Characterisation of Ventilatory Constraints During Swimming

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Abstract

This paper discusses and evaluates the characterisation of ventilatory constraints during swimming, a research project currently being piloted in the School of Sport and Exercise Science. Reflections are made on the project, with collecting the research data, presenting data for discussion, and conclusions. The discussion reflects upon my experience as a researcher, with the rationale for the project presenting a review of supporting literature, and the methodology applied. Key areas of the student's development, including the assembly and use of laboratory equipment, as well as the oral skills developed in working with participants. By highlighting elements of the testing, the student would do differently, including setting the participants expectations with regards to booking in testing sessions, findings acknowledge key skills for further development from data analysis, as well as how the research will influence future learning and progression. The results of the study found that when lying face down in water at rest, there were breathing constraints observed, indicating a possibility that during swimming there is a reduced capacity to breathe oxygen in and out.

Keywords*:* Swimming / physiology, end-expiratory / inspiratory capacity, lung function, maximal flow volume loop, expiratory flow limitation, examination of minute ventilation

Introduction

In October 2021, in collaboration with the University of Portsmouth (UoP), a staff/student team within the School of Sport and Exercise Science at the University of Lincoln (UoL) embarked upon a new research initiative. The project funded by the Undergraduate Research Opportunities Scheme (UROS) examined the impact (if any), that varying postures had both in and out of water on mechanisms of breathing. The project was the first of its kind in terms, the parameters being measured, and the methodology applied. The project was supervised by a senior member of staff within the UoL, with external support and advice provided by staff within UoP. The UROS scheme made it possible to obtain single-use turbines for the breathing measurement apparatus, with testing commencing in August 2022. One of the key aims for the project was to build student researcher experience within a laboratory setting, as a result of limited exposure within the current undergraduate programme, while developing skills in preparation for the final year undergraduate dissertation assessment.

Project Background

On dry land sports, such as cycling and running, there are several studies that characterise breathing patterns, operating lung volumes and limitations during exhalation (expiratory flow limitation or EFL) (Elliot and Grace, 2013; Tanner, et al., 2014). However, research is yet to establish such characterisation of the same criteria within a swimming context, which due to the submersion in water, is absent of spontaneous breathing. For swimming, the environment is unique, with increased hydrostatic pressure (pressure created by resting in water) and restricted breathing patterns, because of face being in the water and horizontal body position. Therefore, ventilatory (breathing) constraints, including EFL, would be greater or more prevalent. This research helps to establish mechanical limitations to breathing, occurring when the ventilatory requirements of the activity meet their individual capacity (Babb, 2013). By measuring participants' limits, it is possible to identify any ventilatory constraints (a mechanism inducing a reduction in breathing response) imposed by different postures in and out of water (Bovard et al., 2018, 2). The research can identify constraints, which may influence future research into maximising/optimising training prescriptions, with a view to working around these constraints to improve performance, not just of elite swimmers but competitive swimmers of varying levels.

Review of literature

In sport and exercise, an increase in activity results in a greater demand for oxygen to fuel the body's movement (Snell and Mitchell, 1984). This increased need of oxygen has inspired researchers to analyse breathing patterns within sport, using breathing parameters to assess the presence and size of constraints during lung function (Babb, 2013; Guenette et al., 2013; Johnson et al., 1999). This led to identification and quantification of EFL (which requires measurement of both tidal and maximal flow volume loops) and measurement of inspiratory capacity (IC).

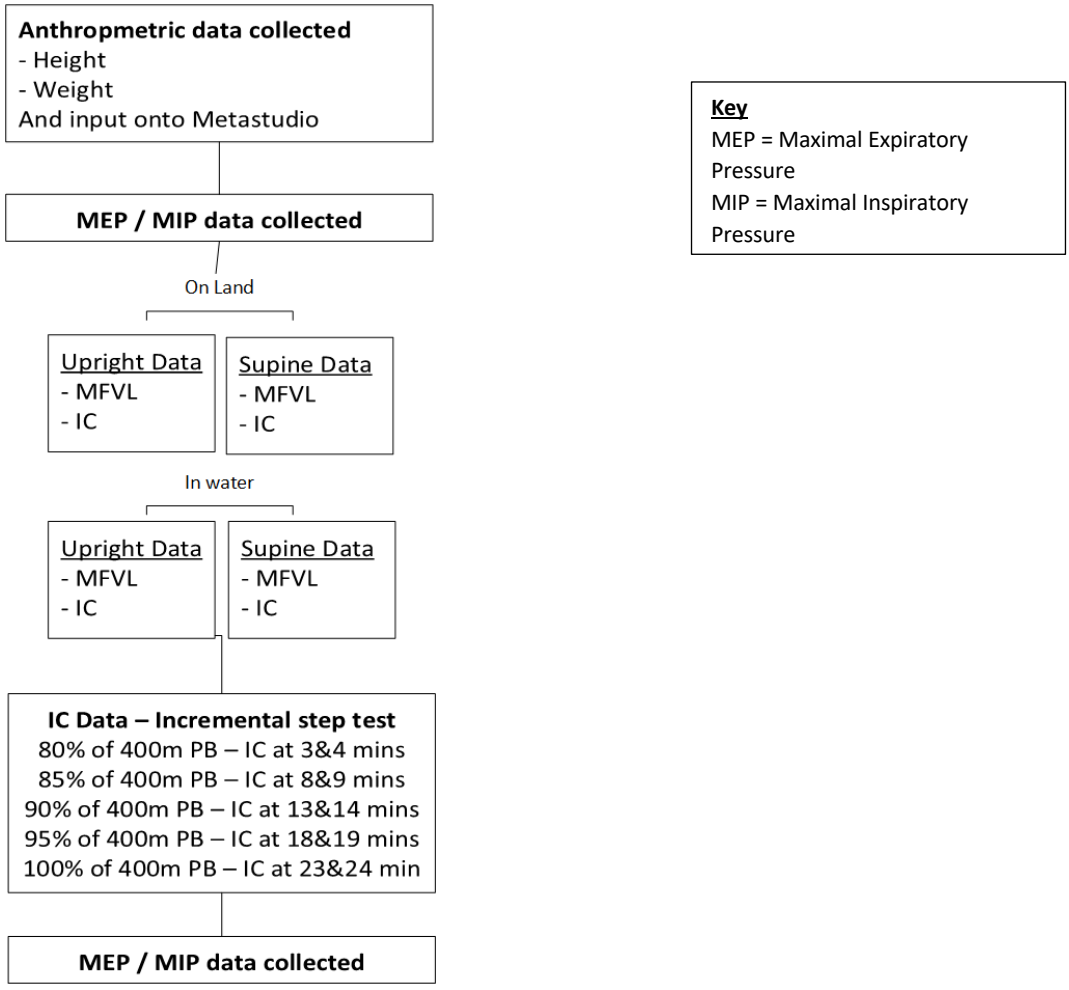
With some competitive adult cyclists, EELV has increased during maximal exercise, despite the ventilatory constraints in the absence of EFL, with a decrease in the presence of EFL (McClaran et al., 1999, Mota et al., 1985). A similar finding was found with runners (Dominelli et al., 2011), the harder the exercise intensity becomes, the greater the breathing restrictions become. This has not yet been explored in water, results of which would be relevant to a competitive swimmer because if restrictions are identified, further research can be done to explore how these are overcome, a) can exercises be implemented to improve these and b) the effect this will have on performance.

The aims of this study are to characterise breathing patterns at rest, both on land and in water, in both horizontal (face down) and upright positions by measuring the capacity of air breathed in (inspiratory capacity or IC) and the reverse of this. The capacity of air expelled (force vital capacity or FVC) when measured together in one cycle, are known as maximal flow volume loop (MFVL).

Methodology

The methodology involved collecting quantitative data through laboratory testing. Over a period of 6 weeks, participants were invited to two sessions, at least 3 days apart:

1. a familiarisation session to become accustomed to the equipment and protocol (see Figure 1).
2. testing session to collect final data



As there is no precedence in swimming for undertaking testing of this nature, the protocol was designed by the supervisor, with the guidance of an external expert in the field of respiration within swimming.

Figure 1

Diagram 1: demonstrating the protocol used at both sessions

The participant was fitted with a heart rate monitor, using a Micro RPM spirometer, with MEP and MIP data collected at rest. The participant was fitted with a respiratory snorkel used to record MFVL data upright, using the MetaSoft Studio programme followed by inspiratory capacity. This was repeated in a supine position and repeated in water.

The participant was then asked to swim 5 x 5-minute stages, starting at 80% of their 400-metre critical swim speed, increasing speed by 5% each stage. IC was measured at the 3 and 4th minute of each stage.

Key Areas of Development

Key knowledge I have developed during this process is that around the ethics application process, as well as documentation needed prior to testing. I have greater confidence working with participants, although an area for development would include undertaking more of the briefing and debriefing with the participants before and after the data collection. Additionally, I have identified building knowledge around analysing and presenting the results using SPSS software as an area that I should focus more of my time on when continuing this research further into my Dissertation project.

Challenges and lessons learnt

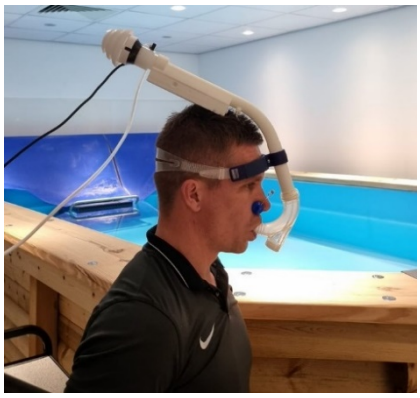
There were many challenges faced around the sampling, recruitment, and availability of participants. These included:

- Technical error messages when operating near water despite being disconnected from the power source
- Developing a brand new protocol originally using kettlebells and resistance bands to keep a participant horizontal in water, at rest (see image).
- insufficient water quality resulting in rescheduled appointments
- Availability of both researchers and participants have learned a valuable lesson that when conducting research, it is important to ensure considerations have been made

for such challenges to be able to set participants' expectations. When a new protocol is being established, it is crucial to be flexible, creative, and resilient to ensure a resolution is achieved.

Within an undergraduate degree, there is exposure to a variety of protocols for a mixture of different sports which is fantastic, but the downside of this, is that there is not enough time to explore any one protocol in further detail and as such as quickly as it was learnt. A benefit of this project was that I was given the time and opportunity to put into practice what I had learned to really cement my understanding with the one-to-one support of a supervisor to aid that learning process.

There are two aspects of the study I have thoroughly enjoyed, the data collection itself and creating the poster. Creating the poster has help me practice how to be clear and concise, whilst make the mental connection between the theory behind the project and how this relates to the data we have been collecting.



Conclusion

This UROS project has been valuable to my undergraduate experience, affording me the extra practical experience I felt I had needed to supplement my undergraduate degree. I am now more confident in navigating the stages of a research process, from gaining ethics approval, recruiting participants, to developing a valid protocol that will produce reliable results and assembling/disassembling equipment and ensuring it is correctly sanitised. This paper has highlighted several challenges which have created opportunities for development and learning. This has resulted in a pilot of research for which I can build upon and explore further within my dissertation project in the final year, and at a postgraduate level. This paper highlights areas for future development in analysing data using SPSS software, and oral skills when presenting, which is something I can develop at the poster presentation day. In conclusion, I would encourage anybody reading this, that may be interested in undertaking a UROS project, to contact your School for support and put an application in, the experience is an invaluable one.

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