

The effects of nasal breathing on exercise tolerance

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Thank you for coming to hear about the effects of nasal (nose only) breathing on exercise tolerance in a group of healthy university students.

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This research was carried out by these third year physiotherapy students at UWE and I was their project supervisor. As this was an undergraduate project we were limited in both time and resources and were restricted to healthy subjects so although ultimately we would like to investigate the effects of nasal breathing training interventions with patients, this was a preliminary study limited to testing potential methodology and providing normal data which could help to plan further research in this area.

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The importance of nasal breathing is well acknowledged due to the 'defensive' and 'air conditioning roles of the nose which has been described as 'the front line defender of the internal respiratory organs'. Mouth only (oral) breathing delivers cold, dry, dirty and possibly infected air to the lungs but breathing through the nose removes ALL large particles and HALF of smaller particles as well as warming and moistening the air to 90% of alveolar conditions in a variety of different environmental situations. The nose also adds nitric oxide to inspired air (which is both a bronchodilator and a vasodilator) and slows airflow, lessening turbulence in the large airways.

Most of us would agree that nasal breathing is important and that we encourage our patients to nose breathe as far as possible – but is this actually sufficient? Should we go further and spend time teaching patients to practice nose breathing and training them to prolong nasal breathing in situations of increased demand such as during incremental exercise? (I shall refer to this as 'Nasal breathing training'.

Nasal Breathing Training is currently included in the Buteyko breathing method, which also aims to reduce minute volume resulting in a lower flow rates which should in turn enable nasal breathing to be prolonged despite increasing levels of activity. Buteyko practitioners tend to focus on rest and moderate exercise, however and there may be some potential for physiotherapists to take this further by training people to nose breathe at high levels of exercise intensity – but to what extent is this possible?

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Previous studies have found that most people breathe through the nose at rest, apparently trading the extra effort needed to overcome nasal resistance for the cleaning and conditioning benefits outlined. We normally switch to a combination of nose and mouth breathing (oronasal breathing), at low to moderate intensity of exercise, although the 'switching point' is very variable between individuals.

Morton et al in 1995 studied the maximal exercise intensity that could be achieved by healthy subjects while nasal breathing compared with normal (ie allowed to switch to oronasal) breathing and found that, on average subjects could reach 90% of their max workload while nasally breathing (at least for the short period during the test).

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These findings suggest that there may be a potential for people to prolong nasal breathing with training, however most of the studies conducted so far have been based in physiology laboratories and have used face masks to direct airflow or measure expired air.

We wanted to find a method that could be used clinically to test the potential for nasal breathing training. Since a facemask might alter resistance and lead to psychological factors that could influence the breathing route, we felt it was important to repeat Morton's study without using the mask, and to use a field test which could be adapted for use in clinical situations as well as providing baseline normal data for further studies

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We decided to use the incremental shuttle run or 'BEEP' test to find out whether it would demonstrate a significant difference between nasal and 'oronasal' breathing in terms of peak workload achieved. Additionally we wanted to identify the intensity of exercise that could be achieved using nasal breathing without a face mask in situ.

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We used a non-blinded within subject design whereby participants (who were student volunteers recruited in lectures) completed an incremental shuttle run on two separate occasions, one week apart, one while breathing 'normally (allowed to switch to oronasal breathing when they wished)', the other while instructed to breathe with their mouth closed. The two conditions were applied in random order. When the mouth stayed closed, subjects were deemed to be breathing through the nose. The test stopped as soon as the participant felt the need to open the mouth or was observed to do so by the researchers who watched closely from strategic positions along the route.

We compared 'calculated' peak oxygen uptakes between the two runs using paired T tests. Heart Rate, Oxygen sats, End tidal carbon dioxide, respiratory rate and rating of perceived exertion were measured before and immediately after the test, but unfortunately we were unable to measure these during the procedure. The study was carried out in the university gymnasium under controlled conditions, with a practice shuttle run completed one week prior to data collection to reduce the practice effect. After each run, participants were asked to comment on their experience of participating in the tests.

Results

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12 healthy physiotherapy students aged between 21 and 27 (8 male and 4 female) volunteered to participate in the study. All participants completed both runs.

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There was a significant difference in calculated $\dot{V}O_2$ peak between nasal and oronasal groups ($p=.0039$)

V_{O2} peak achieved in this test was slightly lower for both runs than that achieved by Morton, suggesting that our runners may not have run to exhaustion – this was supported by relatively low max HR scores. Despite this, the test proved sensitive enough to demonstrate a significant difference with nasal breathing.

Nasal breathing was possible at 85% of maximum workload suggesting that people are capable of nose breathing at much higher intensities than they would normally chose to do, suggesting a potential for nose breathing training interventions even with normal healthy individuals

Runners comments:

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Participants found the nose breathing running quite challenging but were anecdotally surprised at how much exercise they could achieve while nose breathing since many had assumed beforehand that they would not be able to do much. This supports previous research findings that perception of effort may be as important as physical factors that limit air flow in triggering mouth breathing -lending further support to a potential role for nasal breathing training.

So What?

Our data gives a baseline from which to investigate whether people can be trained to breathe through the nose at higher intensity or for longer periods during endurance exercise. But what possible benefits might this bring and why should we bother to try?

Potential benefits of NBT

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Asthma

There is a strong case to be made for ‘Nasal breathing training’ in people with Asthma. Research has shown that mouth only (oral) breathing during exercise significantly increases bronchospasm while nasal breathing protects against any decrease in lung function. Asthmatics are more likely to switch to oronasal breathing than healthy individuals and this may contribute to the development of their asthma.

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COPD and CF

In theory nasal breathing might protect other patients with respiratory disease such as COPD or CF patients from frequent infections and/or cold weather induced bronchospasm, although this has not yet been studied. Additionally nasal breathing training may help individuals to control their breathing more effectively and reduce breathlessness. Nasal breathing may be able to reduce pulmonary hypertension through vasodilation and by facilitating oxygen delivery through nasal cannulae.

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Potential benefits of nasal breathing training are not limited to patients with respiratory disease however. There may be a theoretical advantage to athletes from learning to prolong nasal breathing during training. Athletes have a higher risk of

inhaled pollutants due to a combination of oronasal breathing and increased minute ventilation.

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Air pollution adversely affects athletic performance during both training and competition and this could be significant during competitions like the Olympic games where milliseconds /millimetres often determine success.

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Additionally, the increased resistance offered by the nose acts as a form of inspiratory muscle trainer, strengthening not only the diaphragm but also the nasal dilator muscles. Since this muscle training can be practiced during exercise it may not only be more cost effective but also save time over devices like the powebreathe!

Conclusion

Overall this study has provided some normal data as a baseline for future studies and supports the use of simple observation and field tests for further clinical research. The study also supports the potential for exercising at training intensities while nose breathing, although further studies to investigate the effect on endurance time are needed and a future study to look at this issue is now planned at UWE.

Additional information

Hypoventilation

Carbon dioxide levels were higher in the nasal breathing group ($p=.053$) suggesting that the runners were starting to hypoventilate towards their 'maximal' workload, but there was no difference in SaO₂ between the groups. We suspect that this may have been due to measurement error as the oximeter took several seconds to record the SaO₂, our measurements may not reflect the situation immediately at the end of the run. Raised CO₂ and lowered oxygen levels at the end of the test were suggested by Morton's findings, although the possible implications of this for the individual have not been explored. We cannot assume that this would be detrimental or beneficial to exercise training.

Nitric Oxide

Ricciardolo 2003

Nitric oxide is endogenously released in the airways by nitric oxide synthase. Functionally, two isoforms of this enzyme exist: constitutive and inducible. The former seems to protect airways from excessive bronchoconstriction while the latter has a modulatory role in inflammatory disorders of the airways such as asthma.

Only using two conditions (nasal or normal) is supported by Kirkpatrick et al 1982 study which found no significant difference between oral and oronasal conditions.

Nose can be protective even during exercise and high flow rates– as Kirkpatrick's research shows

Minute volume is reduced further than exercise tolerance

The reductions in MV are 3x greater than the O₂ uptake or workload achieved, suggesting. Also, Oxygen uptake is lower than with oral breathing at comparable (high) workload. Could this be related to a raised FRC during nasal breathing at high workloads?

Hypercapnia can lead to reduced nasal resistance according to Mc Caffrey and Kern 1979

CO₂ levels rise during nasal breathing with heavy workload according to Nishino in 1994

Flow through the nose can almost equal that through the mouth if the nostrils are flared and the vasculature is constricted (Pertuze et al 1991)

Potential to increase MV 10-12 x resting levels c nasal breathing but work may be twice that of oral breathing according to Saibene 1978

Nasal obstruction not a barrier to nose breathing – Spalding et al in 1988 found that in patients waiting for nasal surgery to overcome obstruction, many patients can functionally compensate for their obstruction to maintain 100% nose breathing

Endurance effects of nasal breathing

Tong et al 2001 found that although nb can be continued at sub max endurance levels for @60 mins, this is significantly less than if oral breathing is allowed (75 mins) but it can be improved by nasal stenting, perhaps strengthening the nostril dilators could have the same effect as these stents and allow athletes to nasal breathe

Nasal dilator muscle training

Vaiman et al 2005 show this is possible and they use biofeedback to support this

Nasal breathing lowers resp drive – Shi et al 1999 found that breathing route affects ventilatory responses to hypercapnia (less when nose breathing)