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HIGHLIGHTS ...

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First word

Dear Readers,

Welcome to the spring edition of INSPIRE. Many of you will be gearing up for a trip north to my beloved home city of Glasgow for the annual conference. If you're lucky enough to attend this year then I hope you enjoy the city and get to see some of the sights. I recommend some daytime shopping in the Buchanan Galleries followed on by some food and drink in the Merchant City area. The city's slogan is "People Make Glasgow" and you will always find a friendly face looking for a natter wherever you go.

We have a fully packed edition with three articles from bursary winners. These include two articles on cardiopulmonary exercise testing (CPET); one looking at adult congenital heart disease and the other looking at anabolic steroid use in bodybuilders and an article looking at using forced oscillometry in COPD.

We have two authors submitting work from their recent PhD's. Our Chair, Jo Shakespeare has provided the research committee's **'Fresh Air'** article on ventilatory responses to arm ergometry CPET and Emma Raywood gives us an update with interesting results on **'Project Fizzyo'** which looked at providing insights into airway clearance techniques in children with cystic fibrosis.

Our vice chair, Matt Rutter has written an article on his recent trip to Portugal (that must have been a tough one Matt!) looking at a recruitment drive to support physiologists from there to take up vacancies in NHS England. **'Lab in the Limelight'** has now made it to all four nations with this issue travelling to Wales and getting an insight into Swansea Bay University Health Board, courtesy of the lead physiologist, Hannah Hunt. For this issue's **'Respiratory life stories'** I had the pleasure of interviewing arguably the best known ARTP member we have – Professor Brendan Cooper. It is a must read for any young aspiring physiologists looking for some inspiration! Finally, I have included more of the **'Getting to know the ARTP Committee Chairs'**, looking at our communications, paediatrics and standards committee representatives.

As always, a big thanks to all the authors for providing high quality articles. A special mention has to go to Brendan for giving me his time at short notice to go over his life and career. The editorial committee do a lot of hard work in the background to review all the articles for this journal and I couldn't get this published without their help, so my full heart felt appreciation goes out to them. If you want to get warmed up for your trip to Glasgow, sit back with a cold glass of Irn-Bru and a deep-fried Mars bar supper whilst enjoying this edition of INSPIRE.

Paul Burns
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A Word from the ARTP Chair

Dr Joanna Shakespeare
ARTP Honorary Chair

Hello and welcome to the spring edition of INSPIRE 2025. As I write this, the mornings have just started to get lighter and by the time you read this, we will have moved the clocks forward and so spring will have officially sprung - thankfully!

A lot has happened over the last few months. Planning for the ARTP Conference 2025 has now moved into the final stages with regular meetings of the events committee to ensure that everything is ready for the 1st May. I am really pleased to hear that we have had a record number of abstracts submitted this year. The research team are currently working hard to plan the sessions to enable as many of you as possible to present your work. We are also working really hard to secure a venue for our 50th anniversary conference in 2026 and hope to be able to announce this at the conference in Glasgow.

The ARTP National Strategy Day was held at the Leonardo Royal Hotel on the 22nd November. It was a really well attended event with a total of 129 in attendance. We heard from our committee chairs, who outlined the work of their groups and plans for the future. We were updated on current ARTP work, such as member project development, an update to the website, equality, diversity and inclusion (ED&I) in the ARTP and the sustainability taskforce. We also had workshops covering a variety of topics including social media, workplace efficiency, quality improvements and quality assurance. We were also delighted to have representation from the four nations Chief Scientific Offices. We are extremely grateful to Ian Young (Northern Ireland), Catherine Ross (Scotland), Sarah Bant (Wales) and Delia Ripley (England) for taking time out of their busy diaries to support the event where they led country- specific sessions and took questions from members.

Importantly, the National Strategy Day also enabled us to launch ARTP's first ever formal strategic plan. This strategy provides ARTP with a framework and clear goals and objectives for the Executive Board and ARTP committees to deliver against over the next four years. It has been designed to align with the broader national strategies that have been set out by the Chief Scientific Officers across the United Kingdom. A published copy of this strategy will be shared with all members and stakeholders shortly. We will report back to the membership on our performance against our objectives at the annual general meeting.

As outlined in my last 'Word from the Chair' we advertised for a new Executive Board role of ED&I Chair and I am really pleased to confirm that we successfully appointed Asia Awal into this position. Asia has already attended her first Board meeting and is working on developing the committee and its Terms of Reference.

We also successfully appointed a new Early Careers representative, Deborah Babalola. Deborah is looking to improve ARTP communication with students and early careers members and will also be supporting with international recruitment using her experience of moving to the UK from Nigeria. I am pleased to confirm that we also managed to recruit to the vacant post of Vice Secretary and I am delighted that Sandra Davies has agreed to this position, returning to working on ARTP committees again after a few years off for good behaviour!

I can also confirm that we have signed off on the new website specification document with Light Media, which means that we have now moved into the website build phase. Those attending the National Strategy Day got a sneak preview of what the website will look like and some of its features. The members section is particularly exciting and I am sure that you will all benefit from the easier events and course booking facility and member resources.

Following the official publication of our ARTP strategy we will focus on assuring that we deliver against our planned objectives. One of these objectives is to support the expansion of our workforce. ARTP have been working closely with NHSE in recent months to develop a programme that will support Physiologists in Portugal to take up vacant posts in England. In this edition Matt Rutter describes his recent visit to Portugal, accompanied by Shirley Coelho and NHSE representatives, to encourage suitable candidates to apply.

As always I would like to continue to encourage members to communicate with myself (chair@artp.org.uk) or specific Committee Chairs (via admin@artp.org.uk) as much as possible. Please feel free to ask questions, raise comments or concerns where required.

I will leave you now to enjoy this edition of INSPIRE. I really look forward to seeing as many of you as possible at the ARTP Conference in Glasgow. For those not able to attend and managing the workload within departments to allow others to attend, I thank you.

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Physiologist Life Stories

Professor Brendan Cooper

Interview with INSPIRE Editor - Paul Burns

For this edition of respiratory/physiologist life stories, I had the pleasure of speaking to ARTP stalwart, Professor Brendan Cooper. Brendan is probably one of the best known ARTP members in the country, being previous Chair from 1998-2007 then the first elected ARTP President in 2013. He is currently completing his tenth year as President of the Academy for Healthcare Science (AHCS). With over one hundred and eighty peer-reviewed published papers, his experience and knowledge in respiratory and sleep physiology are second to none.

I first came across Brendan in Glasgow in 2007, which was my first ARTP conference. I was a junior and very new to the job. He was Chair and delivered a rousing and humorous after-dinner speech. I then first spoke to him when I was undergoing my ARTP Part II clinical viva. He was the assessor in the blood gases station. It was daunting enough going into each station not knowing what you would be grilled on but then seeing Brendan Cooper as the assessor put the fear of God into me! However, he was the nicest assessor I had through all the stations. As soon as I sat down, he made some jokes, asked me which football team I supported (once he realised I was from Glasgow) and it put me at ease straight away, which allowed me to perform well in the exam. Don't get me wrong, he didn't go easy with the questions once he knew I was capable, but his examiner demeanour is one I emulate to this day. A few years later when I joined the education committee, I was in ARTP HQ, Lichfield for my first in-person meeting. Brendan was there, and again made me feel welcome and at ease by chatting away to me when I was quite nervous undertaking my first official role in ARTP. I knew what Brendan's standing was in the profession at this point, so it meant a great deal to me for him to speak to me and make me feel welcome.

There were a few things that stood out for me in this interview. Brendan is very passionate about his job and delivering the best care to help make a difference to patients, even after 43 years in the respiratory physiology profession. He has been heavily involved in developing many of the training pathways from the BSc in clinical physiology to the higher specialist scientist training programme and he still has a passion for encouraging young physiologists to be the best they can, especially considering how far the profession has come in the last forty years. A big thanks goes to Brendan for giving me the time to quiz him on his life and career.

Tell me a bit about your background

I'm from the English equivalent of Glasgow – Liverpool! I was born and bred there so I am actually a 'scouser'. I don't have the accent anymore but can put it on when needed! I love Liverpool (well Everton actually!) but feel like a bit of an outsider when I go back there now because I have lost the accent and it has changed so dramatically. I grew up in the seventies as a teenager in Liverpool and the seventies were a bit dull, beige and boring. It was a bit of a drab time with the city being on its knees but it was still a great place to live and I have fond memories of it. It was in the eighties and nineties it started to get on its legs with the docklands being revamped. It's a bit like Glasgow, in that it is a world-famous city that didn't quite know how good or influential it was globally. Of course, like every other scouser I went to school with one of the Beatles…!

I am the youngest of three although people normally say I should be the oldest because I am so gobby! I have a brother and a sister and we all did the diaspora. My brother is in Aberdeen and my sister alternates between New Zealand and Clitheroe in Lancashire so she's the closest to the North West. My brother is a geologist and my sister is a consultant rheumatologist so two of us are quite passionate about the NHS. Whenever we would talk about the lungs, blood and phlegm my brother would hate it! I have two wonderful daughters and one of them has now spiralled back round to living near Liverpool.

Were your parents academic?

My dad was a primary school head teacher, and he had aspirations to go back to university and do more but he was born in 1924 so went in to WWII. He joined the RAF as an aircraftsman and became a pilot. He was obsessed with flying. He became an officer, and it gave him a strong leadership role which I suspect has probably brushed off onto me. He also liked to deliver after-dinner speeches and was quite loud and *gregarious so I imagine that's where I get some of it from! My mum was a fabulous medical secretary and promoted healthcare and the NHS to me and my sister – a great influence on us both. Consequently, I always push for more secretarial support for our lung function services – they are the "oil" to the clinical service "machine" - utterly essential!*

Tell us about your academic training and how you got into lung function

After completing my GCSEs and A Levels at a Catholic grammar school in Liverpool, I went to the University of Sheffield to do my undergraduate degree which was called 'Physiological Sciences', but it was basically physiology and zoology. I loved the physiology aspect and there was one lecturer, Dr Gwendolyn Barer who was an exercise physiologist and just set my passion alight for respiratory and exercise physiology. You need to remember it was all new stuff (Douglas bags and gas meters!) then, so it was very exciting. Breath-by-breath didn't really exist. I also did a large 2,000 word assignment on "Why do we sleep?" After graduating with a 2:2 (...I should have worked harder!) we were in the midst of Tebbit/Thatcher Britain so I had around fifty job applications submitted. In the same week I got an offer to go and work at the Hammersmith in biochemistry or to go to the Freeman Hospital in Newcastle upon Tyne to work in lung function. With the previous inspiration from my exercise physiology lectures I chose lung function at the Freeman.

The job at the Freeman was replacing a name that may be familiar to the readers – Adrian Kendrick, as he had left his post there for Bristol. I loved the place and the people. The hospital had a very modern feel, and they were really eager to advance the lung function services. My boss was Dr John Gibson (author of Clinical Tests of Respiratory Function), who is now emeritus professor. I had a lot of good colleagues in lung function who taught me the art of and the importance of quality in lung function measurement. We were a great team which included Dr JJ Gilmartin, Dr Dan Veale, Dr John White, and the amazing respiratory physiologist, Therese Small who taught me how to measure lung function. Every Tuesday lunchtime we would have an educational/research meeting where you had to either defend your research project or ask questions or make comments on someone else's research proposal/results. This culture gave me some amazing training in research, writing papers and abstracts and presenting. It really kindled my spirit for research and when I speak to Adrian Kendrick about it now, he feels much the same. It was our respiratory physiology "finishing school", although it was really just the start! I did a little "side study" at the time looking at validating overnight oximetry against polysomnography and highlighted the limitations of overnight oximetry - now my most cited paper!

I then did an in-service research Master's thesis on lung function in diabetes. The professor of diabetes was a genius called Prof George Alberti. He was a very inspirational leader and very smart guy. He was good at bringing people on who were keen and hard-working. I tried to start a PhD looking at the physiological changes in a variety of neuromuscular diseases but unfortunately the physicians gave it to one of the registrars as their research MD project. So, I ended up being asked by George Alberti if I wanted to do a PhD in the Department of Medicine at the University of Newcastle upon Tyne. My thesis was titled "Protein Metabolism in Human Pregnancy" which included validating/using indirect calorimetry (just as we do in cardiopulmonary exercise testing - CPET) to measure resting energy expenditure and substrate utilisation. Along with this, I learned and used a bunch of biochemistry techniques including mass spectrometry and infra-red and gas chromatography. I was essentially a research biochemist for four years whilst doing this very methodical work. It was a great experience to see science in a completely different way and see the importance of quality, care and management of processes. It was at this time that I used those metabolic techniques to look at metabolism in sleep apnoea patients on and off CPAP. Serendipity in research is so important.

Tell us how your career developed after completing the PhD

As you well know, a research career can be very frustrating as you can have the best project in the world but fail to be successful in grant applications. I put in three significant grant applications and none were successful. I was getting to work only on short term projects of six months to a year but I had a young family to support, so a steady income and job security was a priority. Therefore, I started to look for a new, secure role and applied for two jobs in Nottingham. One was as the lead of a hospital lung function and sleep service and the other was to become a lecturer at the University of Nottingham (with the team who went on to show the value of high intensity exercise in weight loss). I had the two interviews on the same day and when I presented at the University, about four of the panel fell asleep (a pattern that was to continue at conferences around the world for me)! It was a boiling hot day and they were bored senseless with all the talks they had heard. When I went to the hospital interview, I realised that was what I wanted to do. I wanted to be clinical but also act as a leader, do research that had relevance, and have direct patient contact.

The department was fairly well organised as it had been running for a long time. Sue Revell, who was involved with the ARTP at the time, had been at the helm. It was a great team who knew what they were doing. They had an effective CPET service. The chief physiologist was ex-cardiology, so she was able to pick up anything on the ECG. I was able to expand and develop the service and modernise the service with new equipment.

The hardest parts of that job involved Sue Hazard, who was the deputy head and a brilliant clinical physiologist. She acted as one of our quality control subjects and we noticed her lung function started to deteriorate over a period of months. We knew something wasn't right and she was then diagnosed with the early stages of motor neurone disease/ALS in her late twenties. Living through that time with her illness was tough, but the team were amazing. We actually used to have some of the staff meetings in her house to keep her in the loop. It's such a horrible disease as she was so young and brave with a young family which made it so sad. You'll know that one of the student awards for best mark in the practitioner qualification is called the "Sue Hazard award", which is dedicated to her. It is great that ARTP were able to do that in her memory and it means a lot to me when I see someone awarded it at conference. At the ARTP Conference that year, the Exec Committee launched a sort of "crowd-fund" which meant that Sue and her family went to DisneyLand Paris for the first and last time as a family because later that year she died. ARTP members have always been such good, kind and caring people.

Going back to your time working at the Freeman, did you work with John Cotes at all?

Yes, I did. There was always a bit of friendly academic rivalry between John Gibson and John Cotes. As part of my Master's project, John Gibson made me manually work out predicted values and z-scores on a calculator and then he would send me over to discuss them with John Cotes. I remember going into his office and he had all these box files with all this normal subject lung function data and they were all organised into sex and age. When you looked at the elderly female box, he had approximately ten subjects in it and the whole of his published equations for older females were based on those ten subjects! It shows how far we have come with the Global Lung Initiative (GLI). Working with and learning from him stood me in good stead to be a part of the GLI team. At my first ever clinical presentation (held at the now demolished Shotley Bridge Hospital) he stood up and praised my overnight oximetry validation work. That feeling of success and confidence is something I want to instil into all young scientists on their career path. He was an amazing guy and really one of the greats. Very much the grandfather of UK clinical lung function.

Before he left, Adrian had started doing the first sleep studies for them so when I joined the Freeman my job was to take this sleep work forwards. I was put together with a fantastic medical physics team who built a video polysomnography system. This was years ahead of its time, but we started a clinical and research programme using sleep staging and I was scoring all of the sleep studies with the support of John Osselton. In fact, after a few years or so, I spent the majority of my time analysing sleep studies and working on the sleep physiology side of things. It was by luck that sleep apnoea really came to be a recognised condition and came to the forefront of diagnosis just as my career was taking off. In 1984-ish we had cobbled together a CPAP machine that was like a big vacuum cleaner (an idea of John Stradling's) that was re-wired to blow rather than suck. I remember the first time we used it on a patient. He had horrendous sleep apnoea with regular oxygen saturation dips below 40%, an AHI over 120 and apnoeas lasting longer than thirty seconds - it was lucky he didn't die before getting diagnosed and treated! Anyway, we used the device on him and within ten minutes he was sleeping soundly with no apnoeas. We couldn't believe it! We were metaphorically high fiving each other at the success of it. It was just incredible. It was meeting one of my heroes, Professor John Stradling, that got me into sleep physiology as an addition to my lung function and CPET interests.

Tell us about how the role of the technician to physiologist has evolved and the part you have played in that within the UK

The ARTP have played a massive part in this. It is such a brilliant organisation for your profession and also for your career. At the time when I became involved, it was Sue Hill that brought me in. She was the kingpin - the then Chair. Once the new three-year BSc in Clinical Physiology course was set up, which was a sea change from the national certificate in medical physics and physiological measurement (MPPM), a whole tranche of physiologists came through who then became the band 7s and 8s we know today. It was Sue Hill's vision of recognising that we were much more than the band 3-4 level of operating (that we were classed as at the time) that helped build the development of the job into a higher level. There were only a handful of clinical scientists around. Sue Hill was one and I became one whilst at Nottingham. I remember holding a meeting at one of the ARTP conferences about how we could get more people to become clinical scientists. A lot of people turned up but there was some hostility to it with people saying, "You're not taking away our physiologists, you just think you scientists are the elite". Some of those people who did object then are now clinical scientists and consultant clinical scientists. I think you've just got to take people with you and share the vision.

To see that empowerment of people realising how good they are and how brilliant the profession is really drives me on and is what I love about the ARTP. I have been involved with other organisations like the ERS and the AHCS, but it is the ARTP where I feel at home. I can relate it back to my dad going from a kid at school to undertaking RAF leadership training and then going on to lead in the rest of his career. For me, my RAF was the ARTP with the "FEW" becoming the "FEV$_1$".

Tell us how you go into the ARTP to eventually becoming Chair

I was first talked into joining ARTP by (Dr) Sue Revell as *she thought I might have been useful. However, there wasn't a position for me on the board (executive committee at the time) which meant I would need to make something up! I had been to the annual conference and it had around three manufacturers' stands crammed into a small room. It gave me the idea to set up a manufacturers' liaison group so we could get more involved and work with them. It also meant if we had problems with equipment, we could now show strength to manufacturers in numbers to try and get solutions to problems. The ARTP thought this was a good idea so took me up on the offer. I was in that position for a while, but you know me around a board table... I can get a bit gobby! Eventually Sue Hill decided that as she was becoming Chief Scientific Officer of England, so she would need to step down and she asked me if I would take on the position of Chair. I said I would think about it. We then had the next board meeting which she was unable to attend; I was sitting around the table with all the executive committee members and someone said, "Who is going to replace Sue then?" The room went quiet then everyone looked at me and said, "We think it should be you Brendan". Hence, I never had much choice!*

To be honest, it was great. I had a blank canvas and so many good and willing people with me who wanted to make a difference. It wasn't down to me; we just had the right people at the right time. In my time as Chair, we managed to launch the website, the forum, publish the handbooks, develop the BSc course and the national assessments and the spirometry certificates as well as produce a large increase in membership. We renamed ARTP to reflect "technology and physiology" and not so much "technologists and physiologists". It was a step-change in ARTP – and not down to one person, just a great team!

I remember we had the conference in 1997 in a tiny hotel in Liverpool with all the manufacturers squashed up together and they weren't happy as they couldn't talk to their customers! The food was crap and the entertainment was an Engelbert Humperdinck tribute act! We thought, "this can't get any worse!" The following year was to be Sue Hill's last one so she named it as the 25th year anniversary so we could go all out (but it was actually the 23rd!) We had it in the Birmingham International Convention Centre and we blew all the ARTP savings! However, after that we always went to big venues and the numbers increased and the manufacturers helped fund it. They really helped us out financially to make the conferences big events over these growth years. I think now, ARTP is in a different league again. It's very well organised and has all its committees, groups and protocols and it makes developing things much easier.

Were you and Sue Hill involved in helping set up the BSc in Clinical Physiology?

Sue Hill drove it centrally with Sue Revell and Angela Evans from Stoke being instrumental in getting it going. Angela was great at driving educational matters through and she had a good knack for that and her team around her were strong. Each of these teams pulled together in the right direction to help it happen. Leadership enables you to empower those great people around you to excel and take things forward. I feel I've been more of a "catalyst" to drive forward change with others rather than being responsible for that change.

You moved from Nottingham to the Queen Elizabeth (QE) in Birmingham. How did that move come about? And tell us about your time at the QE

As I had mentioned, Sue Hill changed jobs to become the Chief Scientific Officer. She had been the lead for the QE and she interviewed me for the job to replace her. It was a three-hour interview with questions and a presentation! Although in her new role with NHS England, Sue kept her office at the QE whilst regularly travelling to London for her new job so I shared with Jo Shakespeare initially (what happened to her?). Eventually Sue decided that I should move into the office with her as I was the new service lead. She was very rarely there so shortly after she left me to have the office and department as my own.

It was a well organised department and there was lots happening but there were plans for expansion due to the increased demands. The new QE PFI build opened in 2010. I thought that I would work in the QE for maybe three to five years then look to move onto something new but it's actually 22 years this week since I started in the job. The hospital move was great for the department. I remember having some ARTP meetings in the old hospital in Nuffield House and at one of the meetings I had a good old argument with the ARTP Treasurer at the time. Let's just say we didn't think much of each other then! The Treasurer at the time was none other than Julie Lloyd! And who was to know what would happen... I have a lot to thank the ARTP for!

Brendan with his trademark white scarf at ARTP gala dinner. Sitting next to previous chair and his beloved wife, Dr Julie Lloyd

The service at the QE expanded from two sets of full PFT kit to eight. Just prior to the pandemic, NHS England told the QE to merge with Heartlands hospital which had Selly Oak and the Birmingham Chest Clinic and they also *had control over Good Hope Hospital. They combined these and formed University Hospitals Birmingham (UHB). I immediately saw this as an opportunity to unify what we did in terms of equipment, training, staff, processes etc. Indeed, we have become a more integrated and united team across four sites and bring the best out of each other to benchmark our services for patients and support each other with trainees, equipment loans and advice sharing.*

We did Improving Quality in Physiological Services (IQIPS) at QE and we were on the roll out to do this at all the sites. Unfortunately, 2 years ago NHS England felt UHB wasn't working and decided we had to have one organisation at the top but have separate site operational management teams. I wasn't in agreement with this as I felt it made standardising things very difficult.

Every month we have our cross-site meeting which is great. I go to Heartlands one day each month now. I like to keep connections with all the staff. I have a good old chat with them and see how things are going and act as a kind of mentor to the team there. The service leads and deputies in the three hospitals - QE, Heartlands and Good Hope - all work well together and staff will sometimes rotate, so collectively we have a good team and a healthy atmosphere.

Clinically, I have two sleep clinics per week. My Monday clinic is face to face and Friday morning is a telephone clinic to help reduce waiting lists and get patients into the CPAP follow up clinics if required. I report about two hundred sleep studies a month. I still love doing the clinical side and talking to patients; it is just the best part of my job. Knowing that you are making a difference to people really gives me job satisfaction and the range of people that you see often just makes me laugh and makes the job enjoyable.

You've been quite involved with the European Respiratory Society (ERS). How did that come about and how did you find that?

Having been ARTP Chair, I was told it would be good to get involved in the ERS and I think someone nominated me. There was a hiatus in the Group 9.1, which is the physiologists' group. Normally the secretary replaces the chair after their term and someone new moves into the secretary role but both the previous secretary and chair had left so we had to get two people in from scratch. I volunteered to be Chair and I could see that a lot of the advances and improvements we had made in the ARTP could be emulated within the ERS.

The ERS is good at pulling people in and I got onto a long-range strategy committee for Assembly 9, but it's basically to get you to go to a meeting at 7am at conference with a hangover! Irene Steenbruggen was secretary of the Group and we worked really well as a team. I'm a broad-brush stroke person and Irene was a fine detail person so it was perfect. (Throughout my career, Sue Hazard, Jodie Hunt, and a few others in the ARTP were also that "fine detail" person with me.) Leadership is about "bringing all the skills to the table" and working together as a collective and not a hierarchy. This develops respect in your leadership, something we don't see too much of these days (e.g. Trump, Putin, etc.).

The same thing happened over the Assembly 9 leadership at the ERS where the secretary was due to follow on from the previous Head of Assembly but they had decided not to. I threw my hat in the ring and beat someone else who was running for the position and had been pretty confident of getting it. Therefore, I wasn't very popular for a couple of months! Anyway, that was probably the best professional education leadership training that I have ever had. The ERS Executive Committee has some of the smartest and most powerful people in respiratory medicine, including leading professors, doctors, physiologists, surgeons, and paediatricians etc. The ERS used to hire people from leading global companies like PCW, Ernest Young or Reuters to work as their admin. They tended to drive you and make you do things and achieve goals. It was definitely the best way to learn how to act at and approach board meetings. It was phenomenal. I actually advised Karl Sylvester when he was finishing as chair of ARTP that he should try to get a position at the Assembly 9 in the ERS as it would be a tremendous learning curve. Fortunately, he took my advice and has been great for ERS physiologists. Indeed, we have a great track record with Julie Lloyd being Group 9.1 Chair and Adrian Kendrick as Secretary also.

Being involved and delivering on things in the ERS means that when any task forces or projects to do with physiology, (e.g. Standards or GLI) are being started, your name pops up and you get asked to take part so it all just snowballs. As long as you aren't stupid or lazy and you believe in the work you are doing, the sky is the limit. I've learned that you have to set yourself that goal then just go for it. So, if you want to be Chair of ARTP, President of the Academy, Chair of ERS Assembly 9 or complete a PhD then just do it! I am totally surprised at where I've got to and what I have done! I want younger members to consider that too!

Name some people who have been inspirational and influential in your career

Professors John Gibson, John Stradling and Mike Hughes were real heroes for me. Mike Hughes is just a demi-god, his brain is so sharp. He has a brilliant understanding of medicine and physiology, a really inspirational guy. There were a lot of icons in his era e.g. Pride and Catterall. One huge influence later in my career has been the wonderful and very smart Prof Martin Miller. He was clever, kind, approachable, very hard-working and wonderful with patients.

When I was ARTP Chair, I managed to get Peter Macklem and Joseph Milic-Emili to come and speak at the ARTP *conferences. They were world famous in the respiratory physiology field. I had come across them through different meetings and I wanted the membership to hear them talk about their fascinating part in discovering respiratory physiology and realise that they started off doing the job that we all do. Within the ARTP, there is a list of so many people who have been on the Executive Committee who have been absolutely superb. To mention a few, I would include: Dr Adrian Kendrick and Dr Andy Robson. Andy was fantastic for the research group as he made the poster presenters at conference feel at such ease and they actually enjoyed it. I try to mimic what he did in the poster sessions, but I was never nearly as good as he was because he used to research it much more than I would ever do! I am delighted that UHB's Dr James Stockley has taken on that research mantle. Obviously, Dr Julie Lloyd, as the longest ever member on ARTP Executive Board, has been a brilliant professional colleague from Treasurer to Education Lead and ARTP Chair. She has empowered so many members (especially women) to achieve that ARTP greatness. I can honestly say that without exception everyone who served on Exec Committee in my time as Chair/President have been brilliant to work with - too many to mention!*

Tell us some of the high points of your career

(a) Becoming head of a department for the first time was definitely a high. I was around 33 years old when I took on the role at Nottingham. (b) Getting my doctorate – the first in my family to do so. (c) Becoming a Professor has been both enjoyable and challenging, as it means you have to stay on your game and keep researching and publishing papers. (d) Some of the ARTP conferences, when it became evident it was not just a "flash in the pan" success but you just saw ARTP growing. (e) Every ARTP gala dinner is a highlight. We all get together in that room after all the clever stuff that has gone on the days before we all just shake out and go crazy on that dance floor and we are all part of the same thing, like one big family. I really will miss that in my dotage!

You are President of the AHCS, heavily involved in education and have been at the forefront of trying to get clinical physiologist statutory regulation. We've made some big steps with STP etc. to get more physiologists regulated but we're still not there with it. What are your thoughts on it and what do you see for the future?

It is very frustrating when you see the whole of NHS England, serving a population of 56 million, with lots of hospitals, and the UK Westminster government ploughs the money mainly into England. Then you have Scotland, Wales and Northern Ireland with around four million each and they just don't get the same relative support. They are the same patients, same doctors and same scientists that want to be great at their jobs and the political system doesn't let them do it. It drives me crazy! Northern Ireland is in the worst situation. Scotland is doing a bit better and just needs to get the training programmes sorted out. It's frustrating that it has to be devolved governments, as the other nations could just pull from what has been set up in England. Wales are frustrating as they have a good set up in the government health offices with all the civil servants, ministers and leading scientists all in the same building but they haven't quite nailed the HCS profile fully yet! Having said that, they have done some good stuff with their Practitioner Training Programme at Swansea University.

I think we're close to statutory registration and most people work to regulation standards. Since I have been with the Academy, I have seen it nearly happen three times where we were close to having a "global regulation" for all healthcare practitioners irrespective of what your profession was. Then the government changes and the policy goes to the back of the queue. I do believe it will happen one day.

One thing that really annoys me is that we are all fighting for regulation. The doctors, nurses and allied health professionals have it, but NHS operational managers don't get regulated so they can make grave mistakes then simply move on to another hospital or sideways into the next job. I think that this has to change. They have just as much ability to harm patients as front-line clinical staff but are rarely held to account.

QUICK FIRE QUESTIONS

Favourite food & drink?
Italian food, British beer, French red wine or Scottish single malt whisky!

Celebrity crush?
Joanna Lumley (smart, funny and a great supporter of Nepal)

Favourite film?
Some Like it Hot (the fun Curtis & Lemmon must have had making that film!)

Nicknames?
They are all four letters so I am not prepared to put that in print!

Favourite pastime?
Cars/driving, mountain biking and scuba diving

Karaoke song?
A Peter Cook comedy sketch rather than singing

Favourite holiday destination
The Maldives or Ireland

Favourite memory?
Any family wedding!

Biggest bugbear?
Information Technology drives me crazy!

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FRESH AIR

Edited by **Dr James Stockley**
ARTP Chair of Research and Innovation

Dear Reader,

Welcome back to 'Fresh Air'. These articles are designed to communicate novel trends in research, innovation and clinical practice from both respiratory and sleep sciences. Our aim is to provoke thought and conversation within the ARTP community that we hope will benefit the future direction of physiological practice.

For this issue, we are honoured to present an article from our ARTP Chair, Dr Joanna Shakespeare. Joanna began her career in respiratory & sleep physiology over 30 years ago in Birmingham and progressed to Head of Service in Coventry in 2006. She has expertise in many fields, including NIV and exercise and now works as a Consultant Clinical Scientist, having recently completed her HSST training as a member of the second cohort. Her article on exercise testing relates one element of her final year project, highlighting the need for new reference ranges for hand ergometry.

Ventilatory Efficiency in Arm Ergometry Cardiopulmonary Exercise Testing

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Introduction

Cardiopulmonary exercise testing (CPET) investigates response to the metabolic stress of exercise for the purpose of assessing the ability of the cardiorespiratory system to accommodate the increasing respiratory demands of contracting muscles. This requires graded exercise with increasing muscular exertion that transitions cell metabolism from aerobic to anaerobic, whilst measuring the associated increase in oxygen uptake and carbon dioxide output. The prerequisite for effective testing is the ability of the subject to perform sufficient exercise to generate metabolic stress in a controlled setting. Arm ergometry exercise is an alternative exercise mode to standard cycle ergometry or treadmill testing. As it is performed in the seated position, it is a useful form of exercise for those unable to use standard exercise modalities, such as those with limited lower limb function. It is a recognised tool for the evaluation of fitness and the prescription of exercise in subjects with spinal cord injury or with lower limb amputation[1,2].

The absolute physiological values of peak oxygen uptake ($\dot{V}O_2$) and anaerobic threshold (AT) measured using the arms have been demonstrated in previous studies to be lower than those obtained using the legs[3,4]. Reasons for this include the larger muscle mass of the legs[5,6] and the mechanical differences of cycle and arm ergometers[7]. Studies have also demonstrated that peak heart rate is significantly greater when leg cycling than arm cycling, which is explained by the greater muscle mass in the lower limbs stressing the cardiovascular system more than the upper limb musculature[7-13]. However, as the upper extremities extract less oxygen than the lower extremities, a greater oxygen delivery is required for a given oxygen demand, resulting in a greater cardiovascular strain when exercising with the arms[14].

There is limited evidence in the literature to explain how other commonly determined CPET variables differ when measured using arm ergometry. The ventilatory slope or $\dot{V}E/\dot{V}CO_2$ slope is a key metric in CPET, assessing ventilatory efficiency by the following equation:

$\dot{V}E/\dot{V}CO_2 = 863/PaCO_2 * (1/Vd/Vt)$

Where $\dot{V}E$ = minute ventilation, $\dot{V}CO_2$ = carbon dioxide output, $PaCO_2$ = arterial carbon dioxide and Vd/Vt = dead space (Vd) to tidal volume (Vt) ratio.

In healthy individuals, the $\dot{V}E/\dot{V}CO_2$ slope is linear with a proportional increase in $\dot{V}E$ as $\dot{V}CO_2$ increases, with a value of <30 considered normal, although this will increase slightly with age. The $\dot{V}E/\dot{V}CO_2$ slope has become widely adopted in the assessment and prognostication of cardiovascular impairments such as heart failure and pulmonary vascular disease. Elevated slopes (>45) are found in those with pulmonary hypertension (PAH) and in chronic thromboembolic pulmonary hypertension (CTEPH) (Figure 1) and have been found to predict poor exercise tolerance and a higher mortality risk.

Physiological differences in arm versus leg ergometry have the potential to influence the $\dot{V}E/\dot{V}CO_2$ slope. Arm exercise recruits smaller muscle groups and tends to be less efficient, leading to a greater ventilatory demand for a given level of CO_2 production. The lower AT demonstrates an earlier reliance on anaerobic metabolism, which leads to a compensatory increase in ventilation, resulting in a higher ventilatory drive. In addition, the decreased cardiac output has the potential to decrease the efficiency of CO_2 clearance.

This study aimed to compare the $\dot{V}E/\dot{V}CO_2$ slopes obtained by both arm ergometry (AE) and cycle ergometry (CE). It also assessed the components of ventilation to identify which may be contributing to any measured differences in the $\dot{V}E/\dot{V}CO_2$ slope.

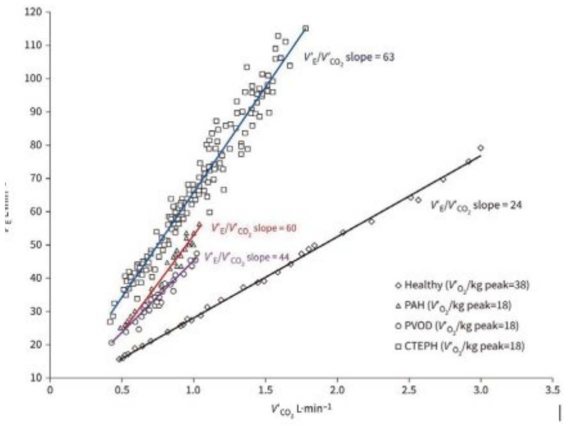

Figure 1: Illustration of the increase in $\dot{V}E/\dot{V}CO_2$ slope with increasing severity of pulmonary vascular disease[15].

PAH = pulmonary hypertension, PVOD = pulmonary veno-occlusive disease, and CTEPH = chronic thromboembolic pulmonary hypertension.

Methods

Participant recruitment

Participants were members of staff within our organisation, identified through advertisements including weekly electronic communications, intranet posts and all-user emails. Participants were required to be of working age (18-69 years), free from any known cardiac or respiratory impairment and not taking any prescribed medication likely to affect exercise performance.

Participants

Prior to participation, individuals were assessed for any potential health risks associated with exercise by completing the PAR-Q & You questionnaire. Following successful health screening, volunteers were assessed for respiratory or cardiovascular impairment by undertaking baseline spirometry, 12-lead ECG and blood pressure measurements prior to recruitment. All participants provided written informed consent prior to participating in the study. Ethical approval was granted by the Health Research Authority, Wales REC 7 (REC Reference 17/WA/0284; IRAS Project ID 226248).

Incremental exercise

All participants undertook maximal cardiopulmonary exercise testing to volitional exhaustion using each of arm and cycle ergometry in a randomised testing order, with a

FRESH AIR

rest interval of at least 24 hours. Incremental ramp protocols using the equations of Cooper and Storer[16] were calculated for each subject individually. All subjects undertook a rest phase of at least two minutes to allow the individual to become acclimatised to the equipment and ensure accurate equipment function. This was followed by a three-minute unloaded phase. A cadence of 60 rpm ± 5% was used throughout. On completion of the unloaded phase, the calculated exercise protocol commenced immediately. The subject was actively encouraged to exercise to their symptom-limited end point i.e., intolerable arm/leg fatigue or breathlessness.

Measurements of gas exchange were analysed using the breath-by-breath analysis system Ultima CPX (Medical Graphics, UK) with an averaging method of five of seven breaths. Heart rate was continually monitored using a 12-lead Mortara ECG system (Mortara, model X12+, Milwaukee, WI, USA). Maximal heart rate was defined as the highest value recorded during the test[17]. A plateau in $\dot{V}O_2$, peak ventilation >85% predicted, peak heart rate >85% predicted or peak work rate >85% were all accepted criteria for the achievement of maximal effort. The $\dot{V}E/\dot{V}CO_2$ slope was calculated, using linear regression, from the start of exercise up to the respiratory compensation point.

Statistical analyses were performed using a paired t-test to compare differences between modalities, while Pearson's correlation coefficient was used to assess relationships between variables. A significance level of $p < 0.05$ was considered statistically significant. Statistical analysis was performed using IBM SPSS Statistics 27.0.1.0 statistical software (IBM Corporation).

Results

A total of 116 (62 female) healthy volunteers were recruited. No participants were active smokers, but 14/116 (12%) had a smoking history with 2/14 (14%) reporting exposure >15 pack years. All participants had normal spirometry (FEV_1/FVC ratio, FEV_1 and FVC all within ±1.645 SR). Relevant characteristics and distributions of study participants are shown in Table 1.

Table 1: Subject characteristics

n=116	Mean (SD)
Age (years)	38 (11)
Height (m)	1.73 (0.10)
Weight (kg)	76.09 (14.95)
BMI (kg/m^2)	25.27 (4.02)
Smoking History (pack years)	1.03 (3.52)
FEV_1 (L)	3.71 (0.89)
FEV_1 (SR)	0.03 (0.83)
FVC (L)	4.62 (1.14)
FVC (SR)	0.14 (0.78)
FEV_1/FVC (%)	80.67 (6.68)
FEV_1/FVC (SR)	-0.16 (0.93)

Results of cycle ergometry CPET for the group were normal. Peak $\dot{V}O_2$ achieved during cycle ergometry was 107% (30.77) predicted. AT occurred at 60% (24.37) predicted $\dot{V}O_2$ and 56% (11.52) of achieved peak $\dot{V}O_2$. Peak heart rate was 87% (8.74) predicted with a peak ventilation of 75% (22.33) predicted, based on FEV_1 x 35. The peak work rate was 118% (38.25) predicted.

Despite a significant correlation (r=0.554; p<0.001), the $\dot{V}E/\dot{V}CO_2$ slope obtained via arm ergometry was significantly higher than that achieved during leg cycling (p<0.001). The arm ergometry $\dot{V}E/\dot{V}CO_2$ slope was >30 in 84/116 (72%) of healthy volunteers.

As $\dot{V}E$ is the product of Vt and breathing frequency (BF), these parameters were assessed to identify possible physiological causes for the difference in slopes (Table 2).

All ventilatory parameters were significantly greater during leg cycling compared to arm cycling with the exception of resting breathing frequency, which was not significantly different.

Discussion

This study has demonstrated that the $\dot{V}E/\dot{V}CO_2$ slope measured during arm ergometry is significantly greater than that measured when exercising with the legs. 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 CO_2 output when exercising with the arms.

Table 2: Ventilatory parameter data obtained from arm ergometry and cycle ergometry exercise testing.

	Arm Ergometry (SD)	Cycle Ergometry (SD)	Mean Difference (arm - cycle)	Z score
$\dot{V}E/\dot{V}CO_2$ 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
$\dot{V}CO_2$ 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.

During exercise, $\dot{V}E$ increases in direct proportion to $\dot{V}CO_2$ (i.e. the metabolic demand). Initial increases in $\dot{V}E$ are achieved by predominantly increasing Vt, followed by larger increases in breathing frequency. Several physiological adjustments enable the increase in Vt including, increased inspiratory muscle activity, a reduction in end expiratory lung volume (EELV), increased lung compliance, increased neural drive and recruitment of expiratory muscles.

Studies have demonstrated that the mean decrease in EELV from rest to peak exercise is significantly lower during arm exercise than leg exercise. It has been suggested that this reflects the lower relative peak workloads achieved during arm exercise. However, when changes in EELV were compared at equivalent ventilations in a healthy population, the change in EELV for arm exercise remained significantly lower[18].

This smaller reduction in EELV may relate to the smaller Vt increases seen in arm ergometry exercise, negating the need to decrease EELV further[19]. Arm ergometry exercise requires the thoracic musculature to assume non-respiratory functions during exercise. These functions, which include stiffening the spine, maintaining torso stabilisation and maintaining arm position, have the potential to alter and limit the ability to increase Vt. As the expiratory muscles (e.g. abdominal muscles) are mainly responsible for the control of EELV when upright on a cycle ergometer[20], their use in torso stabilisation makes them less able to contribute to decreasing EELV.

The influence of arm position on Vt could also explain the significantly smaller values seen in our subject group at rest. Previous studies have suggested that Vt increases when arms are in the elevated position. However, arm positioning was directly in front, and Vt was indirectly calculated in this study[19]. As well as positional differences, subjects in our study will have been influenced by the additional static exercise component created by gripping the arm crank[7].

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 are associated with a decrease in peak tidal volume and breathing frequency and a lower CO_2 output, altering the relationship between $\dot{V}E/\dot{V}CO_2$. Consequently, accepted normal ranges for $\dot{V}E/\dot{V}CO_2$ leg exercise cannot be applied when exercising with the arms, for which further work is required to identify new normal ranges.

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The Effect of Anabolic Steroids on Cardio-respiratory Fitness of Male Bodybuilders: What Does Cardiopulmonary Exercise Testing Tell Us?

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Introduction

Regular exercise is one of the fundamentals of a healthy lifestyle. Many of the health and wellness benefits are based on the improvement in cardiorespiratory fitness (CRF)[1]. Cardiopulmonary exercise testing (CPET) is believed to be the gold standard for the quantitative assessment of cardio-respiratory fitness (CRF)[2]. A standard CPET requires the subject to undergo an incremental exercise challenge until exhaustion on a treadmill or cycle ergometer[3]. During the test, multiple parameters are recorded breath-by-breath, beat-by-beat, and are expressed as numbers and graph plots displayed in real time[2]. The primary outcome of CPET is the maximum oxygen consumption (VO_2max) along with various secondary cardiac, pulmonary, and metabolic parameters[4].

VO_2max is defined as the highest rate of oxygen uptake and utilisation by the body at maximal exercise using large muscle groups[5]. It represents the highest integrated functional capacity of the pulmonary, cardiovascular, and muscular systems to uptake, transport, and utilise oxygen during sustained exercise, respectively[6]. Numerous factors are known to affect VO_2max. These include genetics, age, gender, body composition and the type and mode of exercise practiced[7].

Bodybuilding is a high-performance sport that predominantly involves progressive strength and resistance exercise training, aiming to develop hypertrophy of muscle groups[8]. Some bodybuilders train to participate in competitions, others work out for an aesthetically looking physique, while others train primarily for health benefits[9].

The use of food supplements is fairly common among bodybuilders for enhanced muscle growth. Some bodybuilders resort to the use of anabolic steroids (AS) with an intention of achieving their desired results in a short span of time. This is at the cost of known deleterious effects on multiple body systems[10].

The illicit use of AS has been frequently reported in Europe and Australia[11]. There are thought to be over 3 million users in the United States, the majority being recreational male bodybuilders aged between 20-40 years[12]. The data regarding AS abuse in a developing country like Pakistan are scarce.

Despite the apparent benefit of muscle gain, AS have a negative impact on multiple body systems[13]. AS doping in sports like bodybuilding is irrefutably widespread across the world. However, there are limited experimental data evaluating the effect of AS on cardiorespiratory and metabolic functions of the body.

Study aims

- To determine the baseline cardio-respiratory fitness (VO_2max) in bodybuilders using anabolic steroids compared to non-users and non-bodybuilders.
- To compare various CPET parameters in bodybuilders using AS, non-users, and non-bodybuilders to explore the effects of AS on exercise physiology.

Methods

After ethical approvals from the Institute and the University of Health Sciences, this cross-sectional comparative study was conducted at the Physiology Research Lab, Postgraduate Medical Institute, Lahore, Pakistan from January 2019 until June 2021. The participants were recruited using non-probability convenience and snowball sampling. The sample size of five per group was calculated using the WHO calculator v12.2.6. For better statistical analysis, sample size was increased to ten per group (recommended by university advanced review board). The study population consisted of healthy male subjects in the age range of 20-35 years divided into three groups. Non-bodybuilders: those who have not carried out any resistance or endurance exercises for at least 2 years and have never used AS. Bodybuilders non-users of AS: carrying out resistance and endurance exercises for ≥ 5 hours a week for the past 6 months to 2 years. Bodybuilders training for less than 6 months and over 2 years were excluded. Bodybuilder AS-users (n=10) carrying out resistance and endurance exercises for ≥ 5 hours a week for the past 6 months to 2 years and have used anabolic steroids via any route (oral/IV/IM) in the past 6 months. Participants with a history of smoking, cardiovascular, metabolic, neurological, pulmonary or orthopaedic disorders were excluded. All participants passed the Physical Activity Readiness Questionnaire (PAR-Q+)[14] to be included as eligible for exercise testing.

Data Collection

Recruitment and Preparation

All participants were contacted initially via video phone call (contact session 1) and briefed about the study, confirming their verbal consent for a mutually agreed appointment date and time for the testing (contact session 2). The pre-requisites for testing were conveyed at the time of booking that included avoiding ingestion of heavy meal, tea or coffee on the test day and wearing loose clothing with jogging shoes.

Equipment

Track master 2500 Treadmill (3.0 horsepower) was used as the exercise equipment. CPET equipment consisted of Cortex Biomedical (Germany) with Cortex Metalyzer® 3B-R Gas analyzer (MetaSoft® Studio v1) and accessories. Borg Rating of Perceived Exertion (RPE)[15] scale was used to assess level of exhaustion. The equipment was placed in a well-ventilated room and calibrated for both flow and gas composition at the start of each test.

Testing Session Protocol

Demographic data was input into the CPET software with measurements of weight, height and BMI. The modified Bruce protocol, a staged protocol, was selected as the testing exercise protocol[16]. The participant completed a warmup phase at a speed of 1.5 kmph at 0° incline for two minutes to get comfortable with the testing equipment and range of movement. Starting with the Modified Bruce Protocol, the participant underwent a graded exercise test on a treadmill in which the grade of exercise (speed and incline) was increased incrementally after every three minutes until exhaustion followed by a recovery phase for two minutes back at 1.5 kph at 0°. Breath-by-breath gas analysis measured various respiratory parameters including VO_2, VCO_2, RER, VT, V'E and BF which were displayed continuously on the screen during the entire exercise test. Borg score was recorded by showing the participant the RPE scale at each incremental workload stage.

Data was analysed using IBM SPSS Version 21. Normally distributed quantitative variables were presented as Mean ± SD. Paired t-tests were applied to analyse the differences of means between pre and post-exercise quantitative variables. One-way ANOVA was used with post hoc Tukey test for comparison among the study groups. p value < 0.05 was considered statistically significant.

Results

A total of 30 male adults participated in the study (ten per group). Participant characteristics are shown in Table 1. The mean difference of weight and BMI between the three study groups was found to be statistically significant ($p = 0.032$, $p = 0.014$ respectively) when assessed with a one-way ANOVA test as shown in Table 1.

Table 2 shows the recorded CPET variables across the three groups. The mean VO_2max value of the participants in non-BB, BB non-users and BB AS-users was 35.4±4.8 ml/min/kg, 43.4±4.2 ml/min/kg and 38.0±3.1 ml/min/kg respectively. When tested with One-way ANOVA, the results showed a statistically significant

Table 1: Comparison of general characteristics of study groups. Variables assessed by applying one-way ANOVA.

Variable	Non-BB (n=10) Mean ± S.D	BB non-users (n=10) Mean ± S.D	BB AS-users (n=10) Mean ± S.D	p-value
Age (years)	24.8 ± 4.0	25.6 ± 2.9	26.8 ± 3.3	0.457
Height (cm)	172.2 ± 4.3	175.7 ± 8.4	173.9 ± 5.4	0.469
Weight (kg)	68.7 ± 13.3	74.5 ± 11.8	83.0 ± 9.0	0.032*
BMI	23.1 ± 4.0	24.0 ± 2.9	27.4 ± 2.6	0.014*

*p value statistically significant.

(p = 0.001) difference between the study groups (Table 2 and Figure 1). When analysed with Post hoc Tukey test (Table 3), the VO_2max of participants in Non-BB differed significantly (p < 0.001) from the participants in BB non-users. A statistically significant difference (p = 0.016) was seen between BB non-users and BB AS-users.

At peak exercise, the maximum carbon dioxide output recorded in non-BB was 2.7 ± 0.9 L/min, in BB non-users this was 3.9 ± 0.5 L/min and in BB AS-users was 3.7 ± 0.5 L/min. VCO_2 max compared between the groups was found to be statistically significant (p = 0.001) (Table 2 and Figure 1). Comparison with Post hoc Tukey test, a statistically significant difference in mean VCO_2 max when non-BB were compared with BB non-users (p = 0.002) and BB AS-users (p = 0.005). However, there was a non-significant (p = 0.902) difference in mean VCO_2 max levels between BB non-users and BB AS-users (Table 3).

Mean minute ventilation at maximal exertion (V'E max) increased to 98.6 ± 38.2 L/min in non-BB, 121.6 ± 18.2 L/min in BB non-users and 109 ± 15.3 L/min in BB AS-users. However, a non-significant (p = 0.103) difference was found between the three study groups (Table 2).

Discussion

To the best of our knowledge, this is the first study in Pakistan that determined the cardiorespiratory fitness (VO_2max) using CPET in young male BB AS-users, non-users and non-BB. The results of the present study showed that BB non-users achieved higher VO_2max values as compared to the AS users. Non-BB reached the lowest VO_2max values. Globally, other studies that investigated VO_2max in the adult population have shown comparable results[17].

A study was conducted in Brazil[18] to investigate the cardiopulmonary effects of anabolic steroid use in adults. Twenty-four age-matched (29±3.4 years) physically active men divided into two equal groups (AS users and non-users) were assessed during and after a maximal treadmill exercise test. The findings of the study

Table 2: Comparison of Oxygen uptake, Carbon dioxide output, respiratory exchange ratio and minute ventilation among the study groups.

Variable	Non-BB (n=10)	BB non-users (n=10)	BB AS-users (n=10)	p-value
VO_2 Rest (ml/min/kg)	6.9 ± 1.1	6.8 ± 1.6	6.1 ± 0.9	0.306
VO_2max (ml/min/kg)	35.4 ± 4.8	43.4 ± 4.2	38.0 ± 3.1	0.001*
VCO_2 Rest (L/min)	0.54 ± 0.1	0.54 ± 0.1	0.52 ± 0.1	0.932
VCO_2 max (L/min)	2.7 ± 0.9	3.9 ± 0.5	3.7 ± 0.5	0.001*
RER Rest	0.9 ± 0.1	0.8 ± 0.1	0.83 ± 0.1	0.148
RER Max	1.2 ± 0.1	1.1 ± 0.1	1.1± 0.1	0.097
Minute Ventilation Rest (L/min)	14.9 ± 3.5	16.6 ± 4.4	15.4 ± 2.7	0.555
Minute Ventilation Max (L/min)	98.6 ± 38.2	121.6 ± 18.2	109 ± 15.3	0.103

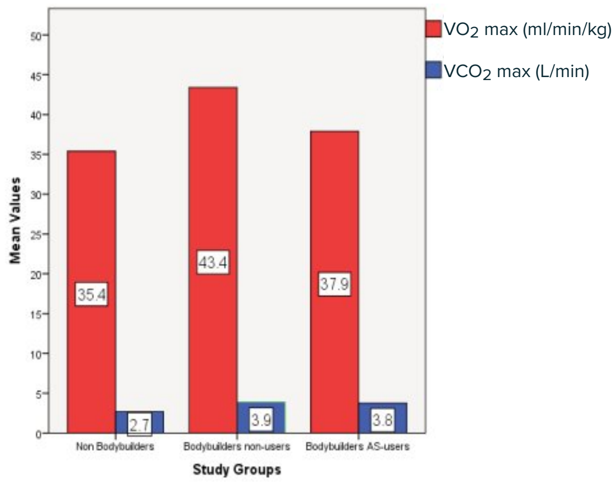

Figure 1: Graphical representation of VO_2max and VCO_2max among the study groups.

VO_2 max: volume oxygen maximum, VCO_2max: volume carbon dioxide maximum, AS: anabolic steroids

Table 3: Comparison of VO_2max and VCO_2max within the study groups using Post hoc Tukey test

Variable	Groups (I) (Mean ± S.D)	Groups (J) (Mean ± S.D)	Mean Difference (I-J)	Std. Error	p-value
VO_2max (ml/min/kg)	Non-BB (35.4 ± 4.8)	BB non-users (43.4 ± 4.2)	-8.00	1.8	<0.001*
		BB AS-users (38.0 ± 3.1)	-2.50	1.8	0.375
	BB non-users (43.4 ± 4.2)	BB AS-users (38.0 ± 3.1)	5.50	1.8	0.016*
VCO_2max (L/min)	Non-BB (2.7 ± 0.9)	BB non-users (3.9 ± 0.5)	-1.20	0.3	0.002*
		BB AS-users (3.7 ± 0.5)	-1.07	0.3	0.005*
	BB non-users (3.9 ± 0.5)	BB AS-users (3.7 ± 0.5)	0.13	0.3	0.902

n = 10 participants in each group, *p value statistically significant suggested that non-users of AS showed a significantly higher VO_2max when compared to the AS using group (63.7±9.3 ml/min/kg vs 49.7±4.7 ml/min/kg, $p = 0.001$) respectively. The probable explanations for these results may be that anabolic steroids cause alteration in the haemodynamic response to exercise. Studies demonstrate the administration of AS in supraphysiological doses causes dysfunction of cardiac autonomic regulation[19], affects endothelial homeostasis, leads to enhanced norepinephrine-induced vasoconstriction and decreases systemic arterial compliance thus potentially limiting or reducing maximum oxygen consumption[20].

An additional observation noted in the present study was a mean difference (although non-significant) of weight between the BB non-users and BB AS-users. It may be fair to say that AS use tends to increase body mass but it's not always functional muscle. However, it can be acknowledged that this difference in weight may cause some of the difference in VO_2max as we have reported the VO_2max relative to body weight.

Unlike our observations, studies undertaken by Urhausen[21] and Yeater[22] did not find a significant difference in VO_2max between groups of AS users and non-users. The earlier studies monitored the use of a wide variety of anabolic steroids taken via oral and intramuscular injections and followed by a graded exercise test for VO_2max assessment on a cycle ergometer. Methodological differences could be a reason for the discrepancies between the results of these studies and the present study given that exercising on a treadmill uses larger muscle groups than exercising on a cycle ergometer hence yielding a larger VO_2max in subjects. Also, in the present study, the type, dose and intake route of AS intake was not monitored which could potentially cause a difference in outcome.

Previous international studies have highlighted the importance of physical training leading to an improvement in the VO_2max[23]. The present study supports the point that exercise training leads to an increase in VO_2max as a significant difference of VO_2max was found between the trained (bodybuilders) and the untrained (non-bodybuilders) with trained subjects having a greater VO_2max (43.4 ml/min/kg) as compared to the untrained (35.4 ml/min/kg). In a similar study, Gim *et al*[24] reported a significantly higher VO_2max in trained healthy male adults (37.4 ml/min/kg) as compared to the untrained group (28.9 ml/min/kg). This marked difference in VO_2max is attributed to the fact that bodybuilders undergo concurrent strength and endurance training that causes an increase in muscle mass along with cardiovascular, respiratory and muscular metabolic adaptations that successfully result in a significant improvement in oxygen uptake.

Interestingly, the results of the present study showed a lower VO_2max in untrained and trained individuals when compared with large age-matched international studies. Aspenes *et al*[25] conducted VO_2max testing on a total of 2,368 healthy Norwegian men of various age groups and physical activity status. In the age range of 20-29 years, they reported values of 42 ml/min/kg in inactive healthy men and 56 ml/min/kg in active men. The VO_2max values found to be closest to the present study's results were from two separate studies done in India. Kathayat and Kumar[26] reported mean VO_2max of 42.5 ml/min/kg in trained individuals, while Varghesse *et al*[27] reported VO_2max of 38.4 ml/min/kg in healthy untrained. The probable explanations for these lower VO_2max values in our set of participants may be due to a lack of targeted nutrition and physical training that boosts VO_2max. There is also a probability that a difference in genetic makeup and environmental factors could be the reason or the reference values for VO_2max in our part of the world are altogether different – an area that needs to be explored further.

In summary, this study is unique in Pakistan in terms of the population chosen as well as the equipment used. The results of the present study reinforce the idea that physical exercise (bodybuilding) enhances cardiorespiratory fitness and muscle metabolic capacity as shown by VO_2max values. However, the use of AS did not lead to significant improvement in cardiorespiratory fitness as shown by change in VO_2max.

Limitations

The exact types, composition and doses of anabolic steroids taken by the bodybuilders were not known since the steroids were bought illegally and were given to them by their trainers. Our study participants verbally confirmed that they were AS users. Due to financial constraints, we were unable to test plasma or urine drug levels. We could not induct a separate group of females due to limited resources, cultural barriers as well as difficulty in finding female bodybuilders in Pakistan.

Conclusion

Bodybuilders in Pakistan achieve a higher VO_2max as compared to non-bodybuilders. Amongst the bodybuilders, AS users showed a significantly lower VO_2max than non-users. Despite apparent gain in muscle mass, anabolic steroid use is not associated with a significant improvement in cardiorespiratory fitness, and may negatively affect CRF.

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Fizzyo
A Cystic Fibrosis analysis and treatment initiative from UCL Institute of Child Health

Project Fizzyo

Providing insights into Airway Clearance Techniques for Cystic Fibrosis

Emma Raywood (centre) after passing her PhD viva in June 2024, pictured with PhD supervisors: Associate Professor Harriet Shannon (left) and Professor Eleanor Main (right)

I'm Emma Raywood, Respiratory Physiologist and ARTP member since 2012. My PhD in digital health was part of Project Fizzyo and my PhD was funded by the UCL Rosetrees Stoneygate prize. At the start of the project in December 2019 I shared an update in INSPIRE[1]. Thank you to Paul for the invite to provide a further update. I'll summarise the background of the study, as well as some of the published results and gaming data which were most recently presented at the North American CF Conference, 2024 (Boston, USA)[2,3]. It is not possible to cover all of the project aims in this article, so there is more information available at tinyurl.com/ProjectFizzyo.

The project was led by Professor Eleanor Main at the UCL Institute of Child Health. It aimed to provide insights into daily Airway Clearance Techniques (ACTs) and physical activity by children and young people with cystic fibrosis (CYPwCF) aged 6 to 16 years using novel remote monitoring. It also developed ACT-driven games in collaboration with Microsoft, UCL computer science and Abertay University. Breath-by-breath ACT data from 145 children and young people from three CF centres in London was captured over 16 months. In total over **50,000 ACT treatments** containing over **5 million breaths** were recorded.

What are airway clearance techniques?

Current CF care guidelines recommend daily physiotherapy ACTs to facilitate the removal of mucus from the airways for all people diagnosed with CF[4]. ACTs, though considered important by people with CF and their clinical teams, are also reported to be one of the most burdensome treatments and the most likely to be skipped[5].

The latest UK CF registry report (2023)[6] states that 80% of CYPwCF aged <18y and 47% of adults with CF used positive expiratory pressure (PEP) and/or oscillatory PEP (OPEP) devices as their primary or secondary ACT. Therefore, Project Fizzyo focused on these devices/techniques in CYPwCF. PEP is proposed to enhance mucus clearance by physiological mechanisms, including collateral ventilation, improving the effectiveness of subsequent forced expiratory techniques (e.g. huff, cough). A PEP is achieved by breathing multiple times through a device which provides expiratory resistance and sometimes oscillation. There is not a commercially available electronic PEP device which includes a sensor that allows breaths to be recorded or visualised by users or clinical teams. For Project Fizzyo a specialist team developed piezoelectric pressure sensors which were able to be attached to four commonly used PEP and OPEP devices; one is shown in Figure 1.

The bespoke sensors were battery powered and wireless (using Bluetooth to sync data). The sensor had two roles – first to record ACT data and second to work as a breath-controlled joystick for gaming control. A data cleaning and processing pipeline for raw pressure-time data was also developed. The data provided unique insights – for the first time the quantity and quality of every breath of routine daily treatments were captured.

Figure 1 : Fizzyo sensor attached to an Acapella OPEP being used to play a game (left) and as a labelled diagram (right). The sensor can also be attached to other common devices (not shown).

ACT *Quantity* was easy to measure – how many breaths per treatment and how many treatments per day. This was compared to personalised prescriptions (adherence). Though adherence to treatment frequency varied between individuals, generally the recorded treatments contained the number of breaths prescribed[7].

ACT *Quality* was harder to measure. Common advice for performing daily PEP and OPEP is that: "*Breathing through the device should be at tidal volume with only slightly active expiration (not prolonged or forced)... at a stable mid-expiratory pressure of 10-20 cmH$_2$O*"[4] . These criteria were used to define 'conformant treatments'. When an ACT treatment had breaths which on average met these criteria, it was considered to have been performed in accordance with guidelines.

Figure 2 shows single breath examples from different patients using different ACT devices. Before the study it was expected that breath profiles should be comparable to breath example D - the breath has a sustained mid expiratory pressure around 20 cmH$_2$O. However most treatments had different breath profiles, which was not what we expected! Sometimes the differences were due to the specific PEP device used, and other times participants had their own signature breath profiles.

Treatment characteristics including the expiratory length and mid-expiratory pressure of breaths and treatments were analysed. The proportion which were considered to meet recommendations (conformant) and those which did not (non-conformant) was identified. This is described in more detail in the ERJ by Filipow *et al*[8]. Of over 45,000 treatments recorded, only 21% (9,359) were considered conformant – the majority of recorded treatments did not meet recommendations (Figure 3 left). There were differences by the ACT type, with a higher proportion of conformant PEP treatments than OPEP treatments. OPEP treatments most often contained short sharp breaths (comparable to A and B in Figure 2) that were not sustained. However conformant treatments were recorded on all device types.

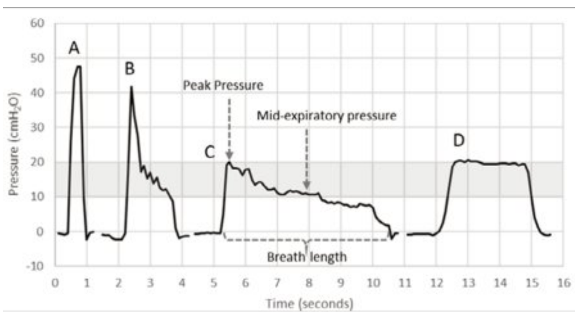


Figure 2 : Schematic of common breath profiles recorded during the study. Modified from Fig 2 Raywood et al. 2023

Did doing ACTs as recommended matter?

An analysis which accounted for factors such as if the participant was on CFTR modulators, their age, CF centre, and the number of IV antibiotic courses in the past twelve months was carried out. It identified that there was no association between doing more ACTs and FEV$_1$ % predicted[8] (Figure 3 right).

However, using the same analysis but when the treatments were classified as conformant or not conformant the quantity of treatment became important. The more conformant ACT

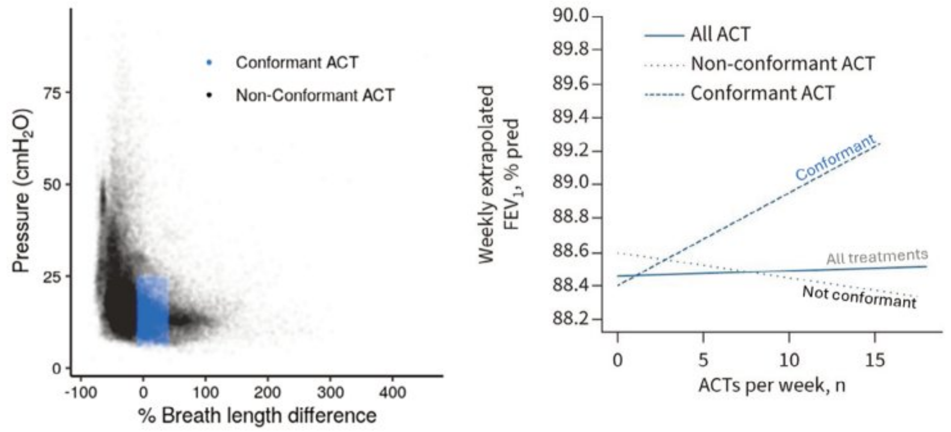


Figure 3: Scatter plot (left) or treatment quality features (mid-expiratory pressure vs expired breath length as a percentage of a personalised age related threshold). Treatments in blue meet recommendations (conformant). Regression plot (right) of weekly extrapolated FEV_1 %pred vs number of ACTs per week. Modified from Filipow et al. 2023

treatments performed per week, the higher the weekly increase in FEV_1 % predicted (Figure 3, right). It's not only important if people do their treatments, it matters if they do them correctly.

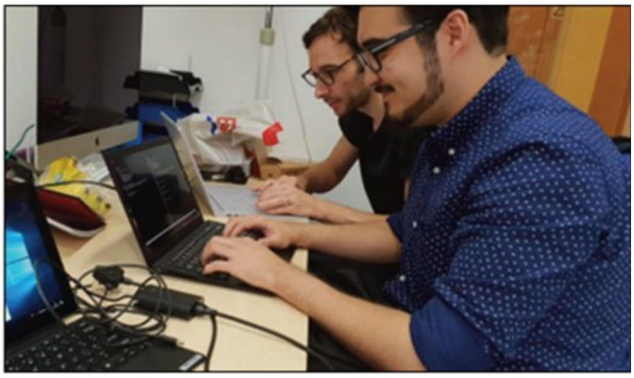
What was the impact of gaming on ACTs?

Gaming presents an opportunity to modify ACTs and improve performance and enjoyment. As a first step we wanted to see whether we could change ACT techniques. If so, there is an opportunity to modify existing devices to provide breath-activated feedback. In 2017 a team of experts from Microsoft and UCL held hackathons with computer science students.

At the Hackathons the students and game designers were blowing hard and fast into the ACT devices. Discouraging short peak flow-type blows and encouraging a sustained but not maximal effort (as recommended) was the focus of the gaming framework that was developed. Nothing was done to try to prevent breaths from being too long (spoiler - this did not turn out to be ideal!).

In total over twenty games were designed, and five were taken forward to be released to participants. Though the framework was consistent there were a variety of different mechanics chosen to improve the potential acceptability to a wider range of patients.

Data were analysed from participants with at least 20 treatments with games (about 2,000 breaths). Each participant's data were compared with their own data and assessed by ACT device category, using the criteria to define a conformant or not conformant treatment. For the OPEP devices, without gaming 19% of treatments were conformant, whereas with gaming 42% were as recommended. In general, there were fewer treatments with "too short" breaths when using gaming. Conversely for the PEP devices, without gaming, 46% of treatments were conformant, whereas with gaming 32%



Game development at a Hackathon and by study collaborators from Microsoft, UCL and Abertay University

Examples of ACT driven games developed by Project Fizzyo

were as recommended. In general, there were more treatments with "too long" breaths. For the PEP devices, treatments had longer expiratory lengths without gaming in the first place; while those treatments that had breaths which were too short became longer, PEP breaths that were previously conformant were now too long.

Changes to techniques were possible with gaming but not always beneficial. The same games had the same effect (breath lengthening) but different outcomes (conformance vs non-conformance), which appeared to be related to baseline breath profiles and device type. Game designs must be carefully considered and compatible with the optimal technique or they have the potential to make treatments less effective. Giving patients and clinicians appropriate tools to monitor and train techniques could be an important future application of ACT-driven gaming.

In summary

My PhD was part of Project Fizzyo. The project provided an insight into how children and young people with cystic fibrosis (CYPwCF) do routine daily ACTs. Five million ACT treatment breaths were captured improving understanding of treatment quantity and quality and the impact of gaming. Quality of ACT treatment is important to understand clinical benefits. A relatively simple sensor provided novel insights into what CYPwCF are doing each day to better guide quality treatments – just 21% of the treatments recorded met guidelines. People with CF do these treatments every day but we and they have been blind to what they are actually achieving.

Prof Main, project data scientists Nicole Filipow and Gizem Tanriver, and Emma Raywood returning to the office in late 2020

Breath-controlled games can be developed for use with ACTs and they can change people's treatment patterns; however, this may not always be beneficial. Future game designs and mechanics should consider the specific impact of gaming on breath profiles in relation to the desired improvement to technique.

Acknowledgements: Thank you to the children and young people with CF and their families who contributed to the design of the study and shared these precious data with us. Thank you to the remarkable team of over 100 people who worked on the project, led by Professor Eleanor Main.

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Supporting International Recruitment in Respiratory and Sleep Physiology: An ARTP Mission to Portugal

Matthew Rutter
ARTP Vice Chair
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Addenbrooke's Hospital

In a collaborative effort to address staffing shortages in respiratory and sleep physiology services in England, particularly in the community diagnostic centres (CDC), NHS England invited key representatives from the Association of Respiratory Technology and Physiology (ARTP) to assist in an international recruitment drive aimed at attracting trained and skilled respiratory and sleep physiologists from Portugal. Wye Valley Trust Sleep service lead, Shirley Coelho, and ARTP Vice Chair Matt Rutter were asked to take part in this important collaboration, with the aim of sharing insights about the profession, the UK healthcare system, and the opportunities available for international recruits.

ARTP and its Commitment to Respiratory Care

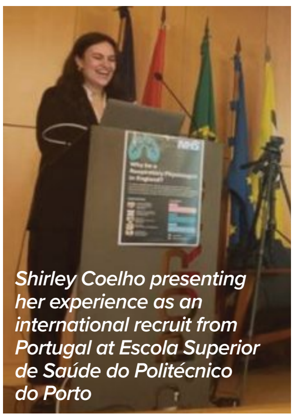
ARTP has played a pivotal role in setting high standards for the respiratory and sleep physiology profession. It provides educational resources, professional development, and support to ensure that respiratory and sleep physiologists have the knowledge and skills necessary to deliver high-quality patient care.

The ARTP has also been heavily involved in the development of training, education and recognised qualifications to support the development of physiologists and graduate scientists within the UK.

As the demand for respiratory professionals in the UK increases, especially within the NHS, ARTP's involvement to support international recruitment efforts has become essential. ARTP is working closely with NHS England to attract talented professionals from around the world, ensuring that the NHS has the workforce needed to provide excellent respiratory and sleep care.

A Call to Portugal: ARTP Representatives on the Ground

To strengthen international recruitment, NHS England, represented by Nathan Hall (deputy director of the NHS England diagnostics programme), Amy Taylor Gonzalez (Physiological Science Transformation Implementation Lead at NHS England) and Elizabeth Taggart (NHS England national cancer and diagnostics programme Project Coordinator), invited Shirley Coelho and Matt Rutter to travel to Portugal for a recruitment campaign. The team visited three universities in Portugal that offer a clinical physiology-focused degree programme: Escola Superior de Saúde do Politécnico do Porto, Politécnico de Lisboa, and Instituto Politécnico de Coimbra. Each stop was aimed at engaging students and graduates in the field of respiratory and sleep physiology, informing them of the opportunities to work in England, and addressing any questions they had about the recruitment process.



Shirley Coelho presenting her experience as an international recruit from Portugal at Escola Superior de Saúde do Politécnico do Porto

Shirley Coelho: A Personal Account of Being an International Recruit

Shirley Coelho, Sleep Service Lead at Wye Valley Trust and originally from Viana do Castelo, Portugal, brought a personal perspective to the recruitment effort. Having made the transition from Portugal to the UK to work as a respiratory physiologist, she shared her journey and provided insights into the process of becoming an international recruit.

Her story resonated with many students as she spoke candidly about the challenges and rewards of moving abroad, joining the NHS, and integrating into the UK healthcare system. She highlighted the strong professional support available, including structured training, mentorship, and career progression opportunities. While she was initially drawn to the UK for better career prospects, it was the professional growth, the supportive work environment, and the strong relationships she built with colleagues that ultimately made her stay.

By sharing her first-hand experience, Shirley helped to demystify the recruitment process, offering reassurance that international recruits would receive the guidance and resources needed to succeed in their new roles. Her insights encouraged many students to consider a future in the UK, reinforcing the message that they would be joining a welcoming and well-supported professional community.

Matt Rutter promoting ARTP at Escola Superior de Saúde do Politécnico do Porto

Matt Rutter: Introduction to ARTP and Opportunities for Respiratory Physiologists in the UK

As Vice Chair of ARTP, Matt's role was to provide an overview of the organisation, the experience new members could expect, whilst elaborating on the benefits of being a member. Furthermore, Matt shared the ARTP vision for the future and how respiratory and sleep physiologists would be supported in the UK. During the recruitment tour, Matt spoke to prospective recruits about the role of ARTP in supporting professional development, fostering collaboration, and promoting high standards of practice. He emphasised the importance of joining an organisation that prioritises ongoing education, mentorship, and a supportive professional network.

Matt's experience in the field, coupled with his ARTP role, made him an ideal spokesperson to promote the benefits of working as a respiratory and sleep physiologist in the UK. He highlighted the opportunities for career growth, specialisation, and the positive impact that international recruits can have on both the NHS and the wider respiratory and sleep care community.

NHS England's Role in the Recruitment Process

As part of the recruitment effort, NHS England, represented by Nathan Hall, Amy Taylor Gonzalez and Elizabeth Taggart, presented essential information on the NHS system, the recruitment process, and the support that international recruits can expect once they join the workforce.

Nathan Hall provided an introduction to the NHS, explaining the importance of international recruitment in addressing staffing shortages and enhancing patient care. He detailed why there is a critical need for respiratory physiologists and other physiology diagnostic professionals from abroad, underscoring the NHS' commitment to providing quality care and the positive role international recruits play in achieving this goal.

Amy Taylor Gonzalez spoke in depth about the recruitment process and the support packages available to international recruits. She outlined the steps involved in joining the NHS, from the initial application process to settling into a new role, and discussed the comprehensive support system that international recruits can expect to help them transition smoothly into their new roles. This included: relocation assistance, training programmes, and guidance on adapting to the UK healthcare environment. Amy's presentation offered reassurance to prospective recruits, ensuring them that the transition would be as seamless and supported as possible.

A Successful Collaboration

The recruitment mission to Portugal was a crucial initial step to making good connections. By engaging directly with students and recent graduates, NHS England and ARTP were able to provide valuable information about the opportunities for respiratory and sleep physiologists in England. The presentations from Nathan, Shirley, Matt, and Amy helped prospective recruits understand the recruitment process, the support they would receive, and the potential for professional growth in the UK.

The international recruitment representatives meeting their hosts Rita and Cristina in Porto

This initiative also highlighted the importance of international recruitment in addressing workforce challenges within the NHS. As the healthcare sector continues to face staffing shortages, efforts like this recruitment campaign play a critical role in attracting talented professionals from abroad, ensuring that patients receive the high standard of care they deserve.

There were opportunities for discussion, which identified the barriers to international recruitment for potential candidates. The universities highlighted that they had lost connections with sites in the UK that allowed students the opportunity to have placements. There were also issues in obtaining visas to work in the UK. Despite this, the UK was still identified as the first choice to have a placement or to work as a physiologist by attendees at all three events.

What are the next steps?

Students and graduates were given the opportunity to express their interest to NHS England; these would be collated by Elizabeth Taggart, leading to discussions of suitability, preferences and review of CVs. Candidates will require a healthcare worker visa, which requires a B1 English language certificate. Accepted candidates would complete the ARTP international certificate of competence (ICC). This involves undertaking the MCQ and calculations exam, usually associated with the ARTP Practitioner exam. On passing they would be eligible to apply for positions within the UK. As part of this project, candidates successfully recruited would receive relocation costs, travel expenses to destination from the airport, accommodation support for an initial period and reimbursement for English language certificates. After being recruited, candidates would then complete the ARTP individual record of clinical practice (portfolio), practical exam and clinical viva, whilst being supported by a work-based supervisor in the employing department. Candidates have 24 months to complete the aforementioned qualifications to allow adjustment to life and work in England. In addition, the project covers the costs of ARTP membership and Academy for Healthcare Science registration. ARTP will look to develop further support for these candidates through the equality, diversity & inclusivity, workforce, education, and research committees.

While international recruitment is an essential strategy to strengthen the NHS workforce to support the CDCs, ARTP and NHS England remain committed to ensuring that training opportunities are available to individuals already based in the UK. Several funded routes exist for those looking to enter the field, including:

- The Practitioner Training Programme (PTP), which, while fully funded in Wales, remains under-subscribed across the UK.
- The Scientist Training Programme (STP), which provides another pathway for individuals seeking advanced roles and who have a relevant degree.
- Apprenticeships at Levels 2, 4, and 6: these offer structured training while candidates earn a salary, for those who did not go through the higher education route.
- The Graduate Diploma in Clinical Physiology, which allows professionals from related fields, such as sports science, to transition into respiratory and sleep physiology, while postgraduate qualifications in sleep medicine offer further career development.

These routes, alongside international recruitment efforts, ensure a sustainable workforce capable of delivering high-quality patient care both now and in the future.

Conclusion

The collaboration between NHS England and ARTP to support international recruitment in Portugal marked a significant step forward in addressing staffing challenges in the English healthcare system. Shirley and Matt's involvement helped to personalise the recruitment process, with Shirley's personal experience as an international recruit offering valuable insights and reassurance to prospective candidates.

The expertise of NHS England representatives Nathan Hall and Amy Taylor Gonzalez provided clear and concise information about the NHS, the recruitment pathway, and the support system available to international recruits. Together, this collaborative effort represents a positive and successful model for international recruitment in respiratory physiology, paving the way for talented professionals to contribute to the UK healthcare system.

The international recruitment representatives meeting their hosts Herminia Dias and Joana Belo in Lisbon

The international recruitment representatives meeting their hosts Telmo Periera in Coimbra

Is the Forced Oscillation Technique a Suitable Surrogate for Volitional Lung Function Testing in COPD?

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Introduction

Chronic Obstructive Pulmonary Disease (COPD) is a progressive condition characterised by inflammation and damage to lung tissue, which causes obstruction of the airways. As the disease advances, emphysematous changes occur, leading to gas trapping and hyperinflation (Figure 1), typically quantified using whole-body plethysmography or gas dilution techniques. Increasing evidence has shown that COPD is a heterogeneous and multi-system disease that manifests in various phenotypes[1,2], each associated with different clinical outcomes.

The identification of phenotypes in COPD can be achieved through both physiological testing[3-5] and imaging[6], which are valuable for identifying the primary cause of symptoms in patients. By determining the predominant phenotype, treatment can be optimised[4], leading to more targeted interventions that can improve the patient's quality of life[7] and assist in predicting mortality[8]. Consequently, accurate physiological testing is essential for identifying the type of disease affecting the patient, ensuring that those who could benefit from invasive treatment options are appropriately identified[9].

The potential of the Forced Oscillation Technique (FOT) has been studied[10,11] for quantifying airway resistance in patients with asthma. Over time, the technology has advanced, and its applications in respiratory testing have expanded.

Aim

This study aimed to evaluate whether FOT can serve as a viable alternative to whole-body plethysmography for detecting gas trapping in patients diagnosed with COPD.

Methods

Ethical approval was obtained from the Health Research Authority. Fifteen patients (five female, ten male, mean (SD) age 66.7 (9.5) years, mean (SD) height 170.7 (11.3) cm, and mean (SD) weight 76.8 (14.5) kg), all diagnosed with COPD in accordance with the GOLD 2023 guidelines[12], were enrolled in the study. Patients had no contraindications to lung function testing. Respiratory impedance measurements were taken using the FOT Resmon Pro Full (Restech Milano, Italy) at frequencies of 5, 11, and 19 Hz (Figure 2). In addition, static lung volumes were measured using body plethysmography (Jaeger Master-Screen, Vyaire Medical, Germany). The data were analysed using Spearman's correlation with R statistical software (v1.2.0; R Studio, 2023) to assess the

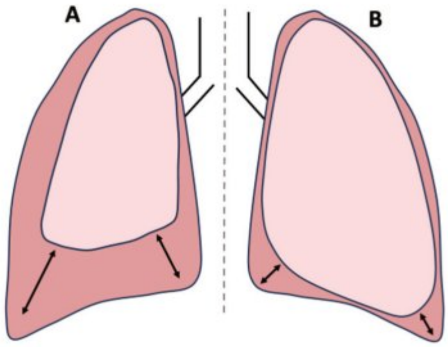

Figure 1: Variations in mechanical stretch during inspiration and expiration. (A) Shows the volume difference in a healthy lung, while (B) highlights the volume difference in a lung exhibiting emphysematous hyperinflation.
Adapted from Leslie et al. (2021).

Figure 2: Resmon Pro Full (Restech, Milano-Italy): a forced oscillation device used to measure resistance.

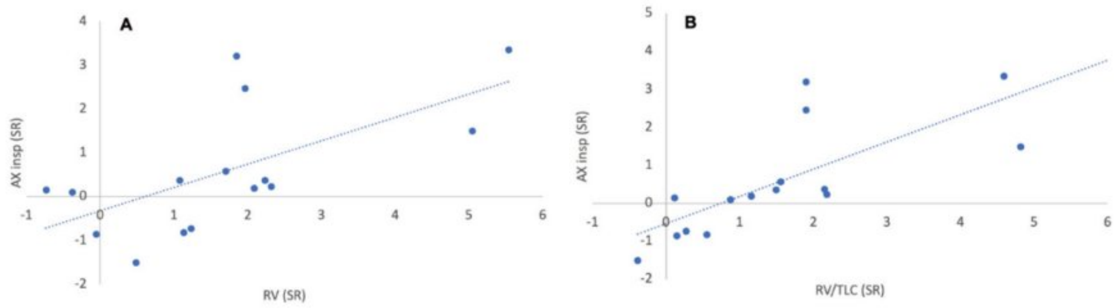

Figure 3: Comparison of residual volume (RV) measurements from body plethysmography and AX inspiration (AXinsp) measurements from FOT in 15 patients diagnosed with COPD. (A) Correlation between RV standardised residual (SR) and AXinsp SR. (B) Correlation between RV/TLC ratio and AXinsp.

relationships between the measurements. Oostveen 2013[13] and Hall 2020[14] reference values were used to calculate SR scores for FOT and static lung volumes respectively.

Results

When analysing the relationship between standardised residuals for both AX (the measurement of the area under the curve of reactance between 5 Hz and the resonant frequency) during inspiration (AXinsp) and residual volume (RV) as measured by body plethysmography (Figure 3A), a strong positive correlation (R = 0.68) with statistical significance (P = 0.006) was found. Additionally, a strong positive correlation (R = 0.84) was observed between the RV to total lung capacity (RV/TLC) ratio SR and AXinsp SR, with statistical significance (P = 0.0001) (Figure 3B).

Discussion

This study sought to explore the relationship between FOT and body plethysmography measurements that detect gas trapping in patients with COPD. Specifically, the correlations between RV (a common marker for gas trapping) as measured by body plethysmography and AX measurements from FOT were examined. The results of the study show that measurements taken using FOT correlate with traditional lung volume assessments.

The benefits of tidal breathing analysis are well documented, including reduced patient effort and simpler instructions compared to other tests[15,16]. FOT offers these advantages because it is quick, non-invasive, and requires minimal effort from the patient. Forced oscillations are applied at the airway opening to measure respiratory system impedance, resistance, and reactance, which reflect the elastic and inertial properties of the lungs[11, 17]. The clinical application of FOT is becoming more diverse, with an increasing body of literature supporting its use in the diagnostic and monitoring pathways for both asthma and COPD.

Although much research has focused on the relationship between resistance measurements from FOT and spirometry results, the comparison with body plethysmography data and reactance has not been as widely explored.

The AX measurement in FOT, particularly low-frequency reactance in smaller airways (where elastance exceeds inertance), is well established[18]. The results of this study are consistent with previous research investigating the relationship between AX and GOLD severity staging of COPD, as well as the RV/TLC ratio, with strong correlations identified in the cohort[19]. Overall, the relationship observed in this study was strong and statistically significant. However, it is important to note that the sample size was relatively small (15 patients), which limits the robustness of the conclusions. Furthermore, the relative lack of severe disease cases in this cohort means that caution should be exercised when interpreting results for patients with more advanced stages of COPD.

Frantz *et al*[20] reported a high correlation between AX and gas trapping in COPD patients, with good sensitivity for detecting gas trapping. However, as in our study, the study population did not include a statistically robust number of patients with severe COPD, which limits generalisability. Early detection of changes in lung elasticity, as reflected in low-frequency reactance, may be valuable for identifying small airway disease. Given that COPD is often underdiagnosed and identified too late in its progression, early detection is critical for initiating pharmacological interventions that can improve patient outcomes. Moreover, detecting early changes in lung function among smokers may help prevent the onset of COPD[11].

Studies have shown that FOT is sensitive to small airway dysfunction in COPD[15,21] and is more sensitive than spirometry in detecting early COPD, both cross-sectionally[22] and longitudinally[23].

Limitations

A major limitation of this study is the low sample size, which weakens the statistical power of the results. During the winter months, many patients were unable to participate due to chest infections, which further restricted recruitment. Future studies should also include testing across seasons to determine the impact on FOT measurements. Additionally, referral bias should be considered, as the patient population referred to secondary care is typically more complex and severe than that managed in primary care. This limits the representativeness of the study findings, and future studies should aim to include a more balanced distribution of disease severity. Furthermore, future studies should include a safety trial identifying the impact of completing FOT when spirometry may be contraindicated, such as during exacerbations.

Conclusion

The results of this study suggest that AXinsp (SR) measurements from FOT may offer a promising alternative to body plethysmography for detecting gas trapping in patients with COPD. Further research with larger sample sizes is needed to better understand the relationship between these tests and established markers of physiology, to fully assess the potential of FOT in COPD diagnosis and management.

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Lab in the Limelight

Hannah Hunt
Head of Respiratory and Sleep Physiology for SBUHB

Swansea Bay University Health Board (Morriston Hospital, Singleton Hospital and Neath Port Talbot Hospital)

History & Overview of the Department

Swansea Bay University Health Board (SBUHB) was formed in 2019 following a restructure of the NHS Health Boards in Wales. SBUHB covers a population of around 390,000 in the Neath Port Talbot and Swansea areas, has a budget of around £1.4bn, and currently employs over 14,000 staff.

SBUHB has 3 main hospital sites:

Morriston Hospital initially opened in 1941 during World War II to cater to the urgent needs of the wartime population. It now serves as a regional centre for trauma, burns and critical care, as well as a major provider of cardiothoracic surgery, neurosurgery and orthopaedics.

Singleton Hospital which dates back to 1912. The hospital was built on land gifted by the Singleton family, whose name the hospital bears.

Neath Port Talbot Hospital situated in Baglan, Port Talbot. Opened by the Prince of Wales in 2003 and has been chosen by the Bevan Commission as a Bevan Innovation Hub, leading the way for quality improvement in NHS Wales.

Our workforce currently consists of fifteen members of staff – a mixture of Clinical Scientists, Respiratory & Sleep Physiologists, Associate Respiratory Physiologists, Administrative staff and STP students across the health board, with a plan to recruit two further members of staff and two first year STP students over the next six months.

We have ten Respiratory Consultants within SBUHB and work closely with our colleagues in other specialities who require input from our service. Across the three sites, we offer a range of investigations to the adult population of Swansea and Neath Port Talbot. These include: pulmonary function testing, bronchodilator responsiveness, respiratory muscle function, FeNO, capillary blood gases, methacholine and mannitol challenge testing, hypoxic challenge testing and cardiopulmonary exercise testing (CPET). Our team also delivers a sleep disordered breathing service, performing pulse oximetry, multi-channel sleep studies and initiation and follow up of patients on CPAP, BiPAP and ASV therapy.

The team are often asked to deliver teaching and training sessions to other health care professionals and have recently engaged with our COPD and Respiratory Nurse teams, as well as presenting at the health board Respiratory Audit session.

Lead Physiologist Background & Career

My name is Hannah Hunt and I am the Head of Respiratory and Sleep Physiology for SBUHB. My career in Respiratory and Sleep Physiology began in 2006 when I enrolled on the BSc Clinical Physiology degree course at Swansea University. I always had an interest in healthcare, but knew the traditional 'doctor or nurse' roles weren't quite hitting the spot for me.

Upon qualifying, I undertook a number of locum posts around the UK to gain experience until a permanent role came up closer to home. I started my first permanent Physiologist role in University Hospital Llandough in Cardiff, where I stayed for just under ten years, working my way up to Unit Manager. In 2022, I moved to Swansea Bay UHB to run the service at Neath Port Talbot Hospital before obtaining the position of Head of Respiratory and Sleep for the health board in 2023.

During my time in SBUHB, I have undertaken the STP Equivalence to obtain Clinical Scientist status.

I have recently been appointed as lead physiologist for the Respiratory Strategic Network within the NHS Executive, which I currently undertake alongside my Head of Service role.

Throughout my career, I've always actively promoted Respiratory & Sleep Physiology, attending careers events, engaging with STEM Pen-pal schemes and even hiring 12-foot-tall inflatable Mega Lungs for the Swansea Science Festival!

Outside of work, I am married to my husband Chris, and we have two boys, Oliver (10) and Joshua (7). Alongside their busy schedules, I manage to squeeze in some time for myself and have recently started playing touch rugby for the Baglan Bombshells, an over-30s women's touch rugby team.

The Team

We have a wonderful team within SBUHB, all passionate about the profession and dedicated to improving patient experience.

In Morriston, we have Jess (site lead), Rob and Lottie (physiologists) and Jo (admin). Our Singleton site is led by Joleta and Sophie, working with Lesley and Emma (physiologists) and Alex (admin). The Neath Port Talbot site is led by Adam, who works with Alex (physiologist), Stacy (associate physiologist) and Natasha (admin).

Pictured left to right: Holly Higson, Sophie Bond, Lesley Newton, Joleta Hooper-Lee and Jess Hill

Across the health board, we also have two current STP students, Holly (Year 3, Singleton) and Redmond (Year 2, NPT). We are also due to recruit two first year STP students in September 2025.

The team have worked extremely hard to transform the service over the last 18-24 months, introducing new patient pathways, SOPs and more recently, the Morriston team moving into their brand new, purpose-built department.

Pictured left to right: Adam Croft, Hannah Hunt, Alex Roberts, Natasha Landry, Stacy Smith and Redmond Earlie

Future directions/developments for the lab

The last 18-24 months has been focussed on building the foundations for the SBUHB service. Now that we have that in place, we can look ahead to developments that harness the skills of our workforce to enable each individual to reach their full potential. This will hopefully include the development of Clinical Scientist/Physiologist-led clinics in sleep, interstitial lung disease and CPET.

The team regularly undertake audits and look for service improvement projects which is an ongoing cycle. As well as this, a number of members of the team have become STEM ambassadors and engage in outreach activities, promoting the profession of Respiratory & Sleep Science.

The Utility of Cardiopulmonary Exercise Testing to Investigate Dysfunctional Breathing in Adult Congenital Heart Disease

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Background

Patients who reach adulthood with congenital heart disease (CHD) not only suffer from cardiac disease but also non-cardiac comorbidities which may contribute to patients' symptoms of shortness of breath (SOB)[1]. Many patients transition from paediatric services having undergone previous open surgical repair (OSR) to improve prognosis and quality of life. Several physiological factors, including previous surgery, may contribute to patients' non-cardiac comorbidities including dysfunctional breathing (DB) which is likely underdiagnosed and undertreated. Ventilatory impairments impact exercise intolerance and increase mortality risk particularly in adult CHD (ACHD)[2]. DB can be diagnosed with the assistance of cardiopulmonary exercise testing (CPET)[3], though current prevalence in ACHD is unknown.

Introduction

CHD is diagnosed before, at, or shortly after birth with defects in the structure and functioning of the heart. Currently around 8 in every 1000 babies are born with CHD[4]. Due to advancements in medical care, many babies with CHD survive into adulthood. These infants often undergo OSR, though will usually need further surgical intervention in adult life. OSR can lead to impaired chest wall mechanics and may contribute towards SOB in this group of patients[5]. Patients also commonly experience SOB which can be disproportionate to the severity of their cardiac disease[6]. In these patients, a possible alternative cause may be DB.

DB is an umbrella term describing a collection of conditions where the normal biomechanical pattern of breathing is disrupted, leading to SOB and associated non-respiratory symptoms failing to be fully explained by a disease pathophysiology[7]. The causes of DB can centre around physiological and psychological stress[8]. These include bereavement or health-related illness[9], emotional stress, respiratory diseases, musculoskeletal dysfunction, pain or an altered chest wall shape[10].

Previous OSR and respiratory disease in ACHD have been described in the literature[1] as possible contributors to DB. In addition, emotional stress surrounding exercise is often elevated in ACHD. Considering this, we hypothesise that adults with CHD may be more susceptible to the development of DB.

CPET has emerged as an essential tool to assess patients' physiological limitations and functional exercise capacity in ACHD informing when surgical or percutaneous reintervention is required. Previous research has supported the use of CPET as a method to objectively diagnose DB3,[11,12] while ruling out other causes of exercise limitation[13]. Patients with DB typically present with an erratic breathing pattern through elevated breathing frequencies (B*f*) and atypical tidal volumes (V*t*) which are visible on the respiratory panels of the Wasserman nine-panel plot.

DB has an overall prevalence of ~9% in the general population and 29% in asthmatics[14], however, to our knowledge there are no studies which have looked at the prevalence of DB in ACHD. We therefore sought to determine the number of ACHD patients with a probable diagnosis of DB who attended a multidisciplinary ACHD clinic over an eight-year period. Furthermore, we evaluated if there were any associations between DB and several patient demographics.

Methods

Patients

Data were collected retrospectively as part of patients' routine NHS care. Patients who had a confirmed diagnosis of ACHD and underwent a CPET between February 2016 and February 2024 were included. Spirometry and CPET data were collected from the patient's first clinic attendance. Patient demographics including age, smoking history, body mass index (BMI), and relevant medications (specifically beta-blockers) were obtained using the clinical records from the patient's first clinic visit. Information on previous OSR and any symptoms of

SOB were obtained from patients' most recent cardiology clinic letters.

Cardiopulmonary exercise testing (CPET)

CPET was performed using a cycle ergometer (Ergoselect 100, Ergoline GmbH, Germany) using a ramped test protocol (Wasserman), and a metabolic cart for breath-by-breath gas analysis (Ultima™ CardiO2® MedGraphics, USA). All tests were performed by a suitably qualified healthcare scientist (HCS) in accordance with local policy and protocol based on current recommended guidelines for spirometry[15] and CPET[16]. Patients diagnosed with high risk ACHD, for example double outlet right ventricle (DORV), performed CPET in the presence of a cardiologist to monitor the patient's ECG and ensure patient safety.

Spirometry was performed prior to CPET to calculate the patient's maximal voluntary ventilation (MVV) which was estimated using forced expiratory volume within 1 second (FEV_1), multiplied by 35[17]. It also provided information on the presence of undiagnosed lung disease or how the patient's ACHD was impacting on respiratory function.

All patients were encouraged to perform a symptom limited maximal effort until exhaustion. Premature test termination criteria and maximal effort criteria were in accordance with ARTP guidelines[16] or, for those patients who performed CPET before publication of these guidelines, alternative thresholds were used, for example Respiratory Exchange Ratio (RER) >1.10.

Data for the following CPET parameters were collected directly or calculated within the CPET equipment software:

- Peak oxygen uptake (peak $\dot{V}O_2$) (ml/kg/min)
- Oxygen uptake at the anaerobic threshold ($\dot{V}O_2$ at AT) (ml/kg/min)
- Ventilatory equivalents for carbon dioxide at the anaerobic threshold ($\dot{V}E/\dot{V}CO_2$ at AT) (ml/kg/min)
- Ventilatory efficiency slope ($\dot{V}E/\dot{V}CO_2$ slope) (L/min)
- Resting oxygen saturations (SpO_2)
- Peak O_2pulse (surrogate for stroke volume) (mL/beat) (ratio of oxygen consumption ($\dot{V}O_2$) to HR)
- Percentage of predicted HR_{max} and $\dot{V}E_{maO}$
- Heart rate reserve (HRR) in bpm (HR_{max} - resting HR)
- Chronotropic index (CI) (calculated in those who performed a maximal test using (HR_{max} – resting HR) / (pred HR_{max} – resting HR))[18].

Predicted values for CPET variables were based on either Hansen, Sue & Wasserman[19] (used prior to August 2023) or Glaser *et al.*[20] reference equations. Goldman classification[21] (alternative to the New York Heart Association (NYHA)) for cardiovascular functional status was decided based upon peak metabolic equivalents (METs) achieved during CPET. Predicted maximum heart rate (HR_{max}) was estimated according to Tanaka's formula[22] (208 - 0.7 x age). Based on Wilkoff, Corey and Blackburns work[23], chronotropic incompetence was defined as an CI score of less than 0.8.

CPET reports provided information on abnormal ECG responses, reasons for test termination (e.g. SOB), and the primary CPET outcome (e.g. cardiovascular disease/ ventilatory impairment/ probable DB). A probable diagnosis of DB was made by expert clinical opinion using visual analysis of data from the Wasserman nine-panel plot[3]. This included assessing the presence of an erratic or irregular ventilatory pattern demonstrated specifically on panels 5, 8 and 9 as seen in Figure 1. As no objective or standardised criteria currently exists for identifying DB, the use of these panels to identify irregular ventilation also required the pattern recognition ability of the clinical expert interpretating the CPET data.

The patient's signs and symptoms during exercise (e.g. periodic sighing or unpleasant SOB) were also reviewed to aid the diagnosis of probable DB which were obtained from the patient's CPET report. Patients with missing data were not excluded and all available data were analysed.

Statistical Analysis

Demographic and CPET variables are presented as percentages, medians (interquartile range (IQR)), or means (±standard deviation (SD)). Associations between DB and sex, medication, SOB, or previous OSR were identified through Pearson Chi-square test using Stata/SE 14.0 (StataCorp LLC, USA).

Results

Patients

In total 107 patients performed CPET. Patient demographics demonstrated a male predominance, a raised BMI and over a fifth were taking beta-adrenoceptor blocking medication. Most patients had undergone previous OSR with over a third of patients reporting SOB. Table 1 shows the demographic results.

CPET parameters

Patients CPET parameters are shown in Table 2. Overall, greater than 75% of patients performed a maximal test, with fewer than 15% of patients

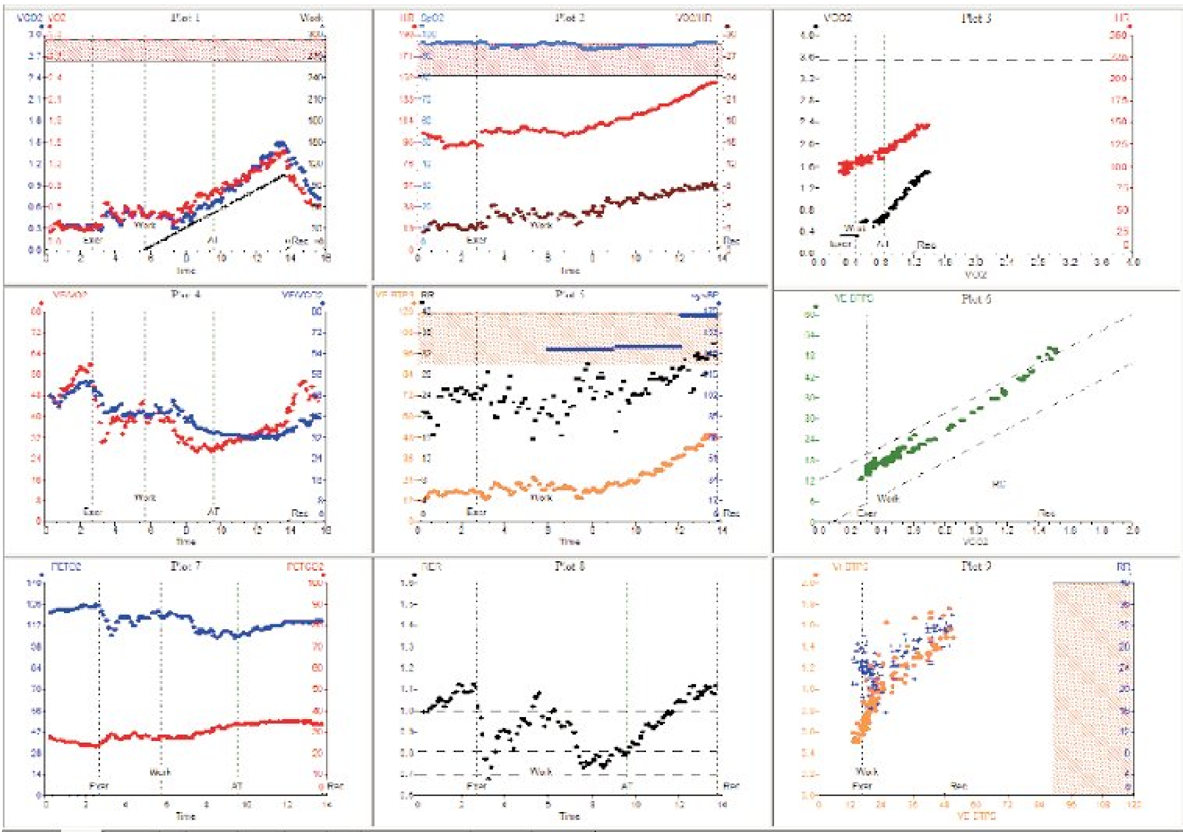

Figure 1. Wasserman nine-panel plot[25] taken from our patient cohort demonstrating probable DB.

Table 1. Data expressed as medians with 25-75% percentiles, or percentages.

Demographics	All patients (n = 107)
Age (years)	31 (23-45)
Male sex	83
BMI (kg/m^2)	26 (23-31)
Smoking (years)	0 (0-4)
Beta-blockers	21
Previous OSR	70
SOB	38

Table 2. Data expressed as percentages, medians with 25-75% percentiles, or means with ±SD.

Exercise Parameters	
Maximal effort	76
Peak $\dot{V}O_2$	20.7 (17-28)
Percentage predicted peak $\dot{V}O_2$	75 (61-85)
$\dot{V}O_2$ at the AT (n=101)	12.3 (10.7-16.1)
Percentage predicted $\dot{V}O_2$ at the AT (n=101)	43 (38-51)
$\dot{V}E/\dot{V}CO_2$ at the AT (n=101)	32 (4.8)
$\dot{V}E/\dot{V}CO_2$ slope	29.6 (27-33)
Resting oxygen saturation % (n=72)	96 (95-97)
Goldman Functional Status Class: I/II/III	34/37/29
Peak O_2pulse	10 (9-13)
Percentage predicted peak O_2pulse	91 (25.3)
Chronotropic Index (n=89)	0.76 (0.66-0.88)
Percentage predicted maximum HR	86 (79-93)
Heart rate reserve	31 (20-41)
Percentage predicted maximum $\dot{V}E$	65 (18)
Reason for Test Termination, SOB	11
Reason for Test Termination, Abnormal ECG	2

terminating the test due to SOB or an abnormal ECG response. Median percentage predicted peak $\dot{V}O_2$ and peak $\dot{V}O_2$ were both reduced[24]. Each Goldman functional status class was evenly represented within the group. Median O_2pulse was within normal limits, however median CI was reduced.

Dysfunctional breathing

Of the 107 patients, 31 (29%) were diagnosed with probable DB. Figure 1 demonstrates an example of a nine-panel plot for one of these patients. Panel 9 shows B*f* and V*t* plotted against $\dot{V}E$ with significant variability present throughout exercise.

Pearson Chi-square demonstrated no significant relationships between presence or absence of DB and patient characteristics: Sex (χ^2 [1, n = 107] = 0.015, p = 0.90), Beta-blocker medication (χ^2 [1, n = 107] = 7.573, p = 0.056), SOB (χ^2 [1, n = 107] = 0.148, p = 0.700), OSR (χ^2 [1, n = 107] = 0.647, p = 0.421).

Discussion

We believe this to be the first study to investigate the prevalence of DB in ACHD. We did not find any association between DB and previous OSR, sex, beta-blocker medication and SOB.

Interestingly, there were more patients with probable DB who were taking beta-blocker medication than those who were not. Clinically this may be important, especially in those patients where beta-blocker medication could be titrated down or stopped when undergoing cardiology review. However, this was not statistically significant (p = 0.056).

Our data shows a probable diagnosis of DB in 29% of patients which is comparable to previously reported studies including in a predominately asthmatic cohort (29%), but significantly higher than studies performed in the general population (~9%)[14].

This was a small sample, single centre, retrospective study and therefore the use of our data to inform future clinical practice may be limited. Further studies assessing this question across multiple centres, in a larger clinical patient cohort, and across a wider range of ACHD subgroups would help further substantiate our findings.

Submaximal tests were not excluded from our study which may have limited some clinical interpretation. However, it is not uncommon for patients with DB to terminate testing at a HR <85% of predicted or with an RER <1.0, justifying their inclusion. Furthermore, as data was collected retrospectively, changes in guidelines, both local and national, meant that maximal test and test termination criteria may not have been equally applied. Likewise, a submaximal test does not exclude a probable diagnosis of DB.

Though DB may have been a factor in causing patients' SOB, we cannot conclude that this is the primary cause of the patients' symptoms given the role confounding variables play. However, alongside known aetiologies of SOB, identification of DB can still lead to beneficial treatment options such as respiratory physiotherapy.

Future considerations

DB is challenging to diagnose and overall, poorly understood having historically relied upon a clinical diagnosis. More recently a series of high-quality clinical trials have used validated cut offs including $P_{ET}CO_2$ below 30mmHg at rest or work[26] or $\dot{V}eqCO_2$ above 35mmHg at a 40-50W workload[27] to complement a patient's clinical examination, helping to make a DB diagnosis. However, such thresholds would need to be assessed alongside the measurement of blood gases to ensure hyperventilation from DB was the primary cause and not the result of e.g. shunts or poor pulmonary perfusion which is often raised in CHD. This would provide a more complete and necessary clinical picture. Though this study did not assess all validated parameters previously outlined in the literature, this would be beneficial for any future research.

Considering this, the assessment of associations between physiological variables and DB across ACHD subgroups or previous OSR type (e.g. sternotomy vs lateral thoracotomy) could be an area of future inquiry. For example, it is not known the extent to which cardiac, respiratory or metabolic parameters correlate with DB in ACHD. This was outside the scope of this study though represents an important area to explore in any future research.

As it is recognised that the symptoms associated with DB often cross over with other respiratory diseases, including asthma, making diagnosis challenging, CPET should be considered as a first line test to improve the diagnosis of DB. However, no gold standard validated method has been consistently applied in the literature. Future research with the use of either plethysmography (optoelectronic or inductive), qualitative measures (e.g. self-evaluation of breathing questionnaire (SEBQ)[28]) or thoracic and abdominal investigations (e.g. fluoroscopic studies) would further support a DB diagnosis. The adoption of a multidisciplinary team (including the use of physiotherapy specialists) is also an attractive proposition strengthening future research on this topic.

Conclusion

DB is prevalent in ACHD though not statistically associated with several demographics including previous OSR, sex, beta-blocker medication and SOB. Despite these findings, it should still be considered as a probable cause of SOB in this group if other cardiac responses are normal. CPET is an important physiological tool to assess the presence of DB and how it negatively impacts a patient's functional status and symptomology. A timely and accurate diagnosis of DB is important to ensure patients have the opportunity for appropriate treatment options including respiratory physiotherapy.

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Getting to know your ARTP committee chairs

Who am I?

I am a Senior Respiratory & Sleep Physiologist based at Mid Cheshire Hospitals NHS Foundation Trust in Crewe and have been working in respiratory and sleep physiology for nine years.

Following the completion of my undergraduate degree in Biomedical Science, I joined Royal Stoke University Hospital where I was able to train as a Physiologist on-the-job and undertook my ARTP Practitioner Qualification.

Around eighteen months ago I moved to a new trust, Leighton Hospital, and took on a new position to help develop and expand the Respiratory and Sleep Physiology service.

A bit about me

I have been involved with ARTP Committees since 2020, originally joining the Communications Committee as the Social Media Representative, before quickly moving into the Vice Chair role. I really enjoyed being an active part of the committee, so I jumped at the chance to step into the role of Chair and I'm really excited to see what more ARTP can achieve over the coming years.

I'm currently undertaking a PGCert in Sleep Medicine at the University of the West of England – there is a huge gap in the current NHS workforce and I'm hoping this course will provide me with the theoretical knowledge and practical skills to deliver a larger Sleep Service, with the aim of improving care for our local patients with sleep related disorders.

Outside of work - I love to travel, I enjoy watching live music, I'm a huge fan of Formula 1 (Sundays are for racing!) and quite often I'll be found spending quality time with my family and friends.

What would you like to achieve in your role?

In my new role, I'd like to improve communications between ARTP and the membership – as part of that, we're in the process of creating a new website which will be far more user friendly and functional for all. The Communications Committee and the Executive Board also have some great ideas on how we can enhance our social media presence across all the channels...watch this space! We will continue to promote respiratory and sleep physiology widely.

Introducing ARTP Board Members

Jake Brown – ARTP Communications Vice Chair

ARTP

Who am I?

I am the lead physiologist and manager of respiratory and sleep physiology services in NHS Tayside. I was fortunate to receive my training from a variety of established centres across Scotland, including Aberdeen, Glasgow and Edinburgh, which provided me with great insight and knowledge into what is needed to build a service that best serves patients and staff.

In my current post, I have been tasked with expanding the respiratory and sleep department and provide an efficient service that meets and supports the clinical requirements of primary and secondary care services across NHS Tayside.

Before entering the world of clinical physiology, I spent my undergraduate years studying exercise physiology so it will be of no surprise that one of my clinical areas of interest is cardio-pulmonary exercise testing.

A bit about me

I'm originally from the south coast but moved up to Scotland in 2013 and have never looked back (or down!). I live for adventure and I'm always looking for that next quest.

I'm mad for all things outdoors and spend most of the time living out the back of my van!

When I'm not in work you'll find me either hiking or bike-packing across some of the most scenic places across Europe. If you've got any recommendations – let me know!

What would you like to achieve in your new role?

The ARTP has provided me with so much training and support over the years and I am now in a position where I feel like I am able to give something back.

I'm excited to work alongside so many incredible individuals across the organisation, and help promote our profession and support the continued growth of the ARTP in the future.

Introducing ARTP Board Members

Emma Fettes – ARTP Paediatrics Chair

Who am I?

I am the Lead Respiratory Physiologist for the Lung Function Unit at Great Ormond Street Hospital for Children (GOSH), where I have worked for the past 21 years. I am part of the Cardiothoracic Transplant MDT assessing children and young people pre and post lung transplantation. In 2021 our service was the first paediatric respiratory lab to achieve IQIPS accreditation.

A bit about me

When I started at GOSH my role was a joint clinical and research post, working on preschool and infant research projects with the UCL Institute of Child Health, where I was fortunate to be under the guidance of Prof Janet Stocks and Dr Paul Aurora. I work with children and young people of all ages, from infants to when they transition to adult services and I really enjoy the patient and family interaction. I pay close attention to detail which suits the IQIPS lead role and enjoy examining what we do as a service.

I am happiest outdoors, I live outside of London with my husband and children, I love sport (watching or playing!) and keeping active, I'm usually busy horse riding and running or walking with my dogs. I'm also a music lover and an avid reader.

What would you like to achieve in your new role?

I first became involved with the ARTP when I joined the education committee and I'm currently chair of paediatrics. I want to provide paediatric content and options for the practitioner qualification and advanced practitioner modules. I'm keen to support all the great ideas coming through from the committee members and their links with different ARTP committees.

Introducing ARTP Board Members

Philip Lawrence – ARTP Paediatrics Vice Chair

Who am I?

My name is Phil and I am the vice chair of the paediatric committee. I currently work as the Senior Respiratory Clinical Scientist at Alder Hey Children's Hospital in Liverpool. I joined Alder Hey in 2016, not knowing a large part of the job was to set up a lung function service. It's been a great challenge and one of great reward building by developing something new over the last 8 years, which now serves over 4500 patients a year. The ARTP and the Paediatric committee have been a great source of help and encouragement over those years.

I graduated from Liverpool John Moores in 2010 with a BSc (Hons) in Sport Science, before completing my MSc in Clinical Exercise Physiology. I went on to work as a research technician at the Medicines Evaluation Unit in Manchester, before taking on the role at Alder Hey.

A bit about me

I am married to Ela, who works as a solicitor and we have two young boys, Elijah and Andrew who keep us on our toes. I enjoy sport and support Liverpool whilst playing football and cricket myself. I also enjoy music and play drums in an Alder Hey band. I am a Christian and help lead at my local church.

I am passionate about paediatrics and improving health for our children and young people. I am currently looking to expand my career into further research and am looking forward to advancing respiratory health in this population.

What would you like to achieve in your new role?

As Paediatrics Vice Chair, I am looking to support Emma in her role as Chair whilst also learning from her and other experts on the Paediatric committee.

I would also like to expand and improve the paediatric network of physiologists to help support each other and encourage further collaboration both clinically and in research.

Introducing ARTP Board Members

Andrew Pritchard – ARTP Standards Chair

Who am I?

I am the lead clinical scientist and clinical service lead for respiratory physiology at The Royal Wolverhampton NHS Trust and have been working within the field of respiratory physiology for 21 years.

My background is in sports and exercise science, and this has provided a solid foundation for my passion and involvement within CPET throughout my career.

I enjoy working with some fabulous individuals daily and lead on a very busy service in the heart of the Black Country.

A bit about me

I'm passionate about service innovation, improving quality standards and patient experience. I try to do my bit for the profession through my work within the ARTP. I have been a Standards Committee member for about eight years, I regularly assess during the ARTP professional exams and have recently started contributing to the assessment of spirometry portfolios. I sit on the ARTP CPET faculty and contribute to ARTP CPET courses.

For my sins, I am a lifelong Nottingham Forest fan. I would like to say that a return to the topflight following a 23-year absence has settled my nerves, but I think the opposite has happened and I'm constantly on the lookout for grey hairs!

I am a keen mountain biker and can sometimes be found flying down hills or Welsh mountains. I'm also a dad to a 4 year old daredevil, who seems to be following in my footsteps (tyre tracks?), has no fear and keeps me on my toes!

What would you like to achieve in your new role?

I would like to continue progressing the Standards Committee in the same direction as my excellent predecessors.

I would like to contribute to the membership through projects aimed at raising professional standards, improving on clinical standards, and promoting involvement of ARTP members in these projects. The committee will also represent the membership during consultation with other organisations or professional bodies. I already have a list of exciting projects to get off the ground!

Introducing ARTP Board Members

Joanna Purvis – ARTP Standards Vice Chair

Who am I?

I am a trainee Consultant Clinical scientist and the Physiological Science Service Manager at the George Eliot Hospital in Nuneaton, North Warwickshire. I started my career in 2005 as a student Respiratory Physiologist in Leicester and worked at respiratory physiology centres in Coventry and Nottingham before moving to my current place of work.

In 2015, I was appointed as a band 6 Respiratory Physiologist at the George Eliot Hospital, covering all aspects of respiratory and sleep. Over the last 9 years, I have developed my role within the department; in 2017, I was promoted to Lead Respiratory Physiologist and, most recently, to head of the department for respiratory, sleep, cardiac, and upper GI Physiological Sciences. During this time, I have expanded the respiratory workforce from a small team of three to a team of nine respiratory clinical scientists/ healthcare scientists, respiratory nurse specialists, and apprentices. One of my most recent challenges has been taking over the head of the service for cardiac physiology and learning their ways of working, but the team has been great and very supportive in helping me through this.

Clinically, my passions lie with cardio-pulmonary exercise testing and the clinical scientist-led breathlessness pathway that I developed in 2023; this will also be the main focus of my consultant clinical scientist training.

A bit about me

I have been a member of the ARTP for about sixteen years and have been active in the standards, education, and events committees over the last fourteen years. For the last five years, I held the position of spirometry chair, which was a challenging but rewarding role; I hope the skills I learned during this time can be used in my current role. I am passionate about our profession and raising our profile and professional standards across healthcare science.

Firstly, I am a mum to an animal-loving, bonkers toddler who can't sit still for two minutes - I'm not sure where she gets that from!

I am also a keen competitive horse rider. I have ridden since before I could walk and competed in various disciplines over the years. I think the horses have given me a great foundation of dedication to work hard, and perseverance, with a bit of competitiveness thrown in there too, which has helped me to succeed throughout my professional career.

What would you like to achieve in your new role?

As an organisation, the ARTP has grown and developed our profession tremendously over recent years. As vice chair for standards, I plan to work alongside different areas of the ARTP to continue growing our profession and using the expertise of many within it to support our members and their clinical services.

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ON THE BLOWER

Paul Burns
ARTP INSPIRE Editor

Vyaire Respiratory Diagnostics Name Change

JAEGER

Vyaire Respiratory Diagnostics is now Jaeger Medical

As mentioned in the December issue, Vyaire announced that the Vyaire Respiratory Diagnostics (RDx) business had been purchased by Trudell Medical Limited. The new RDx business name is now **JAEGER MEDICAL**, and we will start to see the new brand rolled out globally.

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ARTP Annual Conference

Once again, we look forward to catching up with everyone at the ARTP annual conference in Glasgow. As part of our continued commitment to education we have also sponsored two workshops at this year's conference:

Lunchtime Workshop – A clash of the titans!

We are proud to present a once in a lifetime opportunity to witness and engage with two leading experts as they debate the pros and cons of multiple breath nitrogen washout and whole body plethysmography. Our two experts need little introduction, being leaders in the field of respiratory and sleep diagnostics – Professor Brendan Cooper and Dr Adrian Kendrick.

Breakfast Workshop – Elevate your CPET: Discover the power of VitaloXRT

Join Tasmin Sharley, PFT Solutions Senior Product Specialist and previous Lead Paediatric Respiratory and Sleep Physiologist in Bristol, as she runs through the unique features of the latest addition to our cutting-edge PFT range. The VitaloXRT provides in-depth analysis of cardiovascular, ventilatory, and metabolic responses to exercise via precise gas exchange measurements (VO2/VCO2). Offering accurate breath-by-breath analysis and seamless data switching during testing, the VitaloXRT enables you to actively monitor and get the best from your patients in real time.

Spaces are limited for these workshops, so please sign up as soon as possible.

New Starters

Connie Sondhi joins the UK team as Sales Support Specialist. She will be on hand to guide customers through our respiratory diagnostic solutions and answer any questions.

Ben Coombes joins the UK team as UKI Country Manager. Ben will be working closely with Adrian Fineberg, EVP PFT Solutions, to ensure that Vitalograph offers the very best solutions and support to our customers in the UK and Ireland.

Speaking on this, Adrian said: "We have been looking for the right person to join our growing team at Vitalograph to ensure that Vitalograph represents the very best in the market, beyond offering devices but instead providing complete solutions to our customers. I am so glad to welcome Ben to the team and look forward to working with him on this."

To discover more about the Vitalograph's respiratory diagnostic solutions, and to discuss your PFT needs with one of our consultants, please get in touch!

Enquiries and Updates

Click HERE for updates and news.
Reach us on 01280 827110 or customersupport@vitalograph.co.uk

We look forward to your feedback of **"On the Blower"** and the issues we have presented. We want the MLC to be your voice and to help us pursue projects and taskforces that affect your service and patients. We look forward to hearing your responses via our ARTP Watchdog link on the website.

ARTP National Strategy Day 2024

22nd of November, Leonardo Royal Hotel, Birmingham

An overview of the day by **Paul Burns,** *INSPIRE editor*

The ARTP annual National Strategy Day (NSD) was held in November 2024, in Birmingham. There was an excellent attendance for this event. The meeting brings together ARTP leadership, heads and deputy heads of departments, and offers the opportunity to keep up to date on professional issues and developments in the world of respiratory and sleep physiology. It gives heads of department a chance to ensure the services we are delivering are meeting the expected standards.

This year's meeting was the first with Dr Joanna Shakespeare and Matthew Rutter at the helm as chair and vice chair respectively. Along with the events committee, they created a fantastic programme. The first session was looking at issues facing the profession and strategy going forward. The different ARTP chairs presented on the challenges facing each committee. This was then concluded by Joanna and Matthew presenting their vision and strategy for ARTP during their terms.

Next, we had updates on various ongoing projects and developments within the ARTP followed by skills workshops where delegates were able to choose two of four workshops to attend. These included: social media, quality improvement, quality assurance/quality control (QA/QC) programs, and efficiency improvement.

The final session of the day split the audience into their four respective nations where delegates had the unique opportunity to sit with prominent leaders in healthcare science from their own country, discussing current issues and challenges.

Following is a summary of the sessions that were delivered.

Session 1 – Issues and Strategy within the Profession

Education - Helen Purcell

Education has always been at the heart of ARTP. Our education chair, Helen Purcell, gave an overview of 2024 – which has been a busy year! We had sixty-seven students enrol in the practitioner exam, which was similar to the previous year. Eight courses ran in 2024 which included CPET, occupational asthma, advanced sleep and research. Many members are interested in masterclass/interpretation, blood gas, NIV and basic sleep courses going into 2025. We also had the first cohort of students complete the graduate diploma in Respiratory Science at Sheffield Hallam University and in Sleep Medicine at the University of the West of England (UWE), Bristol.

Looking ahead to 2025, where education will be going paperless, Helen discussed the addition of a respiratory science graduate diploma at UWE, introduction of the CPET competency, development of advanced practitioner modules, and the potential for international candidates to sit the practitioner exams. She then presented results of a member education survey which asked a variety of questions, including training pathways for current trainees where in-house training was found to be the predominant pathway, with STP and apprenticeships close behind. There were also questions on advanced practitioner modules with many wanting an 'old style part II' qualification back and accreditation through universities, but the cost implication will be a large barrier to this.

Spirometry – Claire Francis & Chris Harding

Spirometry has been the largest-growing committee with ARTP being the gatekeepers of spirometry certification within the UK. Our spirometry chair, Claire Francis and vice chair, Chris Harding, started off by summarising results from a recent survey on the spirometry certificates, which was completed by the Association of Respiratory Nurse Specialists (ARNS). Generally, the certificates are well received but many struggle with the portfolio and sometimes find inconsistencies between markers. There is a lot of current work being undertaken in the committee including: reviewing all the documents, auditing of the MCQ, OSCE and portfolios. The committee are looking to improve transparency around decision-making, have regular meetings, and produce a quarterly newsletter. On the horizon is also an update of the OSCE process, the MCQ terminology around reporting and a review of sections of the portfolio and introduction of a pass mark (rather than a pass or fail.) The spirometry committee are also looking to develop an E-learning module in collaboration with NHS England.

Standards – Andy Pritchard

Everyone loves a standard operating procedure but none more so than our new standards chair, Andy Pritchard. He gave a summary of a membership survey which asked the question: 'Are there any guidelines/protocols that you feel it would be beneficial for ARTP to develop to support you in the workplace?' Key themes were: IQIPS, testing guidelines, sleep standards, department specifications and prescribing. He discussed the current work being undertaken by the committee to review all the workforce documents.

An update on the ARTP 2020 PFT guideline is underway and he gave some more detail on the CPET competency, which Andy has led on. He gave a preview of the online document with details on the different levels of certificate. Sleep standards was discussed as an area to be prioritised and a member of the sleep committee will act as link to the standards to help develop this.

Andy then presented a section on prescribing and looking to see if there was any progress for registered practitioners to work within a patient group directive (PGD) rather than a patient-specific direction (PSD) framework. Any changes in this have to be passed by law at government level and although work had begun on this, it was delayed due to the pandemic. It was noted that ARTP has raised this with Dr Martin Allen – National Speciality Advisor for Physiological Measurement and Nathan Hall – NHS England Deputy Director of Diagnostics, to see if they can get this back on the agenda.

Andy then discussed research and the barriers that staff are currently facing with complex approval processes like the Integrated Research Application System (IRAS), being the main hurdle. He noted that the research and innovation committee are open to suggestions on how to best support departments through the research process. He finished on turnaround times (TATs) which is the interval between a diagnostic test and a verified report being made available to the referring clinician. He discussed developing a standard for acceptable TATs for respiratory and sleep diagnostic tests.

ARTP Strategic Approach – Joanna Shakespeare & Matthew Rutter

Joanna and Matthew laid out their ambitions and strategy for their terms whilst heading the organisation. They referred to Professor Sir Mike Richards' independent report titled "Diagnostics: Recovery and Renewal". The report recommended significant reform and investment in critical diagnostic services. This led to the development of diagnostic and physiology transformation programmes and Chief Scientific Office documents that contained recommendations in line with the report. Joanna made it known that the ARTP strategy to guide its activities would be aimed at supporting the delivery of these recommendations.

The four key areas that they would like to target are: education, workforce, quality and innovation. With respect to education, ARTP will look to develop new roles and opportunities for progression, co-ordinate training and provide more leadership opportunities. The strategy for workforce will look to expand, increase ARTP membership and raise the profile of respiratory and sleep scientists. Quality assurance will focus on increasing IQIPS accreditation, increase the number of statutory and accredited registered respiratory and sleep physiologists, and improve standardisation across departments in the UK. Promoting the use of innovation to improve services is a key strategy and this would be achieved by supporting research projects, helping with the dissemination of research and expanding the social media platforms used by the ARTP.

Joanna and Matthew outlined current work being undertaken that is already targeted towards this strategy which included: the new website, a contract with the BMJ Open Respiratory Research, the introduction of the ARTP research course and the new position on the board for chair of the Equality, Diversity & Inclusion (ED&I) Committee. The session was concluded by presenting proposed actions to continue to develop the new strategy such as: international recruitment in collaboration with NHS England, grants for STP and PTP equivalence and new membership projects, which Matthew detailed in the next session.

Session 2 – ARTP Projects

ARTP Projects Update – Matthew Rutter

Our vice chair introduced ARTP membership projects which will be created and managed by committees but will allow ARTP members, who are not on committees, to get involved and help support the delivery. This will allow a taster of what it would be like to be on a committee and therefore help identify future members, encourage participation and give people the chance to undertake CPD. Some project ideas discussed were: MCQ question bank, IQIPS, Inspire articles and a buyer's guide.

ARTP Website Preview – Tony Probert

Managing director of Light Media communications – the new website provider – gave an overview of what the new site would look like and the improvements that would be made. He discussed the primary objectives, which are: make it modern, contemporary and professional, better navigation, enhanced members' area with improved membership subscription and renewal functions and simpler more intuitive event booking. He gave some sneak previews of what the new website would look like – impressive!

Equality, Diversity and Inclusion – Byron Batten

The new ED&I non-executive director, Byron Batten delivered a talk on ARTP's commitment to ED&I. Interestingly, he presented some demographics on the ARTP membership and showed that the ARTP executive board had a fairly even match of males to females but had nobody from an ethnic minority group. A members' survey showed that only 38% of the participants felt that ARTP was a diverse organisation, 58% thought ARTP's approach to equality was positive and 62% felt ARTP was inclusive. Byron then outlined the ARTP strategy for developing and improving ED&I. This will focus on defining vision and objectives, collating and analysing data and strategic planning which will then lead to implementation and engagement which can be continuously monitored and improved.

Sustainability Taskforce – Danny Pender

The ARTP manufacturers' liaison committee vice chair and sustainability taskforce lead, Danny Pender, delivered his talk over video link and began by outlining the goal of improving sustainability within respiratory and sleep physiology whilst working collaboratively with our industry partners. He introduced the taskforce which included: Danny, Matthew Rutter, Joanna Shakespeare, Cal Mclean, Joshua Hayter and Sheri Scott. He delivered the mission statement which included championing recycling initiatives, advocating for greener industry practices and striving to achieve carbon neutrality in our operations. Danny then went on to present results of an ARTP sustainability survey which was undertaken by ARTP members. Key findings were: the majority of departments do not have a sustainability lead/representative within their department. Although most are actively seeking to recycle inhalers, this occurs in only 17% of respondents' departments. The majority would be influenced by manufacturers' sustainability goals when making new purchases and 66% of departments actively recycle with only 23% completely paperless. There was the introduction of a sustainability network which is hoped to be up and running by the ARTP 2025 conference. This will allow a platform for collaboration, engage manufacturers and support research. There was then some focus on the implementation of an inhaler recycling programme. Danny finished off by looking at how we can foster a culture of sustainability by using communication, sustainability champions and industry partner recognition.

Session 3 – Skills Workshop

Social media – Katie Connan & Abbie Jarvis

Quality improvement – Michaela Mahoney

QA/QC Programs – Patrick Jamieson

Efficiency Improvement: 5S and 6 Sigma – Holly Le Winton

In the post lunch session after delegates had networked with the manufacturers, there was the chance to attend two of the four above skills workshops that were on offer.

Katie Connan, digital engagement specialist, and Abbie Jarvis, digital content producer, both from Cambridge University hospitals (CUH) delivered some top tips on using social media to help promote your department, aid recruitment, reach out to patients and recognise achievements. They first looked at the positives but then also the negatives associated with social media accounts and which platforms best to use.

Michaela Mahoney, the IQIPS programme manager at CUH delivered a workshop on quality improvement. She gave an overview of quality improvement and its importance in delivering services. She described Root Cause Analysis (RCA) and the five steps of: defining the problem, collecting data and information, identifying causal factors and root causes and implementing solutions. She then described the fishbone diagram as a visual tool to identify the potential cause of a problem or effect.

Patrick Jamieson, Chief Respiratory Physiologist in University Hospital Hairmyres, Lanarkshire, Scotland, presented via video link and gave a detailed tutorial on QA/QC within the respiratory function laboratory. He looked at the correct way to plot and analyse calibration data from pulmonary function and cardiopulmonary exercise testing systems. He described some common pitfalls that can occur when performing our daily calibrations and how to spot these. He also discussed inter and intra device variation and how you can plot and evaluate this on your biological QC.

Holly Le Winton, Senior Respiratory Physiologist at The Royal Papworth hospital delivered her workshop on improving efficiency in the workplace. She described the 5S methodology of: sort, set in order, shine, standardise and sustain. This workplace organisation method helps create a clean efficient safe environment. She then discussed the 6 Sigma methodology which is data-driven and looks to make processes more efficient and reduce problems.

Session 4 – Four Nations Breakout

Northern Ireland – Ian Young, Professor of Medicine, Queen's University Belfast, Chief Scientific Advisor, Department of Health, NI

Scotland – Catherine Ross, Chief Scientific Officer for Scotland

Wales – Sarah Bant, Associate Director of Workforce Transformation for Healthcare Science, Health Education and Improvement Wales

England – Delia Ripley, Deputy Chief Scientific Officer and Head of National School of Healthcare Science

In the final session, delegates got to breakout into their respective nations and have a discussion with a leading figure in the Chief Scientific Offices of each of the four nations. This was a unique opportunity for members to get access to influential figures within the profession and to ask questions that mattered to them.

It was a packed day with lots of positives to take away. One of the noticeable features for me was the hard work that all the ARTP committee chairs and members put into improving our standards and profession with the ultimate goal of improving patient care – going above and beyond.

Association for
Respiratory Technology
& Physiology

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