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# Anxiety During Respirator Use: Comparison of Two Respirator Types

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*Anxiety may interfere with proper respirator use. This study directly compares the effect of two types of respirators—elastomeric half-face mask with dual-cartridges (HFM) and N95 filtering facepiece—on anxiety levels. Twelve volunteers with normal or mildly impaired respiratory conditions performed a series of simulated work tasks using the HFM and N95 on different days. The State-Trait Anxiety Inventory (STAI) measured state anxiety (SA) before and during respirator use. STAI also measured trait anxiety (TA), a stable personal characteristic. The effect of the respirator was measured as the difference between SA pre-use and during use. Work with HFM was associated with an increase in SA (2.92 units, $p < .01$), whereas work with the N95 had no observed effect. Anxiety should be considered in the selection of the best respirator for a user. Impact on anxiety should be considered for respirator design and certification purposes, particularly if the device is to be widely used in workplace and community settings.*

**Keywords** anxiety, personal protective equipment, respirator

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## INTRODUCTION

Effective protection by respirators depends on proper and consistent use. Studies have suggested that respirators may induce or worsen anxiety[1–3] and that 10% of potential users have psychological problems interfering with their use. Understanding the significance of respirator-related anxiety is important for encouraging proper use and for identifying workers who should not use respirators.[1,4,5] In addition, respirators should be designed to minimize anxiety.

Several investigators previously studied whether an individual's characteristic tendency toward anxiety predicted his or her tolerance for respirator use, suggesting that assessment of a worker's anxiety might be a useful medical tool for precluding certain workers from respirator use.[1,2,4] The current study, in contrast, focuses on the respirator type itself rather than viewing anxiety as a worker fitness issue. We conducted the study to evaluate the impact of respirator use on anxiety induction and to compare two commonly used respirator types (elastomeric half-face mask with dual cartridges, and filtering facepiece N95). The study was part of a series of experiments to assess respirator effects during both simulated work and exercise in a laboratory.

## METHODS

The research project was approved by the institutional review boards of the University of California, Los Angeles (UCLA) and the Greater Los Angeles Veterans Administration Medical Center. Research subjects were recruited from newspaper advertisements, physician contacts, and the ambulatory clinics of the West Los Angeles Veterans Administration Medical Center. Subjects were compensated for participation. Recruitment targeted subjects with both normal lung function and with mild manifestations of chronic obstructive pulmonary disease (COPD), asthma, or chronic rhinitis. Specific criteria are described in detail elsewhere.[6]

Each subject underwent a limited medical examination prior to participation. The 12 subjects in the study were among a larger number who participated in the overall project. (Data from an additional subject were excluded from the primary analysis because he showed an extreme outlier value in one specific period. A secondary analysis was conducted including him, and the overall results remained the same.) The subjects in this study were not specifically selected for this component; rather, they include all subjects who participated in the project over a specified time during which the anxiety measurement scales were incorporated in the protocol.

Each subject participated on three days. On one day, studies were done using respirator surrogate loads in a pulmonary

exercise laboratory setting; these data were not included in this report. On the two other days, each subject completed a series of eight simulated work tasks, each lasting 8–10 min with short breaks allowed between each task. The tasks included activities such as sorting bolts while seated, computer-simulated vehicle driving, and carrying items/stocking store shelves. The tasks were sedentary or required low to moderate exertion.[6–8] On one day, the subject used a filtering facepiece N95 respirator without valve (Model 8510; 3M, St. Paul, Minn.), and on the other day the subject used a dual cartridge half-face mask (HFM) device (Comfo-Elite with P100 cartridge; MSA, Pittsburgh, Pa.). The order of days and the order of tasks within days were randomized.

Several categories of effects were recorded, including respiratory volumes and timing using a respiratory inductive plethysmograph, heart rate, work productivity, and multiple subjective response scales. Results of these tests on the overall study population, which included all of these subjects as well as many others, are reported separately.[6–9]

Anxiety was measured with the State-Trait Anxiety Inventory (STAI),[10] which is a standardized psychological instrument that includes two sets of questions. One set of questions measures trait anxiety (TA), which is a stable characteristic of the individual. The other set of questions measures state anxiety (SA), designed to reflect the anxiety level at the specific time of measurement. Each set was composed of 20 questions. This psychological instrument has been widely used and has extensive normative data. The composite score for SA and TA is calculated using standardized weightings where a high test score reflects a high level of anxiety. The test was administered on paper.

The TA inventory test was administered prior to initiating the study. The SA instrument was administered four times to each subject: On each of the two work simulation experimental days, it was administered prior to beginning work with the respirator (Pre); it was also administered at the midpoint of the work simulation using the respirator, immediately after completing the fourth task (During). Thus, on each day, the difference between the Pre and the During SA score represents the increment due to respirator use.

The effect of work with each type of respirator use was calculated for each subject as the difference between the Pre and During SA scores. This was calculated separately for the N95 and the HFM. In addition, the difference between the effects of respirator type was expressed as the difference between the increment for the HFM and the N95 for each subject. For a pilot assessment, the analyses were then repeated separately for the subjects with and those without respiratory disease. (This was done to assess patterns rather than in anticipation of statistically significant effects in view of the small sample in each subcategory.)

Data were managed using a relational database (Microsoft Access). Analyses were conducted using SAS for PC (version 9.1; SAS, Cary, N.C.). Statistical significance of differences was determined by t-tests, using group comparisons or paired t-tests as appropriate. A $p < 0.05$ was considered statistically significant.

## RESULTS

The participating subjects included six men and six women. The average age was 36.33 years (range 21–54 years). Of the group, eight had early respiratory disease (including chronic obstructive pulmonary disease [COPD], asthma, or chronic rhinitis); four had no identified respiratory disorders. All subjects successfully completed the study.

Pre state anxiety scores for the group averaged 26.54. Trait anxiety scores averaged 31.24 for all participants. These scores were consistent with normative standards[10] and results for respirator research subjects of Morgan[4] and Wilson.[1] For perspective, neuropsychiatric patients hospitalized for anxiety had average TA scores of 48; hospitalized patients without psychiatric problems averaged 43.[10]

Table I summarizes the effects of respirator use on SA. The HFM led to a statistically significant increase in SA, whereas there was no demonstrable effect of N95 use. Furthermore, the table directly compares the two respirator types by comparing the change due to N95 to the increment due to HFM in each individual. There was a highly statistically significant difference.

Table I also shows the same data stratified by respiratory disease status. Although the subsamples were too small to meaningfully assess statistical significance, there does not appear to be any distinct difference between the two subject groups.

Figure 1 shows that there was no relationship between TA and the increment in SA due to use of the HFM ($r = 0.14$). Trait anxiety, however, has a borderline significant relationship with baseline SA (average of Pre SA for N95 and HFM) ($r = 0.52$, $0.05 < p < 0.10$). There was no statistically significant correlation between TA and level of SA during HFM use ($r = 0.38$, $p > 0.10$). The lack of statistical significance may be due to the small sample size.

The statistical analyses and graphs were based on 12 subjects. One additional subject had an extremely large increment in anxiety during HFM use (+23), whereas the maximum for all other subjects was +8. Analyses including the subject showed comparable statistical significance to those reported. (The investigator supervising the study reported that the subject did not appear to have qualitatively greater anxiety, and it is therefore not possible to differentiate whether he was an extremely sensitive individual or completed that single questionnaire inaccurately.)

## DISCUSSION

The study investigated whether respirator designs differ in their impact on anxiety. The study compared two types of respirators (elastomeric half-face mask with dual cartridges and N95 filtering facepiece). The results show that in

**TABLE I. Effect of Respirator on Anxiety**

| | All Subjects | | No Respiratory Disease | | Respiratory Disease | |
|---|---|---|---|---|---|---|
| | Respirator Use Effect Increment Δ(During-Pre) | | Respirator Use Effect Increment Δ(During-Pre) | | Respirator Use Effect Increment Δ(During-Pre) | |
| | ΔN95 | ΔHFM | ΔN95 | ΔHFM | ΔN95 | ΔHFM |
| Mean | –0.17 | 2.92 | –0.25 | 3.00 | –0.13 | 2.88 |
| SD | 3.43 | 3.00 | 0.96 | 3.56 | 4.26 | 2.95 |
| P | 0.87 | 0.01 | 0.64 | 0.19 | 0.94 | 0.03 |
| | Respirator Type Difference | | Respirator Type Difference | | Respirator Type Difference | |
| | Δ(ΔHFM—ΔN95) | | Δ(ΔHFM—ΔN95) | | Δ(ΔHFM—ΔN95) | |
| Mean | 3.09 | | 3.25 | | 3.00 | |
| SD | 3.20 | | 2.99 | | 3.51 | |
| P | 0.01 | | 0.12 | | 0.046 | |

*Note:* Respirator use effect is described as the increment in state anxiety by respirator use during use of the N95 and the HFM devices. In addition, the effect of respirator type is shown as the difference in increments. The data are also shown for those without respiratory disease (four subjects) and those with respiratory disease (eight subjects).



comparison with an N95 device, working with an HFM respirator was associated with a significantly greater increment in SA. However, because the study was conducted among subjects with normal anxiety scores and without underlying anxiety disorders, this does not imply that anxiety should not be considered in preplacement evaluations of all respirator users, particularly since anxiety disorders are common, affecting 18% of adults in any year.[11]

This study contributes to the understanding of respirator tolerance. Unlike several previous studies, it directly compares two types of respirators rather than focusing on whether use of a single type of respirator increases anxiety. Hence, this study is particularly relevant for comparing designs and for addressing the question "which respirator is best for an individual?" rather than "should he/she be certified to work using a respirator?"

The increment in SA was 3.09 greater for HFM use than for N95 use ($p < 0.01$). When applied to an individual, a difference of this magnitude is unlikely to be clinically significant because of the variability among members of the general population; for example, the standard deviation of SA was 10.4 in a large study of working adults.[10] However, it is likely to be significant when comparing respirator designs for several reasons. First, the studies of Morgan[4] and Wilson,[1] using atmosphere supplying respirators (full-face mask with either SCBA or airline configuration), concluded that a difference of only seven points in TA could effectively predict "respiratory distress." Less severe impacts on tolerance and proper utilization may well occur with smaller differences.

Second, the observed HFM-N95 difference may underestimate the true difference since the STAI instrument, depending

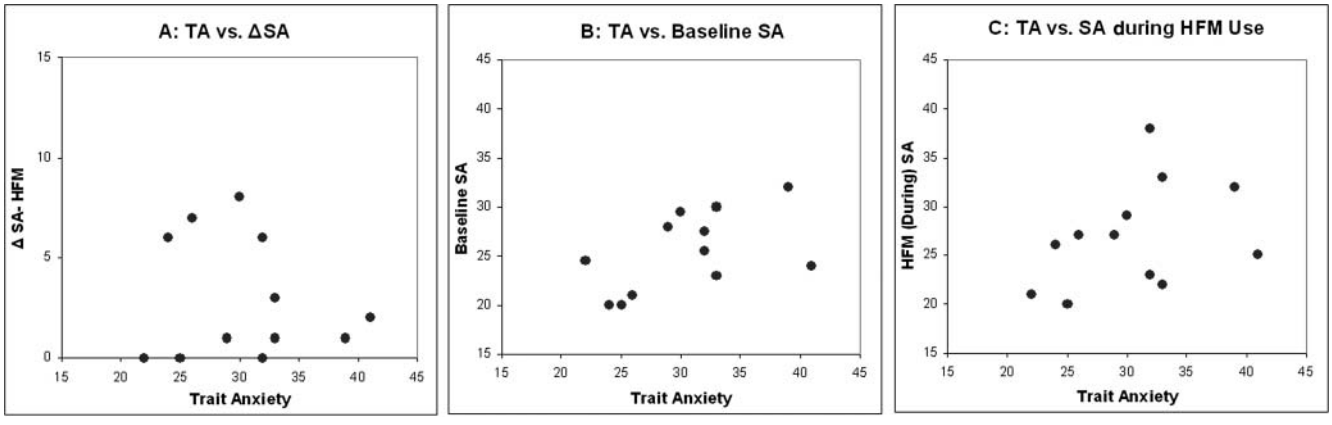


**FIGURE 1**. Trait anxiety (TA) and state anxiety (SA) relationships. Panel A shows the relationship between TA and the incremental effect of HFM respirator use (ΔSA—HFM) per se. Panel B shows the relationship between TA and baseline SA; Panel C shows the relationship between TA and SA during HFM use.

on a small number of self-administered questions, includes considerable noise of measurement. Imprecise measurements bias results toward the null may lead to underestimation of the true magnitude. Third, when comparing overall impact, differences in anxiety may be additive to differences in measures of physiological and subjective effects. Fourth, none of the studies reported, including ours, has sufficient sample sizes to precisely estimate the proportion of persons who will be unusually sensitive.

Several investigators have suggested that anxiety is a significant problem for many respirator users. Morgan estimated that psychological problems interfere with respirator use in approximately 10% of users.[3] Other investigators measured anxiety and found that there were changes related to respirator use when compared with not using respirators.

Persons who are more anxious than average may be particularly prone to adverse subjective effects of respirator use. For example, TA was associated with reduced exercise performance using a full-facepiece military respirator and with reporting of symptoms, perhaps due to the respirator's size or confining nature.[2,12] Other studies have shown that TA partially predicts development of significant respiratory distress with respirator use in the laboratory setting.[1,4] Some respirator studies have included questions about change in anxiety, although they did not incorporate a standardized instrument.[13]

Anxiety during respirator use may occur for several reasons. First, using a respirator may produce anxiety in a nonspecific fashion. For example, some authors have described "claustrophobia," presumably related to presence of the mask itself. Simply putting a mask on someone's face has been shown to lead to changes in respiratory pattern, possibly reflecting anxiety or other nonphysiological response.[14,15]

Second, the laboratory protocol or method of measuring anxiety may itself increase anxiety. A study of respirator use for 8 hr showed a progressive increase in anxiety both with and without the respirator.[16] In the current study, however, methods were the same for both respirator types as well as for the pre-use and during-use measurements. The research staff was particularly careful to avoid any biasing statements. Therefore, it is unlikely that the observed effects are due to nonspecific factors. Nonspecific effects of testing per se could not account for the differences between respirator types.

Third, physiological and subjective effects induced by the respirator use rather than the respirator itself may be the cause of anxiety.[1,17,18] This mechanism differs from the first in that designing respirators to limit the physiological changes would remediate the anxiety. For example, the increased work of breathing to overcome respirator resistance and dead space loads might be sensed and lead to an anxiety response. A comparable effect of physiological worsening on anxiety and panic has been shown among asthmatics.[19,20] Respirator use may also lead to carbon dioxide retention. Laboratory studies have identified some subjects with $CO_2$ retention when using reusable elastomeric air-purifying respirators or filtering facepiece devices.[21]

In addition, this possible mechanism may be associated with a positive feedback loop. Physiological changes may be induced by anxiety; this was suggested by a study of experimentally induced stress.[18,22] Individuals who have significant anxiety may have atypical respiratory patterns[23] and may adapt to respirator use in a manner that increases the physiological impact. Thus, respirator use may induce physiological effects, which induce anxiety, which in turn induces further physiological changes.

Fourth, the workplace situation requiring the respirator use might be the cause of anxiety. In actual application, respirators are used only when there is a significant health hazard. Therefore, the requirement to use a respirator indicates a health threat situation, and the perceived health threat rather than the respirator itself may cause anxiety. This mechanism was not relevant to the current study. The subjects were aware that there was no actual exposure-related health threat. Furthermore, the tasks and conditions were exactly the same for both respirators, yet the increase of anxiety only occurred for the HFM type.

Fifth, some respirator types may be perceived as more threatening. Comparing the use of N95 and HFM, higher anxiety from HFM use may be attributed to the association of the larger respirator with more threatening situations, as portrayed by popular film and media. Based on seeing medical staff using surgical masks and media's portrayal of N95 use during the cold and flu season, severe acute respiratory syndrome (SARS) epidemic, and Hurricane Katrina, subjects may be familiar with the use of N95 respirators, but HFMs are rarely seen except in more specialized situations that may be perceived as more threatening. The use of unfamiliar protective gear may induce anxiety.

This study demonstrates that there is an effect of the respirator itself; however, it does not distinguish between the third and fifth mechanisms. Since the HFM devices produced significantly greater physiological and subjective effects than the N95 filtering facepiece types,[6,7] the difference between the respirators' anxiety effect might be due to direct perception or be mediated by physiological or subjective effects of respirator use. The practical implications are the same—respirator design and preplacement assessment of users should consider anxiety. The effects in actual use may be greater than in the laboratory if the nonspecific perceived threat effects are synergistic with the effects of respirator type per se.

Results were unlikely to be limited to the specific tasks during which measurements were made, since both the order of experimental days (i.e., which respirator was used first) and the order of tasks within experimental day were randomized. Subject characteristics were unlikely to account for the observed effects in view of the repeated measures design in which all subjects used both respirator types. Subjects with and without respiratory disease showed a comparable pattern of response. As shown in Figure 1, the incremental effect of respirator use was not limited to inherently anxious individuals.

Anxiety was measured using a relatively simple, well-validated instrument (the STAI).[10] It was particularly advantageous for this study because this instrument was sensitive to

short-term changes in state anxiety and has been widely used in respirator research.[1,2,4] Random error or insensitivity of the instrument would bias results toward the null but would not lead to statistically significant differences.

The study directly compared use of two types of respirators but did not include test performance with no respiratory protection. It is therefore theoretically possible that the observed difference in anxiety increment between the HFM and the N95 was due to anxiety reduction by N95 use rather than anxiety increase by the HFM.

Since these results are based on relatively short-term use, it is possible that anxiety would change during longer-term use. Furthermore, in traditional workplace settings, workers who develop significant anxiety responses to respirators may tend to self-select to leave jobs requiring respirator use. At least, theoretically, preplacement evaluations for anxiety could identify at risk workers and avoid assigning them to jobs requiring respirator use.[5,24,25] Several investigations suggested that trait anxiety predicted the ability to use a self-contained breathing apparatus (SCBA).[1,4]

However, when respirators were used intermittently or were rapidly deployed for a large number of users (e.g., for SARS, influenza epidemic, or terrorism fears), the traditional paradigm of medical evaluation and self-selection would not be applicable. In addition, while earlier studies were designed to identify persons who should be excluded from jobs requiring respirator use,[1,4] the current study focused on helping to select the optimal respirator for an individual, since respirator use may be mandatory under modern circumstances.[26]

Sample size was adequate for comparing anxiety during work with the two respirator types. However, a much larger sample would be necessary to determine if there is a small subpopulation that has extremely different patterns of response, such as being much more susceptible. For example, studies of carbon dioxide tensions during respirator use identify subjects with potentially clinically significant elevations, even though the overall average effect is not statistically significant.[21,27]

## CONCLUSION

The increment in anxiety level differed between the two types of respirators studied. Simulated work performance with the HFM was associated with higher anxiety levels than with the N95. When recommending the optimal respirator for an individual, assessment of potential impact on anxiety may guide the selection process. In some instances, there may be a trade-off between a higher respirator protection factor and the likelihood that the user will actually employ the device when needed. In addition, impact on anxiety may be a significant factor to include in the evaluation and certification of new respirator models.

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