have shown that the oxygen pulse response in children with CF is not repeatable and abnormal response can change to normal the following year and vice versa. The use of triple modulator therapy does not seem to have any impact on the O2pulse response or aerobic capacity. It does however significantly improve FEV1. This research casts doubt on the significance of an abnormal O2pulse response in children with CF and further work is required to determine the cause of this and the variability seen in repeated measures.

	Pre Kaftrio		Post Kaftrio		
Parameter	Mean	95% CI	Mean	95% CI	P Value
Sex (M/F)	6/4	-	-	-	-
Age	10.5	9.4, 11.5	11.9	10.8, 13.0	-
Height z	0.06	-0.30, 0.41	0.07	-0.14, 0.27	0.48
Weight z	0.51	0.06, 0.96	0.48	0.04, 0.91	0.43
BMI z	0.63	0.12, 1.14	0.53	-0.12, 1.18	0.31
FEV_1 z	0.03	-0.86, 0.92	0.47	-0.57, 1.51	0.04
FEV_1/FVC z	-0.47	-1.07, 0.14	0.12	-0.67, 0.91	0.01
VO_2peak % predicted	88.1	83, 93	87.9	78, 98	0.48
VO_2 peak ml/kg	36.1	33.0, 39.3	36.1	31.1, 41.2	0.5
O2 pulse % predicted	93	87, 99	89	80, 99	0.24
Peak Heart Rate (HR)	190	187, 193	188	184, 192	0.2
Ventilatory threshold (% predicted VO2peak)	52	45, 60	48	40, 57	0.11

P40

A SIMPLE METHOD FOR CHECKING THAT LUNG FUNCTION TEST RESULTS ARE QUALITY ASSURED CORRECTLY AND CONSISTENTLY BETWEEN RESPIRATORY PHYSIOLOGISTS

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INTRODUCTION: The quality assuring (checking) of lung function test results is a mandatory step performed by Respiratory Physiologists (RPs) to ensure confidence in accepting/rejecting results. The cross-checking of quality assured (QA) results between individuals reinforces confidence in results to be used clinically and for research. The process can also facilitate learning and competency in individuals less experienced or new to testing/ results interpretation. Using spirometry, we describe a simple methodological approach to measure the inter-rater reliability between RP's checking results.

METHODS: Test results collected during 3 annual health assessments of children taking part in the CHILL (Children's Health in London and Luton) study were used. 458 (6%) of 7654 results were randomly selected for QA. The level of agreement between 2 RPs was determined using inter-rater reliability and calculation of Cohen's K coefficient. This was for 2 primary parameters, FEV1 (forced expiratory volume) and FVC (forced vital capacity) and for 2 rounds of testing (baseline and post-bronchodilator). Both RPs documented their findings for analysis.

RESULTS: Cohen's K showed moderate to excellent agreement between RPs for baseline and post-bronchodilator FEV1 and FVC. The Cohen's K (and 95% confidence intervals) for baseline FEV1 in years 1, 2 and 3 were 0.817 (0.755 – 0.865), 0.645 (0.541 – 0.73), and 0.848 (0.796 – 0.887). The Cohen's K (and 95% confidence intervals) for post-bronchodilator FEV1 in years 1, 2 and 3 were 0.783 (0.683 – 0.849), 0.647 (0.542 – 0.731), and 0.902 (0.868 – 0.928). The Cohen's K (and 95% confidence intervals) for baseline FVC in years 1, 2 and 3 were 0.73 (0.643 – 0.798), 0.523 (0.396 – 0.631), and 0.745 (0.664 - 0.809). The Cohen's K (and 95% confidence intervals) for post-bronchodilator FVC in years 1, 2 and 3 were 0.77 (0.664 – 0.841), 0.664 (0.564 – 0.746), and 0.88 (0.837 – 0.911).

CONCLUSIONS: This very simple methodological approach showed consistency between both RPs findings and showed that they QA data correctly i.e. agreed in their rejection/ acceptance of FEV1 and FVC. This approach could be applied across routine lung function test results when a comparison between RPs findings is warranted.

P41

THE RISKS OF APPLYING NORMATIVE VALUES IN PAEDIATRIC CARDIOPULMONARY EXERCISE TESTING: A CASE REPORT

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We present a clinical case in a paediatric subject, that highlights an important issue surrounding the limitations of normative reference values (NRV) for the interpretation of cardiopulmonary exercise testing (CPET). At present, there is no single NRV available that encompasses both adult, paediatric and adolescent populations. As a result of this case, there is an ongoing ERS task force for developing Global Lung Function Initiative reference equations for CPET.

A fourteen-year-old female was initially referred to a local Hospital for investigation of exertional breathlessness and chest pain, initial investigations included a CPET. Following a review, she was diagnosed with a sub-acute/chronic right main pulmonary artery thromboembolism. She was deemed technically suitable for pulmonary endarterectomy surgery but the risks of the operation outweighed the benefits and anticoagulation therapy was continued.

Six months later she was referred to a specialist pulmonary hypertension centre with worsening breathlessness. On review, several non-invasive tests were carried out including a second CPET. The results were interpreted using Bongers et al. 2014 NRV and demonstrated a moderately reduced aerobic capacity with an anaerobic threshold consistent with a diseased status. These were in contrast to the initial CPET which was interpreted using Cooper et al. 1984 NRV. These results suggested only a mild reduction in aerobic capacity with an anaerobic threshold suggestive of a deconditioned subject (see table).

Further interrogation showed that absolute values of CPET parameters were comparable for each set of results, with the 9-panel plot demonstrating abnormal gas exchange for both. It was therefore apparent that the perceived change in functional status between CPETs was due to a difference in NRV applied, rather than as a consequence of a physiological deterioration. Subsequently, the patient underwent a right heart catheterization and MRI. This confirmed the diagnosis of chronic thromboembolic pulmonary hypertension and she was deemed suitable for surgical management.

In summary this case has highlighted NRV are not standardised, and therefore, this may lead to a significant difference in result interpretation between different medical institutions. Second, inadequate NRV impact on differential diagnosis, risk stratification and appropriateness for surgical and invasive intervention.

TABLE 1

Results for CPET parameters with two different NRV applied

CPET Variables	Local Hospital (Dec 2018)			Specialist Centre (Dec 2019)		
	Results (absolute)	Bongers 8-18yrs (2014) %predicted	Cooper 6-17yrs (1984) %predicted	Results (absolute)	Bongers 8-18yrs (2014) %predicted	Cooper 6-17yrs (1984) %predicted
Load (W)	89	42%	62%	98	46%	71%
V_{O2peak} (ml.min)	1391	55%	70%	1393	55%	73%
V_{O2peak} (ml.min.kg)	23.5	56%	70%	24.5	59%	73%
V_{O2} @ AT (ml.min)	879			788		
O2 Pulse (ml)	8.9	68%	96%	8.1	62%	90%
V_E/V_{CO2} Slope	45			52		
V_EEq_{CO2} at	44			42		
Lowest oxygen saturation (%)	85			88		
Cardiovascular slope	Normal			Normal		
		Ratio (%)			Ratio (%)	
AT % pred V_{O2max}		35%	44%		31%	41%

V_{O2peak}, peak oxygen consumption; V_{O2} @ AT, oxygen consumption at anaerobic capacity; V_EEq_{CO2} at AT, ventilatory equivalents for carbon dioxide at anaerobic threshold; AT % pred V_{O2max}, anaerobic capacity as a percent of maximal predicted oxygen consumption.

P42

Respiratory Physiologist' Role in reducing the risk of acute deterioration in Paediatric Patients

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Introduction
A clinical incident report, Datix, was submitted in 2021 where a patient with very abnormal spirometry was not reviewed for several months by the requesting clinician.
In January 2022 The Evelina Paediatric Respiratory Service introduced home spirometry monitoring. The realisation that patients with objective evidence of deterioration may not be picked up in a timely manner led to the creation of an escalation policy which was applied to all patients who attended for respiratory assessment or sent results from home monitors.
Criteria for Escalation:
For symptomatic patients or asymptomatic patients who do not appear unwell but their physiological parameters indicate significant deterioration or risk:
- % predicted FEV1 reduced by 20% from previous best result
- Bronchodilator reversibility of 25% or more in FEV1

Escalation pathway:
Patient appointment with requesting clinician same day: Attempt to call clinician, email if unable to contact.
Patient without a same day appointment with the requesting clinician: bleep clinical to assess the patient in the Physiology department.

Methods
The policy was established after stakeholder consultation and a standard operating procedure (SOP) was distributed and relevant parties were made aware. An escalation log book was created to track the number of escalations made. The SOP was continually reviewed and changes to policy made, according to Plan-Do-Study-Act (PDSA) methodology.
44 events were recorded in the first year of the escalation policy, 10 related to home spirometry, five symptomatic patients and 29 due to high bronchodilator reversibility.
After a review of the results in table 1 the SOP was updated to no longer trigger escalation for patients with BDR of 25-30% as these were felt to be lower risk.

Conclusion:
Our results indicate that an escalation policy is helpful for identifying patients who are at risk of having a sudden asthma attack or impending infective exacerbation of suppurative lung disease. This study shows an escalation policy can improve patient safety and outcomes, especially in cases where the testing session and doctor consultation are not on the same day.

Results

Number of Patients	BDR %	Steroids	Await OPA review	ED review	Adherence addressed	Step-up ICS
7	25-30	1	5		1	
18	30-40	5	10	1	2	
4	>40	1	1		1 (smartinhaler)	1

Table 1 summary of escalation events related to high bronchodilator reversibility between 19.04.22 – 30.03.23

P43

Rectal ointment for your aCBG appointment: gunpowder, good reason, no clot

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INTRODUCTION: An arterialised Capillary Blood Gas (aCBG), normally performed on the earlobe using a lancet or scalpel, is a minimally invasive alternative to an Arterial Blood Gas (ABG). However, its accuracy in assessing the true partial pressure of arterial O_2 and CO_2 (PaO_2 and $PaCO_2$) is heavily reliant on the 'arterialisation' of the earlobe capillaries. Prior to discontinuation, Transvasin cream and a hot water filled glove was used by Hampshire Hospitals NHS Trust. Subsequently, two alternative Rubefacient creams were trialled with only mixed success (RadianB and Deep Heat). Glycerol Trinitrate (GTN) ointment for aCBGs has previously been reported in the intensive care setting (Vaquer et al. AIC, 2014). Utilisation in an outpatient setting was discussed with the Drugs and Therapeutics Committee (DTC).

METHODS: Due to the small theoretical risk of hypotension, a six-month trial was approved by the DTC, subject to: 1) provision of a trust wide aCBG SOP, specific to GTN use; 2) addition of a Patient Specific Directive on the eReferral; 3) compulsory administration chart, with contraindications and recorded consent for off-label use (Figure 1) and; 4) reporting Adverse Drug Reactions (ADR) via the Trusts incident reporting system.

RESULTS: Referrals for aCBGs with GTN ointment and hot water filled glove commenced on the 01.10.2023 with a total of 28 successful tests performed to date (23.01.2024). An additional two patients were contraindicated for GTN use (chronic migraines and hypotension). One ADR was recorded, whereby the patient felt faint immediately upon firing of the lancet and was then shown to be hypotensive. It is unknown if the GTN or anxiety related to the blood sampling resulted in the symptoms and hypotension. Anecdotally, most physiologists using GTN ointment reported a higher success rate in achieving a subjectively perceived 'fast flowing' sample vs. the previously used Deep Heat cream.

CONCLUSIONS: Anecdotally, GTN ointment appears to be an effective vasodilator for aCBG. Continued monitoring should better identify the relative risk of side effects. Future research comparing the sampling success rate, the pO_2 and pCO_2 obtained from aCBGs using GTN ointment vs Rubefacient creams and a true ABG, would help evaluate its efficacy.

NHS
Hampshire Hospitals
NHS Foundation Trust

APPENDIX ONE

ADMINISTRATION CHART for Arterialised Capillary Blood Gas (CBG) using GTN 0.4% Ointment

Consultant Request: Consultant _____ ICE Referral Reference & Date _____

Patient details (patient identification label)

Consent for off-label use given	**Yes / No**

Contraindication Screen: if yes DO NOT proceed	
Hypersensitivity to GTN or nitrates	Y / N
PDE5 inhibitor or nitrate use within 24 hours	Y / N
Hypotension	Y / N
Migraine/recurrent headache	Y / N
Aortic/mitral stenosis	Y / N
Hypertrophic obstructive cardiomyopathy	Y / N
Constrictive pericarditis/pericardial tamponade	Y / N
Marked anaemia	Y / N
Closed-angle glaucoma	Y / N

Medication for Administration: Pre-procedure (topical use only): GTN 0.4% ointment to be applied to the inferolateral aspect of the pinna at least 15 minutes before procedure.

Date	Time	Batch Number	Expiry Date	Administered by

Document Written by	Document checked by	Document approved by	Date
Taryn Keyser, Deputy Chief Pharmacist		Drugs & Therapeutics Committee	

P44

An unusual physiological response to exercise in an adult Fontan patient – A case study

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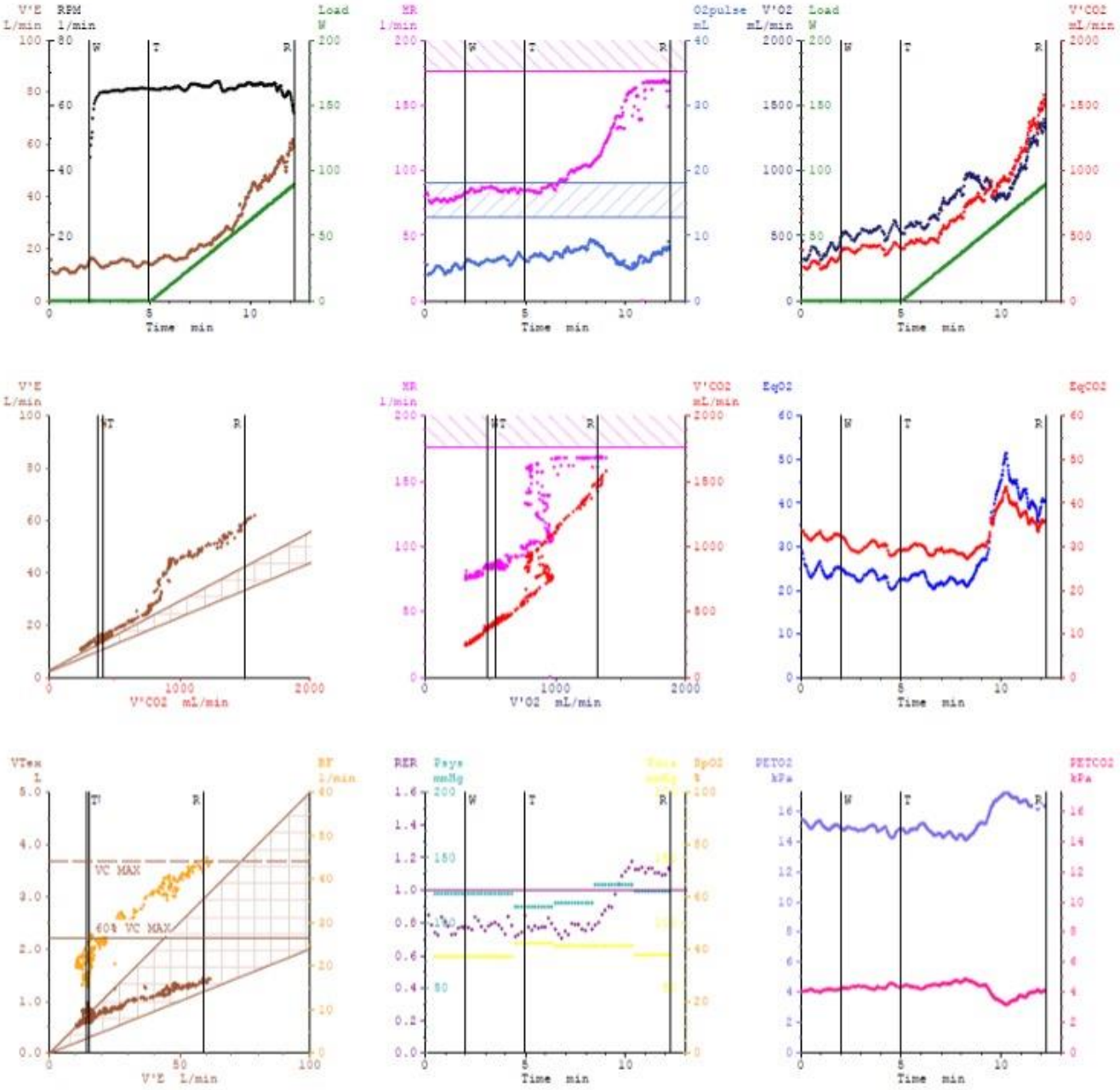
Introduction
A cardiopulmonary exercise test (CPET) provides an objective assessment of exercise tolerance and provides prognostic information in patients who have undergone a Fontan procedure.
A 24-year-old male (BMI: 21kg/m2) was referred for a CPET to assess his exercise capacity. His congenital cardiac diagnosis consisted of complex right atrial isomerism with a hypoplastic left-ventricle, double-outlet right ventricle, atrioventricular septal defect and severe aortic valve regurgitation. Fontan circuit completion was undertaken by age 12 resulting in a total cavopulmonary connection. Ongoing symptoms included occasional breathlessness and infrequent palpitations.

Methods
The patient underwent a CPET on a cycle ergometer to volitional exhaustion in accordance with the Association for Respiratory Technology and Physiology (ARTP) 2021 CPET guidelines (Pritchard et al., 2021). Wasserman et al., (2005) CPET predictive values were utilised.

Results
The test was deemed sub-maximal in accordance with ARTP CPET guidelines, however, the heart rate plateaued towards peak exercise, suggesting no further cardiac physiological reserve. Peak oxygen consumption was 20.1 ml/min/kg (43% predicted). Resting heart rate was 80 bpm and rose to 168 bpm (86% predicted), and no ECG changes were observed. Pre-test spirometry showed a restrictive pattern and peak minute ventilation (VE) was 56L/min (41% predicted). Oxygen saturation (SpO2) was 96% at rest, with a minimum value of 82% being recorded, whilst peak-exercise SpO2 was 94%. The VE/carbon dioxide production slope was 30.6 and VO2/work rate slope was 7.6. Wasserman's 9-panel plot is shown in Figure 1.

Discussion
The aerobic capacity was severely reduced. The cardiovascular and ventilatory responses to exercise were abnormal, given the temporary loss of oxygen delivery mid-test (Figure 1; Panel 3) and oxygen desaturation. Proposed underlying pathophysiological mechanisms responsible for this are, an increase in aortic valve regurgitation and inability of the systemic right ventricle to increase stroke volume. Consequently, an oxygen debt occurs, with compensatory mechanisms including a sudden rise in heart rate (Figure 1; Panel 2) and hyperventilation (Figure 1; Panel 8 and 9). This case highlights a unique physiological response to exercise given the temporary loss of oxygen delivery in an adult patient who previously underwent a Fontan procedure.

Cardiopulmonary Exercise Test: 9-Panel Plot



P45

The role of cardiopulmonary exercise tests in a Leicestershire paediatric respiratory cohort.

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Introduction: In children and young people (CYP) with a background of underlying respiratory disease, exercise induced bronchoconstriction is often considered the likely cause for exercise induced breathlessness (Bahtia et al., 2019). However, cardiopulmonary exercise testing (CPET), considered as the gold standard test to investigate exercise limitation, can be used to investigate potential causes for exercise induced dyspnoea (Ferrazza et al., 2009).

Method: A retrospective evaluation of CPETs performed over 18 months (June 2022-December 2023) was conducted. All CYP were managed by tertiary respiratory services and presented with complaints of exercise induced dyspnoea. CPET's were performed and reported by senior physiologists on a cycle ergometer using a ramp protocol. A maximal CPET was determined using ARTP (2021) criteria.

Results: CPET's from 35 CYP were analysed (median age 13, aged 7-16 years, 22 males (59%)). 30 (81%) of these children were able to complete a maximal CPET. Findings from the CPETs conducted differed in underlying physiological mechanisms (Table 1). Notably, those who had an abnormal cardiac response to exercise also reported dyspnoea and cyanosis of the lips upon exercise.

Conclusion: Our analysis highlights a number of differential diagnoses were present in this cohort of patients. This highlights the importance of further investigation to assess any multifactorial conditions causing exercise induced breathlessness in CYP with lung disease.

Table 1 – CPET findings

Finding	Number of CYP
Deconditioned	9
Breathing Pattern Disorder	5
Ventilatory Limited	4
Abnormal Cardiac Response	4
No significant Abnormality	7
Heightened perception of exercise`	1

P46

Using RER values as a retrospective marker of maximal exertion during cardiopulmonary exercise tests: Findings of a single database review

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INTRODUCTION
Cardiopulmonary exercise tests (CPETs) are used to assess surgical risk, functional or peak aerobic capacity, therefore it is vital the individual reaches maximal exertion (Pritchard et al. BMJ 2021). Although there is no gold standard for defining maximal effort (Radtke et al. European Respiratory Review 2019) a range of guidelines exist utilising an RER of >1.05, >1.10 and >1.15. Recent findings illustrate a RER of 1.05 or below can underestimate some patients' exercise capacity (Thomas et al. BMJ 2021). The aim of this study was to review the utilisation and consistency of the RER in determining a maximal CPET.

METHODS
On the 16 of August 2023 Web of Science, PubMed and Embase databases were searched using: ("respiratory exchange ratio" OR "RER" OR "respiratory quotient" OR "RQ" OR "VCO2/VO2") AND ("cardiopulmonary exercise test*" OR "cardio-pulmonary exercise test*" OR "CPET*" OR "CPEX" OR "CPX" OR "CXT" OR "VO2max" OR "VO2 max" OR "VO2peak" OR "VO2 peak" OR "peak VO2" OR "maximal exercise test*").
Eligibility criteria included studies involving human participants, with an exercise duration of >6minutes. Those included were case, experimental, crossover or parallel studies, randomised or non-randomised studies written in English language, with no restriction on publication year. Exclusion criteria included evidence of dysfunctional breathing, comments on test quality, validity or highly variable RER/minute ventilation and severe illnesses. The RER utilised in each study was compared.

RESULTS
Figure 1 displays the study selection process.
The results show 27% of adults using a cycle ergometry applied a RER baseline of ≥1.05 or below, 52% utilised ≥1.10, 15% utilised ≥1.15 and 6% used a different RER specifically ≥1.09, >1.12, ≥1.13 and >1.20. A RER baseline of ≥1.05 or below, was the highest at 77% in paediatrics using a treadmill. Overall, 33% of the studies used an RER baseline of ≥1.05 or below.

CONCLUSIONS
A variety of RER values have been utilised to determine maximal exertion, which lacks consistency in the literature. Furthermore, 33% of studies have utilised a RER baseline of ≥1.05 or below which may result in an underestimation on a patient's true exercise capacity, consequently influencing diagnosis and surgical risk.

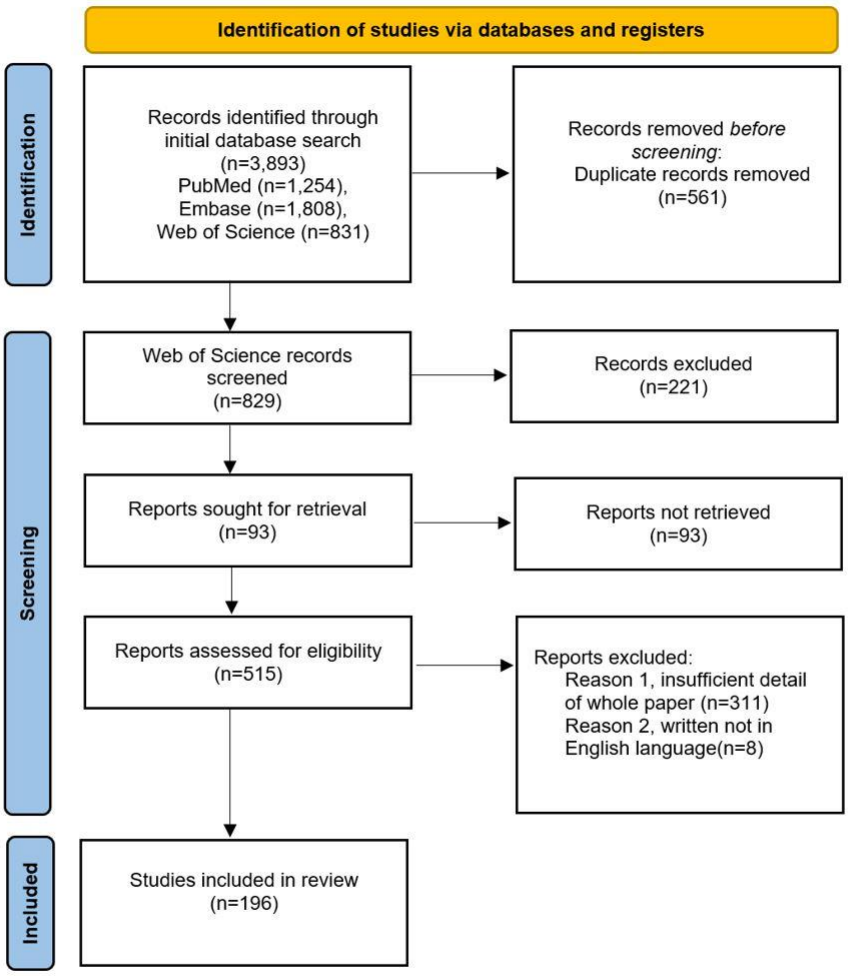

Figure 1: PRISMA 2020 flow diagram showing the study selection process, with only Web of Science records utilised during screening and inclusion.

P47

Accuracy of automated BP machines during maximal exercise testing

Mr Daniel Grant[1]
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Introduction: Many centres perform Cardiopulmonary exercise testing, during these maximal exercise tests many centres utilise automated blood pressure monitors to aid testing. Often accuracy is taken for granted however sometimes questionable values are produced and then manually double checked. How accurate are various automated blood pressure monitors? Research (1) suggests only moderate accuracy, is this good enough when decisions may impact surgical intervention. We hypothesised that values would become less accurate with increasing exercise intensity and also in the presence of arrhythmia (significant ectopy, AF). Internal audit performed to verify accuracy.

Reliability of automated blood pressure cuffs during maximal exercise testing
Category C Grant Daniel
Introduction: Many centres perform Cardiopulmonary exercise testing, during these maximal exercise tests many centres utilise automated blood pressure monitors to aid testing. Often accuracy is taken for granted however sometimes questionable values are produced and then manually double checked. How accurate are various automated blood pressure monitors? Research (1) suggests only moderate accuracy, is this good enough when decisions may impact surgical intervention. We hypothesised that values would become less accurate with increasing exercise intensity and also in the presence of arrhythmia (significant ectopy, AF).
Methods: We studied the accuracy of the tango M2 automated blood pressure machine with patients exercising on a treadmill, we also studied the built in ergoline Via sprint automated blood pressure machine during ergometer testing and compared resting, mid-test and maximal test values against manually assessed blood pressure measurements taken by experienced healthcare staff. We looked at 22 patients on the treadmill and 45 patients on the ergometer. We looked at absolute difference, percentage difference and standard deviation.

Bike excluding arrhythmia

Rest systolic	– AD -0.8mmg (SD 10.6mmHg) - % dif 1.1% (SD 8.1%)
Rest systolic (excluding arrhythmia)	– AD 0.1mmg (SD 9.9mmHg) - % dif -0.4% (SD 7.5%)
Rest diastolic	– AD 4.3mmHg (SD 7.2mmHg) - % dif 5.0 (SD 8.3%)
Rest diastolic (excluding arrhythmia)	– AD 3.9mmHg (SD 7.1mmHg) - % dif 4.5 (SD 8.3%)
Mid systolic	– AD 0.02 mmHg (SD 11mmHg) - % dif -0.3% (SD 7.0%)
Mid systolic (excluding arrhythmia)	– AD 1.9 mmHg (SD 9.5mmHg) - % dif 0.8% (SD 6.5%)
Mid Diastolic	– AD 3.1 mmHg (SD 9.4mmHg) - % dif 2.4% (SD 10.4%)
Mid Diastolic (excluding arrhythmia)	– AD 2.9 mmHg (SD 9.5mmHg) - % dif 2.1% (SD 10.4%)
Max systolic	– AD 3.8 mmHg (SD 23.7mmHg) - % dif 0.6% (SD 13.3%)
Max systolic (excluding arrhythmia)	– AD 1.6 mmHg (SD 15.6mmHg) - % dif -0.2% (SD 10.5%)
Max diastolic	– AD -0.3 mmHg (SD 7.1 mmHg) - % dif 0.6% (SD 9.8%)
Max diastolic (excluding arrhythmia)	– AD -1.0 mmHg (SD 6.7 mmHg) - % dif -1.4% (SD 9.3%)

Treadmill excluding arrhythmia

Rest systolic	– AD 0.2mmg (SD 11.9mmHg) - % dif 0.07% (SD 8.9%)
Rest (excluding arrhythmia) systolic	– AD 1.4mmg (SD 13.4mmHg) - % dif 0.8% (SD 10%)
Rest diastolic	– AD 6.45mmHg (SD 11.4mmHg) - % dif 7.4 (SD 14.7%)
Rest (excluding arrhythmia) diastolic	– AD 9.1mmHg (SD 9.4mmHg) - % dif 11.0 (SD 10.8%)
Mid systolic	– AD 1.1 mmHg (SD 23mmHg) - % dif -2.2% (SD 13.9%)
Mid (excluding arrhythmia) systolic	– AD 6.1 mmHg (SD 24.9mmHg) - % dif 1.1% (SD 14.4%)
Mid Diastolic	– AD 0.8 mmHg (SD 15.4mmHg) - % dif -1.3% (SD 24%)
Mid (excluding arrhythmia) Diastolic	– AD -2.3 mmHg (SD 16.8mmHg) - % dif -6.7% (SD 25%)
Max systolic	– AD 0.9 mmHg (SD 22.7mmHg) - % dif -0.3% (SD 13%)
Max (excluding arrhythmia) systolic	– AD 5.6 mmHg (SD 17.4mmHg) - % dif 1.95% (SD 9.6%)
Max diastolic	– AD 3.4 mmHg (SD 12.2 mmHg) - % dif 0.6% (SD 22.8%)
Max (excluding arrhythmia) diastolic	– AD 5 mmHg (SD 14 mmHg) - % dif 1.3% (SD 26.9%)

Conclusion: No difference in automated BP measurement in the presence of arrhythmia. No difference in the measurement of automated BP with increase in exercise intensity either on bike or treadmill. We were pleasantly surprised that the automated BP systems worked as one would expect of them both

with increasing exercise intensity and in the presence of non-rhythmic pulse thus are reliable rather than just assuming that they produce accurate results apart from occasional erroneous values that are clearly significantly different from others.

Reference list: 1. Diagnostic accuracy of mercurial versus digital blood pressure measurement devices: a systematic review and meta-analysis. Muniyandi et al. Scientific reports. 2022