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Sniff Nasal Inspiratory Pressure: What Is the Optimal Number of Sniffs?

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ABSTRACT

Question of the study: Sniff nasal inspiratory pressure (SNIP) measurement is a volitional non-invasive assessment of inspiratory muscle strength. The maximum value of ten sniffs is generally used. The purpose of this study was to investigate whether the maximum SNIP improved after the tenth sniff.

Methods: 20 healthy volunteers and 305 patients with various neuromuscular and lung diseases were encouraged to perform 40 and 20 sniffs, respectively.

Results: The best SNIP among the first 10 sniffs was lower than the best SNIP among the next 10 sniffs in the healthy volunteers and patients. The SNIP improvement after the 20th sniff was marginal.

Answer to the question: A learning effect persists after the 10th sniff. We suggest using 10 additional sniffs when the best result of the first 10 sniffs is slightly below normal or when SNIP is used to monitor a progressive decline in inspiratory muscle strength.

Key Words: respiratory muscle strength, learning effect, neuromuscular disease, cystic fibrosis

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Conventional non-invasive assessment of inspiratory muscle strength involves the measurement of mouth pressure during an at least 1 second-long maximal inspiratory effort against occlusion (1). Because this static maneuver is difficult to perform, the results vary widely, and low values may reflect not only inspiratory muscle weakness, but also lack of motivation and/or poor coordination.

Sniffing is a natural maneuver that many patients find easier to perform than static efforts. Sniff nasal inspiratory pressure (SNIP) measurement has been suggested as an alternative (1, 2) or complement (3, 4) to maximal inspiratory pressure measurement. SNIP is measured through a plug occluding one nostril during sniffs through the contralateral nostril. The pressure reaches a plateau after five to ten sniffs in most individual (1). Ten sniffs are usually performed for SNIP measurement. We are aware of only two studies of the optimal number of sniffs (5, 6). Stell et al. (5) observed that the highest SNIP was recorded after the tenth sniff in 63% of 51 asthma patients and 45 patients without respiratory disease who performed 15 sniffs. Fitting et al. (6) found that the highest value of the first 10 sniffs was equal to 93% of the highest value of the first 20 sniffs, on average, in 9 patients with amyotrophic lateral sclerosis.

The purpose of this study was to look for a learning effect leading to an increase in SNIP values after the tenth sniff in children and adults with a variety of neuromuscular and respiratory disorders.

METHODS

The study was approved by our institutional review board, and informed consent was obtained from all participants and from the parents of pediatric patients.

First, 20 healthy adults unfamiliar with sniff maneuvers were tested. Tests were conducted in a single session with the individual seated. SNIP was measured from functional residual capacity (FRC) during 40 maximal sniffs, in a standardised manner as previously described (2). One nostril was occluded using an eartip intended for auditory evoked potential recording (Eartips, 13 mm, Nicolet, Madison, WI). The other end of the catheter was connected to a differential pressure transducer (Validyne DP15, Northridge, CA) wired to a carrier demodulator (Validyne CD15) and passed through an analogue-digital board to a computer running appropriate software (Biopac System, Goleta, CA) that provided visual feedback. In practice, the subject was instructed to perform short sharp sniffs with closed mouth, starting from the end expiratory volume after a quiet breath. Each sniff was separated by 30s and associated with a strong verbal encouragement of the observer who continuously coached the subject to obtain maximal pressure amplitude (7). In addition, the pressure signals were displayed on the computer screen to give the patient visual feedback of his performance of the test (7).

Then, 305 patients unfamiliar with sniff maneuvers were studied as part of their routine clinical evaluation, over a 2-year period, at the Raymond Poincaré and Armand Trousseau hospitals. Measurement conditions were the same as above except that patients performed only 20 sniffs, or less in case of fatigue or poor co-operation.

Statistical Analysis

In healthy individuals, the differences between the best of the first 10 sniffs (bestSNIP 1-10), second set of 10 sniffs (bestSNIP 11-20), third set of 10 sniffs (bestSNIP 21-30), and last

set of 10 sniffs (bestSNIP 31-40) were assessed by analysis of variance (ANOVA) with repeated measurements. Pairwise comparisons were performed using Bonferroni's test, if allowed by F. In the patients, the difference between bestSNIP 1-10 and bestSNIP 11-20 was assessed using a paired t test. The significance level was set at 5%. All results are reported as mean±SD.

RESULTS

In the 20 healthy individuals (11 males and 9 females, age 42±13 years), significant differences occurred among the four mean bestSNIP values (bestSNIP 1-10, 92.2±26.2 cmH_2O; bestSNIP 11-20, 97.6±25.5 cm H_2O; bestSNIP 21-30, 98.2±24.3 cmH_2O; and bestSNIP 31-40, 98.4±24.7 cmH_2O; ANOVA P=0.04). The differences seemed largest between bestSNIP 1-10 and the other values; however, the post hoc analysis showed no significant series effect.

Three hundred five patients were included in the study, 248 adults, and 51 children ≤ 16 years (mean age = 11.6 ± 2.7). Forty five patients (33 children) performed fewer than 20 sniffs. The 6 patients (5 children) with ≤10 sniffs were excluded from the analysis. Although 39 of the remaining 299 patients performed fewer than 20 sniffs, the best SNIP after the tenth sniff was better than the bestSNIP 1-10 (Table 1), both overall and in several subgroups (adults, children, myotonic dystrophy, spinal cord injury, cystic fibrosis, and poliomyelitis) (Table 1). However, the improvement in SNIP did not reach statistical significance in the subgroups with Duchenne muscular dystrophy, spinal muscular atrophy, or cerebellar ataxia.

The mean difference between bestSNIP 1-10 and bestSNIP 11-20 was 3.5±7.7 cmH_2O (Bland and Altman plot, Figure 1). Normal SNIP values in children are similar to those in adults (8), and SNIP values greater than –70 cmH_2O in males and –60 cmH_2O in females militate against meaningful inspiratory muscle weakness (1, 9). According to these data, of the 231 patients in our study whose SNIP values were abnormal when only the first 10 sniffs were considered, 19 (8.2%) had normal muscle strength when all sniffs were considered (myotonic dystrophy, n=3; poliomyelitis, n=3; spinal cord injury, n=3; scoliosis, n=2; myasthenia, n=1; cystic fibrosis, n=2; and other neuromuscular or restrictive pulmonary disorders, n=6).

DISCUSSION

The best SNIP during the first 10 sniffs was lower than the best SNIP during the next 10 sniffs. This finding supports a persistent learning effect after the tenth sniff and extends findings by Stell et al. (5) in patients with asthma and non-respiratory diseases and by Fitting et al. (6) in patients with amyotrophic lateral sclerosis.

The majority of children with respiratory or neuromuscular disease are unable to adequately perform a series of 20 sniff manoeuvres. However, because sniff values may improve after the tenth manoeuvre (see Table 1), we suggest to systematically ask for more than 10 manoeuvres in children when possible.

Whether the learning effect is sustained over time is unclear. In healthy individuals, Maillard et al. (10) found that the best SNIP value of 10 sniffs was not different between two sessions 1 day apart or between a third session 1 month later. Thus, learning effects seem to dissipate from one day to the next, indicating that all patients should be considered inexperienced with SNIP measurement.

Of 231 patients with abnormal SNIP values when only the first 10 sniffs were considered, 19 had normal muscle strength when all sniffs were taken into account. Although this proportion is small, over-diagnosis of muscle weakness when only 10 sniffs are used may have a clinical impact, since SNIP measurement serves to identify patients who need further investigations or are at risk for respiratory failure.

Finally our study confirmed the presence of a quick and significant learning effect within each session, when patients are given appropriate visual feedback and verbal encouragement. Thus, a more reliable maximum SNIP may be obtained with optimal technique, but this can need more than 10 sniffs.

We therefore suggest using more than 10 sniffs when the SNIP value is slightly below normal or when SNIP is used to monitor a decline in inspiratory muscle strength.

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Figure 1. Bland and Altman plot: Difference between the best of the first 10 sniffs (bestSNIP 1-10) and the best of the next 10 sniffs (bestSNIP 11-20) plotted against the mean of these two variables (n=299).

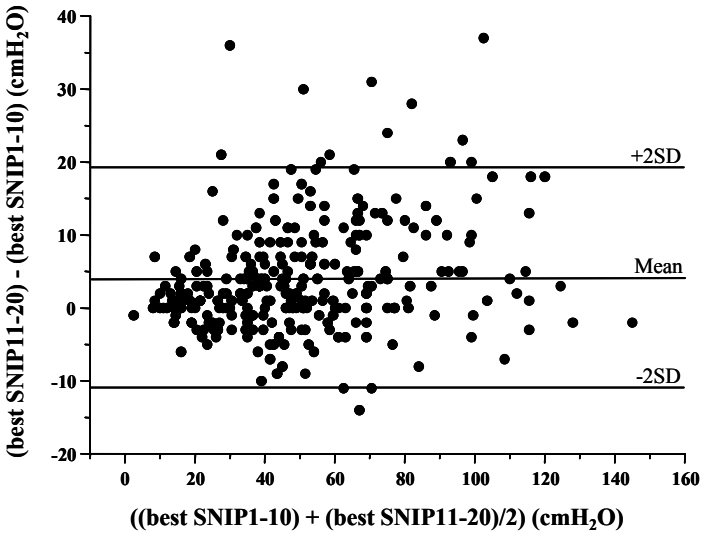

Table 1. Mean best SNIP among the first 10 sniffs compared to mean best SNIP among the next 10 sniffs. The mean best SNIP among all 20 sniffs is reported in the last column.

	Number of patients	Best SNIP1-10 (cmH_2O)	Best SNIP11-20 (cmH_2O)	t-test (*P*)	Best SNIP1-20 (cmH_2O)
Total	299	48.1±25.9	52.9±27.8	0.0001	53.5±29.5
Adults	248	48.3±26.4	52.5±28.3	0.0001	54.1±30.4
Children	51	47.0±23.4	49.6±25.1	0.02	60.0±24.9
Myotonic dystrophy	A 59 / C 0	50.3±24.8	52.7±25.5	0.003	53.7±25.6
SCI	A 41 / C 0	61.4±27.0	67.3±29.6	0.0001	67.7±29.3
Poliomyelitis	A 32 / C 0	51.5±21.2	55.9±25.8	0.0135	57.2±25.4
DMD	A 13 / C 15	24.9±15.7	27.1±16.0	0.14	28.4±16.4
Spinal amyotrophy	A 5 / C 6	32.5±16.7	33.0±16.5	0.48	33.6±17.0
Myasthenia gravis	A 10 / C 0	43.5±19.6	49.7±22.3	0.065	51.0±21.8
Idiopathic scoliosis	A 10 / C 0	44.6±18.3	51.9±24.5	0.06	52.4±24.4
Cerebellar ataxia	A 9 / C 0	61.2±28.7	66.8±30.5	0.14	68.0±30.3
Cystic Fibrosis	A 5 / C 20	56.5±21.0	60.5±22.5	0.02	61.5±21.9
Other neuromuscular or restrictive pulmonary disorders	A 64/ C 10	45.2±28.0	49.2±29.1	0.0001	52.5±36.0

Abbreviations: A, adults; C, children; SCI, spinal cord injury; DMD, Duchenne muscular dystrophy