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A nasal functional test: the opening of mouth during physical effort

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SUMMARY

Apart from rare exceptions (cf Voydeville's Thesis, Nancy 1951), nasal airflow resistance has so far been estimated irrespective of variations in air intake needs. The object of the test presented here is to offer a quick, simple and objective method for determining the level of muscular effort at which a given subject spontaneously switches from nasal to buccal respiration.
A thin flexible tube (1,5 mm across) is stuck at one end on to the subject's lower lip and the other into a carbon dioxyde analyser. The subject is then made to pedal at a speed of at least 30 rev./min. on an ergometric bicycle, while a braking force increasing by 20 W every two minutes is applied.
The emission of carbon dioxyde starts being detected, and graphically recorded, only when the subject starts breathing through his mouth.
Results obtained so far show that this threshold can vary as widely as from 80 to 180 W among healthy individuals. Further aplications of this test to both healthy subjects and patients with impaired nasal function would contribute towards throwing light on the still obscure notion of "nasal comfort".

NASAL fossae offer a resistance to the free penetration of air. This is a useful phenomenum certainly plays a role in other functions of the nasal fossae, (especially in the conditionning of inspired air and also in the regulation of expired air flow).
In most cases, this resistance is adapted to the needs of the lungs, which explains the well known fact that nasal interventions administered to patients with lung deficiencies result in very slight improvements and can notably, in cases of involving emphysema or chronic bronchitis, be harmeful.
Rhinologists are mainly concerned with the measurement of this resistance (which is balanced and modulated between the two nasal fossae by the nasal cycle). Their object being to retain that resistance which is absolutely beneficial i.e. not associated with the lungs requirements.
Voydeville (Med. Thesis Nancy, 1951) in collaboration with Sadoul studied the relative values of nasal and oral respiration, during normal breathing as during Tiffeneau's test (inspiratory and expiratory). The latter test allowed him to detect nasal deficiencies unnoticed during normal breathing.

As the lungs requirements are considered as being of the prime importance, a new test has been conceived. It also seems inadequate to dissociate the nasal functions, and or to separate them from those of the lungs.
The test is easily controlled, regarless of whether or not the patient is breathing nasally. In addition, for any subject healthy or not, who breathes nasally when resting, experience shows that a certain level of muscular activity, when air flow reaches a certain intensity, nasal breathing is abandonned in favor of oral breathing which offers less resistance.
The purpose of the test is the quick determination, for any given subject of the level of muscular activity at which oral breathing becomes necessary. The subject rides an ergometric bicycle and pedals against a gauged electrical brake. The strenght of which increased at regular time intervals. The degree to which the patient opens his mouth is measured by a special collector, pratically unknown to the subject, to whom the purpose of the test has not been revealed.

EXERCISES AT INCREASING INTENSITY

The subject pedals at a minimum speed of 30 revolutions per minute, most often around 50 to 60 revolutions per minute, any excessive slackening being indicated to him by a luminous signal. The braking strength, automatically regulated, is constant even when there is variation in pedaling force. By pushing the buttons of the instrument panel the operator controls the braking intensity which is expressed in watts, by stages of 10 W from 30 to 120 W, 20 W from 120 to 200 W and finally 40 W from 200 to 400 W. (Figure 1).
As an indication of the work intensity required by this type of exercise, it should be remembered that (for an adult) walking casually on a flat surface corresponds to approximately 40 W whereas climbing a staircase corresponds to 60 to 80 W according to the speed. Most subjects excepting those with serious respiratory deficiencies or cardiac ailments can maintain 100 to 120 W during a period of 20 minutes, more during shorter time periods.
In this test, the increase of the required force is obtained by majoration of 20 Watts every 2 minutes, without any rest. This resembles the triangular exercises used during functional breathing tests, so named because the grouth curb, which increases by stages of 30 W every 3 minutes, forms a right-angled triangle as opposed to the rectangle formed by exercises performed at a constant level. Of course, the operator observes the subject in order to determine the exact instant at which the subject ceases the breathe by the nose. However, in using a CO_2 collector which records the results versus time, a more objective appreciation is obtained, with a graphic.
A thin, supple tube (interior bore 1.5 mm) is used. One end of the tube is taped to the subjects lower lip (Figure 1). The other end is attached to a CO_2 fast-analyzer, which meausures the CO_2 instantley, regardlesse of the gas mixture, by infrared absorption. A sampling pump forces the air from the mouth to the analyzer.
The CO_2 concentration transformed into electrical tension and amplified is printed

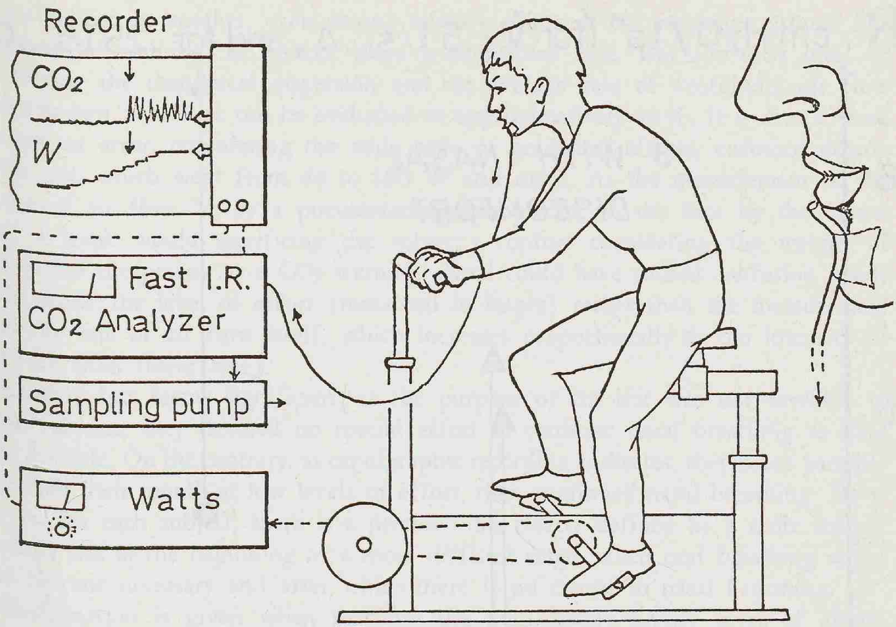

Figure 1. Detection of beginning of oral ventilation, by expired CO_2, during rising exercise (20 Watts stages every 2 minutes).

on a classical rapid response recorder (expiratory capnigram). Thus, as long as the subject exhales nasally, no CO_2 reaches the analyzer, and the line stays at the base of the graph (zero). However as soon as oral breathing begins, the sampling pump (20 ml/sec) takes some CO_2 into the analyzer, which is indicated by the line by successive pikes, according to the breathing frequency.
The operator draws on the recording paper, the moments at which the intensity of effort pass from one stage to another, every two minutes.

FIRST RESULTS

Figure 2 groups the first results obtained with this method (as an indication). As the nasal resistances, R, given in centimeters of water pressure per liter per second, have also been measured for these subjects, they are shown here one the Y axis, where as the level of work at which oral breathing appears is shown on the X axis. The resistances R, were measured at two levels of flow: .25 and .50 liters per second, represented by circles and triangles respectively. The subjects are young adults in perfect health.
It appears immediately that the scattering of the levels of work is important, ranging from 80 to 180 Watts in that it makes it possible to observe the commencement of oral breathing.
The relation between the degree of mouth opening and the inspiratory nasal resistance is not very clear, given the wide their small number.

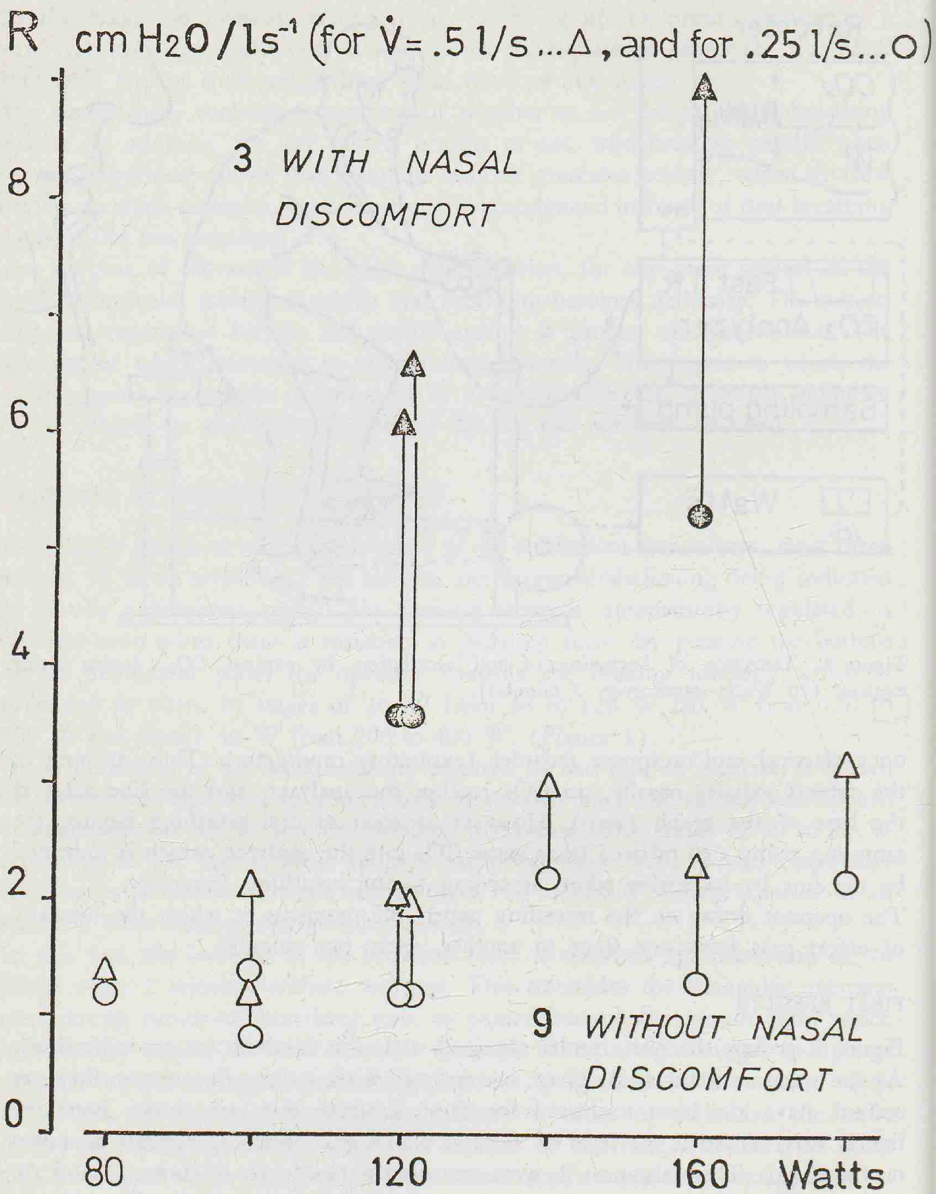

Figure 2. Level of shift nasal to oral ventilation during rising exercise.

DISCUSSION

With respect of this test several criticisms come to mind:
First of all, for an aquivalent level of muscular exercise, the air flow differs from

one subject to another, even among healthy adults of the same age group. The degree of training, of course, plays a significant role. But for each level of exercise, the theoretical dispersion and the average rate of ventilatory air flow are known, the latter can be evaluated to approximatively 20%. It is thus a weak cause of error, considering the wide scale of graduated efforts, enforced during the test, which went from 40 to 180 W and more. As the measurement of the rate of air flow, V, by a pneumotachograph placed on the face by the means of a mask would sacrificing the subject's confort considering the weight of required equipment, as a CO_2 warning signal could have caused confusion inside the mask: the level of effort (measured in stages) rather than the measurement of the rate of air flow itself, which increases proportionally to the intensity of effort (non linear rule).

Another fact seems significant: as the purpose of the test was not revealed to the subjects, they devoted no special effort to continue nasal breathing as long as possible. On the contrary, as capnigraphic recording indicates, they often partially opened their mouth at low levels of effort, then continued nasal breathing. However, for each subject, there is a precise time, clearly defined by a more intense effort and at the beginning of a more difficult stage, when oral breathing seems to become necessary and after which there is no return to nasal breathing.

Confirmation is given when reaching the immediately higher level of effort, which extends the test time for two minutes.

This method seems preferable to the self-willed continuation of nasal breathing which would result from pre-motivation of the subjects. The results, less spontaneous, would have attested to a resistance to hypoxy or to the will-power of the subjects rather than to the pure reflex by which they choose oral breathing when working.

Finally, besides the technical management of the test, the first results lead to some observations.

The absence of any correlation between measured nasal resistances (inspiratory) at .25 as well as at .50 liters per second, and the opening of the mouth seems to indicate that the tested reflex is not exclusively subordinated to nasal resistances. What is called "nasal comfort" seems to be the result of factors other than the resistance of the nose to air flow. Possibly some imperatives associated with other nasal functions are important: the need to humidify and warm inspired air, especially during light efforts maintained for long periods; or the simple closing of the mouth to postpone the moment when oral breathing will dry and irritate the pharynx, thus leading to the abandonment of a too intense effort.

CONCLUSION

Before it can be said whether or not this test has a place in the paraclinical study of nasal dynamics, it will have to lend itself to numerous applications using healthy subjects as well as those suffering from nasal difficulties. Only then will the interpretation of this test become facilitated.

To our knowledge, no other work of this nature has been published even though doctors have asked questions with respect to the nasal problems of their patients for years. Technically, this test is relatively easy to perform. Also it seems probable that closely related tests would produce the same results. It seems desireable that other groups would study this matter that this largely unexplored field of "nasal comfort" be opened up.

RÉSUMÉ

Sauf rares exceptions (cf Thèse de Voydeville, Nancy, 1951), la résistance nasale au débit aérien est généralement estimée sans tenir compte des variations des besoins ventilatoires de l'organisme.
Le but du test proposé ici est d'offrir une méthode rapide, simple et objective pour déterminer le niveau d'exercice musculaire auquel un sujet donné passe spontanément de la ventilation nasale à la ventilation buccale.
Une fine tubulure souple (1,5 mm de diamètre) est fixée par une extrémité à la lèvre inférieure du sujet tandis que l'autre va vers un analyseur à CO_2. Le sujet pédale sur une bicyclette ergométrique, entre 30 et 60 t/minute, contre un frein qui augmente de 20 W toutes les deux minutes.
Le rejet de CO_2 n'est détecté et enregistré qu'à partir de l'instant où le sujet respire par la bouche. Les premiers résultats obtenus montrent que cette transition peut se produire aussi bien à 80 qu'à 180 W chez des sujets sains. L'expérience de ce test, pratiqué aussi bien chez des sujets sains que chez des patients porteurs de troubles des fonctions nasales, contribuera peut-être à éclaircir la notion encore mal connue de "confort nasal".

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