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ORIGINAL ARTICLE

DIFFERENCES IN PEAK COUGH FLOW VALUES ASSESSED BY MOUTHPIECE AND FACEMASK ON HEALTHY SUBJECTS

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Background: Coughing is the most important mechanism for evacuating mucus secretions from the airways. Its efficacy directly depends on the Peak Cough Flow (PCF), which corresponds to the maximum air-flow generated during a cough. PCF is used to assess cough in patients with respiratory muscle weakness, mainly in neuromuscular diseases. This measurement is performed using a peak flow meter. However, the literature describes two forms of evaluation: one using a facemask or using a cylindrical mouthpiece and a nose clip.

Objective: The aim of this study was to analyze the differences in PCF values obtained when using a mouthpiece or a facemask in healthy subjects.

Methods: We recruited 42 healthy volunteers, of which 34 (16 men) were able to finish the study. The PCF was measured using both interfaces (PCFmouth and PCFmask) applied in a random order. At least three valid maneuvers were performed by each one of the subjects to obtain reproducible values.

Results: The population characteristics were: mean age 22.1 ± 2.3 years (range 18-29), 11 smokers (32.4%) and 12 subjects (35.3%) performed physical activity at least 3 times per week. The PCFmouth was 4.6% higher than the PCFmask (499.1 ± 114.5 vs. 477.9 ± 94.5 L/min), exhibiting a statistically significant difference ($p < 0.01$).

Conclusion: In a healthy population, there is a significant difference in PCF values obtained using a mouthpiece with a nose clip versus a facemask. Based on these results, we recommend using a mouthpiece to obtain the best peak cough flow measurement.

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INTRODUCTION

The peak cough flow (PCF) is a measure of the maximum air flow generated during a normal cough (1). Its intensity mainly represents the entrance of the air into respiratory system, the generation of pressure using the glottic closure and production of a violent expulsion by the abdominal musculature (2). The PCF is especially used to assess cough efficacy in patients with respiratory muscle weakness, particularly in patients with neuromuscular disease (3,4). Furthermore, it has been correlated with the success of extubation (5) and as a criterion for tracheostomy tube decannulation (6). The assessment of cough by measuring the PCF can be performed using a pneumotachograph (7) or with a portable flow meter (8). Pulmonary function laboratories commonly use peak flow meters to measure peak expiratory flow (PEF) because of simplicity and low cost (9). Patients generally perform the PEF measurement using a mouthpiece except when a patient's mouth cannot create the requisite seal (10).

In neurological or neuromuscular patients, characterized by weakness of the respiratory muscles, the PCF assessment is widely used by clinicians to assess the disease progression and fundamentally, the PCF is becoming an important tool in deciding the type of the assisted cough that is required to achieve the highest efficacy (1, 11). However, there are no comparative evaluation studies of PCF measurement using the different interfaces of a mouthpiece or a facemask. Trebbia et al. (12) observed in neuromuscular patients who air leakage was markedly lower when using a facemask in place of a mouthpiece. Other authors suggest the use of a mouthpiece is better, except in those with oral muscle weakness that prevents the proper closure of the lips on the mouthpiece (1, 6).

The aim of this study is to analyze the differences in PCF values obtained when using a mouthpiece or a facemask in healthy subjects. We hipothetized that the PCF using mouthpiece is higher than the PCF with facemask.

METHODS

Subjects

Volunteers were recruited from the campus of the University. The sample size was calculated based on prior literature (13), and the expected difference between PCFmouth and PCFmask was assumed to be 5%. A power calculation was performed using a Type I error probability of 0.05 and power of 0.8, the minimum number of patients needed for the study was calculated to be 26.

The subjects were university students, between 18 and 30 years old, with the ability to understand the instructions for performing the tests, and who agreed to participate and signed the consent form. Subjects with any respiratory diseases acute or chronic, neurologic or neuromuscular diseases, digestive diseases, fractures or recent rib cage injuries, facial paralysis or paresis, swallowing dysfunctions and those using medication that could alter respiratory muscle strength were excluded. The research was approved by the institutional board of our institution.

Characterization of the subjects

Before the tests, height and weight were recorded with a precision balance (SECA 225 and 861. SECA. Hamburg, Germany). Body Mass Index (BMI) was calculated, and subjects were also interviewed with questions regarding their lifestyle and physical activity level (defined as 30 minutes of moderous to vigorous physical activity at least 150 min/week(14)), as well as their smoking history (pack/year).

Peak cough flow measures

We evaluated PCF using a mechanical MiniWright peak flow meter (Clement Clarke International. Essex, United Kingdom) calibrated in liters per minute (L/min). For the PCFmouth evaluation we used a disposable cardboard mouthpiece and a nose clip. The subject was asked to close his mouth over the mouthpiece to prevent the leakage of air. For the PCFmask evaluation we used a Hudson model facemask (3 different size were selected to better adapt to the subject's face (90, 120 and 150 ml)) (Hudson, Temecula, CA, USA). The evaluator ensured the mask was well placed on the facial anatomy to prevent leakage of air.

Before the measurements were taken, the volunteers were instructed to perform a maximal inspiration, near to total lung capacity (TLC), followed by a quick, short and explosive cough through the peak flow meter. Subjects performed the test in a sitting position and avoiding bending movements during the maneuver. They repeated the procedure at least three times with each interface to ensure reproducibility. If the evaluator observed a

difference over 5% between two measurements, he encouraged the volunteer to undertake a new one. The value selected was the biggest among the reproducible measurements. Volunteers waited five minutes between each maneuver to minimize the fatigue effect. All maneuvers was performed by the same evaluator. The evaluator recorded the number of attempts needed to obtain reproducible data.

Simple randomization was performed to determine which of the two tests would be conducted first. A trained evaluator supervised all tests.

Statistical analysis

Statistical analysis was performed using STATA 11.1 (Stata Corp, College Station, TX, USA) software for Windows. To ensure a normal distribution of the data, the Shapiro Wilk normality test was applied. Data are presented as the mean and standard deviation. To evaluate the homogeneity of the variances the Levene test was applied. The analysis of differences between the groups was performed using a two-tailed, paired t test. The correlation between the PCFmouth and the independent variables was made by Pearson´s coefficient for continues variables and Spearman´s coefficient for categorical variables. Differences of $p<0.05$ were considered statistically significant.

In addition, a post hoc power calculation based on the number of participants was calculated using the statistical software of G*Power. We choose a principal variable (PCF) for the analysis (15).

RESULTS

A group of 42 volunteers were recruited and 37 met the inclusion criteria. Three subjects were eliminated during the test because of a misunderstanding of the instructions and the assessment process (Figure 1).

The final sample was composed of 18 women and 16 men, whose average age was 22.1 ± 2.3 years (range 18-29). Descriptive characteristics of the volunteers are presented in Table 1.

Figure 1. Subjects selection flow chart

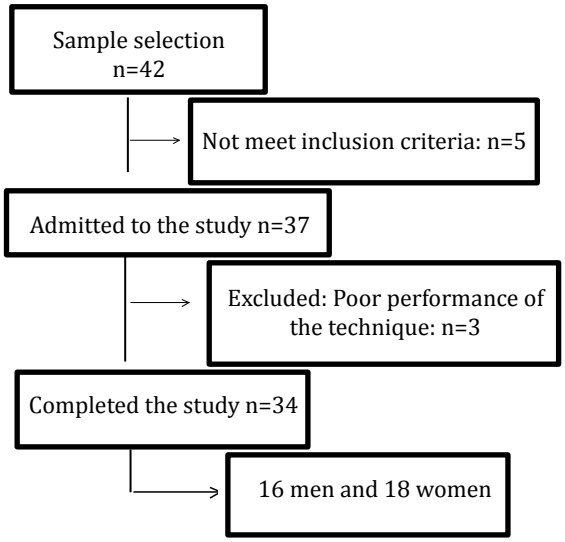

Table 1. Baseline participant´s characteristics. Values are presented in mean ± standard deviation (SD). BMI: body Mass Index.

	Mean ± SD
Age (years)	22.1 ± 2.3
Weight (Kg)	69.4 ± 17.3
Height (m)	1.65 ± 0.1
BMI	25.2 ± 4.1
	n (%)
Gender: male/female	16/18 (47.1 /52.9)
Smokers	23(67.6)
Sedentary	22 (64.7)

The PCFmouth values obtained were 4.6% higher than PCFmask values (499.1 ± 114.5 vs. 477.9 ± 94.5) showing a significant difference, $p<0.01$ (Table 2).

We proceeded to a post hoc analysis by dividing the sample into subgroups by gender, tobacco smoking and physical activity level (Table 2).

Table 2. Peak cough flow values comparing different subgroups.

		PCFmouth (L/min)	**PCFmask** (L/min)	p
Total group	(n = 34)	499.1 ± 114.5	477.9 ± 94.5	< 0.01
Women	(n = 18)	410.6 ± 44.5	418.9 ± 47	ns
Men	(n = 16)	598.8 ± 81.1	544.4 ± 90.8	< 0.01
Smokers	(n = 11)	512.7 ± 142.6	487.3 ± 127.7	ns
Nonsmokers	(n = 23)	492.6 ± 101.4	473.5 ± 76.9	< 0.05
Sedentary	(n = 22)	471.4 ± 119.9	455.0 ± 91.1	ns
Non-sedentary	(n = 12)	550.0 ± 86.8	520.0 ± 89.2	< 0.05

PCFmouth: peak cough flow obtained during the assessment maneuver with a mouthpiece; P

CFmask: peak cough flow obtained during the assessment maneuver with a silicone face mask.

In the non-smoking group, the PCFmouth values were 3,9% higher ($p < 0.05$) than the PCFmask values. In those subjects that had regular physical activity the PCFmouth values were 5.8% higher than the PCFmask values ($p=0.02$).

Moreover, we analyzed the correlation between the continuous dependent variables and the PCF values obtained with both interfaces. For both the PCFmouth and PCFmask values, the variable with the highest rate of Pearson´s correlation was height (0.77 and 0.70, respectively). Don´t found correlation in categorical dependent variables.

On the other hand, the analysis of the number of attempts needed to achieve good reproducibility with both maneuvers showed that 79% of subjects using the PCFmask and 71% of the subjects using the PCFmouth required 4 or fewer attempts.

Finally, we calculate the actual statistical power of our study was 82% considering a variation of 21.2 and a confidence level of 99%.

DISCUSSION

In a group of young healthy subjects, the PCF values obtained with a mouthpiece are significantly higher than those obtained using a mask interface.

We do not find any study to assess PCF mouth vs PCFmask, but the evaluation of PCF was consistent with previous studies of spirometry and muscle strength (13,16), showing that PCF values from subjects evaluated using a mouthpiece were higher than those using a facemask. Our data are consistent with those shown by Fregadolli (13), who evaluated 52 healthy subjects with similar characteristics and found similar results, who evaluates pressures mouth through mouthpiece and facemask. The differences observed between the two interfaces could reflect the increased likelihood of air leakage from the facemask, which requires more contact points on the face to ensure a proper seal. In addition, there is greater dead space within the facemask. Likewise, PCF values obtained from males significant different depending on the technique. However, this effect was not observed in females, whose values were higher using the facemask technique, although this difference not statistically significant. This could be explained, in part, by the higher

flow rates in men (528 ± 50 L/min) compared with the generally lower flow rates in women (410 ± 10 L/min),

PCF values did not correlate with the consumption of tobacco, which could be explained by the fact that the subjects were young (22.1 ± 2.3 years) with a very short smoking history that had not yet altered their lung function. In addition, our sample size might have been too small to detect a correlation. It would be interesting to conduct a further study that evaluates smokers versus non-smokers, but in a larger sample of older subjects. Physical activity was not significantly correlated with the PCF values of the sample. However, the subjects that performed physical activity averaged 5.8% higher PCF values using the mouthpiece interface versus the facemask. Taken together, these results strengthen the observation that the mouthpiece is more effective for measuring PCF than the facemask.

The PCF test evaluation using different interfaces, either a mouthpiece with nose clip or a facemask proved to be easy to implement and execute. In our study using both interfaces, more than seventy percent of the subjects required 4 or fewer attempts to obtain reproducible values. It is important to note that these subjects were young and healthy. However, patients would most likely require additional attempts. Nonetheless, it is plausible to expect reproducibility over 50% of patients tested.

The evaluation of the PCF is essential in people with neuromuscular diseases (17). Many of these patients have weakness in the facial muscles and usually, they cannot make a proper seal with the lips on the mouthpiece. That is why, in this population, using a mouthpiece or a mask is not questioned. However, in the significant number of patients who can perform a proper shutdown of the mouth (spinal cord injury, post-surgery, chronic obstructive pulmonary disease, stroke, etc.), the mouthpiece will yield the best PCF values (7,18,19,20).

Our study has a small sample, but it is higher than the sample size initially established. The real statistical power of our data was 82%, so our results do not opaque. From the above, we can say that the study has sufficient power for correct analysis of the data.

The limitations of this study include the assessment of the subjects' health status using a survey, which can potentially mask adverse health situations that are unknown to them. We further believe that the number of subjects who smoke and those that perform regular physical activity was limited and as such, including additional subjects in these groups may modify our results. In addition, extrapolation of the results to patients with different diseases could be limited because of age, physical condition, cough inefficiency or the inability to close the mouth. The aim of our study is to highlight the differences in between these two measuring interfaces and provide a rationale to clinicians for choosing the best interface for assessing PCF in their patients.

CONCLUSION

From our data, we conclude that there is indeed a difference in evaluating PCF using a mouthpiece and nose clip versus a facemask interface in healthy subjects.

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COMPETING INTEREST

The authors declare no conflict of interest

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