Eur Respir J 2006; 27: 980–982
DOI: 10.1183/09031936.06.00121305

Sniff nasal inspiratory pressure: what is the optimal number of sniffs?

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ABSTRACT: Sniff nasal inspiratory pressure (SNIP) measurement is a volitional noninvasive assessment of inspiratory muscle strength. A maximum of 10 sniffs is generally used. The purpose of the present study was to investigate whether the maximum SNIP improved after the tenth sniff.

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

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 twentieth sniff was marginal.

In conclusion, a learning effect persists after the tenth sniff. The current authors suggest using 10 additional sniffs when the best result of the first 10 sniffs is slightly below normal, or when sniff nasal inspiratory pressure is used to monitor a progressive decline in inspiratory muscle strength.

KEYWORDS: Cystic fibrosis, learning effect, neuromuscular disease, respiratory muscle strength

Conventional noninvasive assessment of inspiratory muscle strength involves the measurement of mouth pressure during at least a 1 s-long maximal inspiratory effort against occlusion [1]. As this static manoeuvre is difficult to perform, the results vary widely and low values may reflect not only inspiratory muscle weakness, but also a lack of motivation and/or poor coordination.

Sniffing is a natural manoeuvre that many patients find easier to perform than static efforts. The 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. A plateau in pressure is reached after 5–10 sniffs in most individuals [1]. For SNIP measurement, 10 sniffs are usually performed. To the current authors' knowledge, there are 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, on average, to 93% of the highest value of the first 20 sniffs in nine patients with amyotrophic lateral sclerosis.

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The purpose of the present 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 authors' institutional review board approved the current study. Informed consent was obtained from all participants and from the parents of paediatric patients.

Initially, 20 healthy adults unfamiliar with sniff manoeuvres were tested. Tests were conducted in a single session with the individual seated. SNIP was measured from functional residual capacity 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, USA). The other end of the catheter was connected to a differential pressure transducer (DP15; Validyne, Northridge, CA, USA) wired to a carrier demodulator (CD15; Validyne) and passed through an analogue–digital board to a computer running appropriate software (Biopac System, Goleta, CA, USA) 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 30 s and associated with strong verbal encouragement from an observer who

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Received:
October 17 2005
Accepted after revision:
January 10 2006

SUPPORT STATEMENT
F. Nicot received support from Vaincre La Mucoviscidose (Paris, France).

European Respiratory Journal
Print ISSN 0903-1936
Online ISSN 1399-3003

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 the performance of the test [7].

Subsequently, 305 patients unfamiliar with sniff manoeuvres were studied over a 2-yr period as part of their routine clinical evaluation at the Raymond Poincaré and Armand Trousseau hospitals (Paris, France). Measurement conditions were the same as above except that patients only performed $\leqslant$20 sniffs in case of fatigue or poor cooperation.

Statistical analysis

In healthy individuals, the differences between the best of the first 10 sniffs (best $SNIP_{1–10}$), second, third and final sets of 10 sniffs (best $SNIP_{11–20}$, best $SNIP_{21–30}$ and best $SNIP_{31–40}$, respectively) were assessed by ANOVA with repeated measurements. Pairwise comparisons were performed using Bonferroni's test, if suitable. In the patients, the difference between best $SNIP_{1–10}$ and best $SNIP_{11–20}$ was assessed using a paired t-test. The significance level was set at 5%. All results were reported as mean$\pm$SD.

RESULTS

In the 20 healthy individuals (11 males and nine females aged 42$\pm$13 yrs), significant differences occurred among the four mean best SNIP values (best $SNIP_{1–10}$ 92.2$\pm$26.2 cmH_2O; best $SNIP_{11–20}$ 97.6$\pm$25.5 cmH_2O; best $SNIP_{21–30}$ 98.2$\pm$24.3 cmH_2O; best $SNIP_{31–40}$ 98.4$\pm$24.7 cmH_2O; p=0.04). The differences seemed largest between best $SNIP_{1–10}$ and the other values. However, the *post hoc* analysis showed no significant series effect.

In total, 305 patients were included in the study. Of these, 248 were adults and 51 were children aged $\leqslant$16 yrs (mean age 11.6$\pm$2.7 yrs). Forty-five patients (33 children) performed <20 sniffs. The six patients (five children) with $\leqslant$10 sniffs were excluded from the analysis. Although 39 of the remaining 299 patients performed <20 sniffs, the best SNIP after the tenth sniff was better than the best $SNIP_{1–10}$, both overall and in several subgroups (adults, children, myotonic dystrophy, spinal cord injury, cystic fibrosis (CF) 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 best $SNIP_{1–10}$ and best $SNIP_{11–20}$ was 3.5$\pm$7.7 cmH_2O (Bland and Altman plot; fig. 1). Normal SNIP values in children are similar to those in adults [8], and SNIP values >-70 cmH_2O in males and >-60 cmH_2O in females militate against meaningful inspiratory muscle weakness [1, 9]. According to these data, out of the 231 patients whose SNIP values were abnormal when only the first 10 sniffs were considered, 19 (8.2%) patients 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 gravis n=1; CF n=2; 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 builds on the findings from patients with asthma and nonrespiratory diseases [5] and patients with amyotrophic lateral sclerosis [6].

The majority of children with respiratory or neuromuscular disease were unable to adequately perform a series of 20 sniff manoeuvres. However, as sniff values may improve after the tenth manoeuvre (table 1), it was suggested that >10 manoeuvres in children should be systematically asked for when possible.

TABLE 1 Mean best sniff nasal inspiratory pressure (SNIP) in the first 10 sniffs (best $SNIP_{1–10}$) compared with mean best SNIP in the next 10 sniffs (best $SNIP_{11–20}$)

	Patients n	Best $SNIP_{1–10}$ cmH_2O	Best $SNIP_{11–20}$ cmH_2O	p-value	Best $SNIP_{1–20}$ cmH_2O
Total	299	48.1$\pm$25.9	52.9$\pm$27.8	0.0001	53.5$\pm$29.5
Adults	248	48.3$\pm$26.4	52.5$\pm$28.3	0.0001	54.1$\pm$30.4
Children	51	47.0$\pm$23.4	49.6$\pm$25.1	0.02	60.0$\pm$24.9
Myotonic dystrophy	A 59/C 0	50.3$\pm$24.8	52.7$\pm$25.5	0.003	53.7$\pm$25.6
SCI	A 41/C 0	61.4$\pm$27.0	67.3$\pm$29.6	0.0001	67.7$\pm$29.3
Poliomyelitis	A 32/C 0	51.5$\pm$21.2	55.9$\pm$25.8	0.0135	57.2$\pm$25.4
DMD	A 13/C 15	24.9$\pm$15.7	27.1$\pm$16.0	0.14	28.4$\pm$16.4
Spinal amyotrophy	A 5/C 6	32.5$\pm$16.7	33.0$\pm$16.5	0.48	33.6$\pm$17.0
Myasthenia gravis	A 10/C 0	43.5$\pm$19.6	49.7$\pm$22.3	0.065	51.0$\pm$21.8
Idiopathic scoliosis	A 10/C 0	44.6$\pm$18.3	51.9$\pm$24.5	0.06	52.4$\pm$24.4
Cerebellar ataxia	A 9/C 0	61.2$\pm$28.7	66.8$\pm$30.5	0.14	68.0$\pm$30.3
Cystic fibrosis	A 5/C 20	56.5$\pm$21.0	60.5$\pm$22.5	0.02	61.5$\pm$21.9
Other neuromuscular or restrictive pulmonary disorders	A 64/C 10	45.2$\pm$28.0	49.2$\pm$29.1	0.0001	52.5$\pm$36.0

Data are presented as n or mean$\pm$SD, unless otherwise stated. The mean best SNIP for all 20 sniffs (best $SNIP_{1–20}$) is also reported. SCI: spinal cord injury; DMD: Duchenne muscular dystrophy; A: adults; C: children.

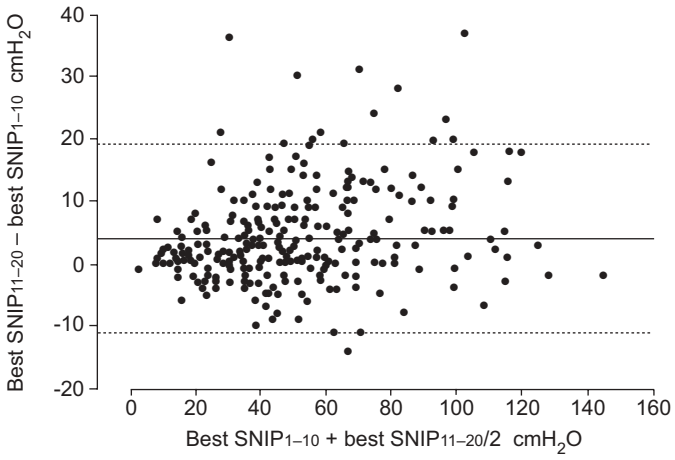

FIGURE 1. Difference between the best of the first 10 sniffs (best sniff nasal inspiratory pressure (SNIP)$_{1–10}$) and the best of the next 10 sniffs (best SNIP$_{11–20}$) plotted against the mean of these two variables.——: mean; ·····: 2SD. n=299.

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.

Out of the 231 patients with abnormal SNIP values when only the first 10 sniffs were considered, 19 patients had normal muscle strength when all sniffs were taken into account. Although this proportion is small, overdiagnosis 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, the present study confirmed the presence of a quick and significant learning effect within each session, when patients were given appropriate visual feedback and verbal encouragement. Thus, a more reliable maximum SNIP may be obtained with optimal technique, but this may require >10 sniffs.

Therefore, the current authors suggest using >10 sniffs when the sniff nasal inspiratory pressure value is slightly below normal or when sniff nasal inspiratory pressure is used to monitor a decline in inspiratory muscle strength.

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