The Importance of Fit-Testing Particulate Filtering Facepiece Respirators!

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Abstract

Filtering facepiece respirators should protect people in healthcare settings and in research and diagnostic laboratories from infection from biological agents or from other hazardous particles. To ensure sufficient personal protection, a properly fitting respirator is imperative. However, data about the usefulness of testing the proper fit of such respirators conflict. Some data from health care settings indicate no difference in performance when the respirators were fit-tested or not fit-tested, but other data suggest better performance when respirators were fit-tested. The goal of this study was to quantitatively test in a laboratory environment the fitting of different filtering facepiece type 3 (FFP3) respirators from various manufacturers and to determine the parameters that are important for a good fit-factor. Another aim was to identify the best-fitting respirator for individuals who wear FFP3 respirators during their daily work in a laboratory/animal room environment. The quantitative fit-testing of respirators was performed using a TSI Portacount®Pro+ Respirator Fit Tester (TSI Incorporated, Shoreview, MN). Fourteen individuals at two different Swiss institutions were tested with 10 different commercially available FFP3 respirators. Only 2 of 14 individuals passed the fit-test with all 10 respirators, and 2 of 14 individuals passed the fit-test with only three respirators. Performance of the respirators varied greatly for the different individuals, and the findings show that several factors contribute to the fitting of a respirator, such as the type of the respirator and the proper donning of the respirator. Study results confirm that a respirator fit-test is necessary because workers often fail to achieve sufficient protection with their respirators.

Keywords

Personal Protective Equipment, Quantitative Fit-Testing, Filtering Facepiece Type 3 (FFP3) Respirators, and Variation

Introduction

Personal protective equipment (PPE) is—after engineering and operational/administrative controls—the last barrier to protect personnel from exposure to biological agents or other dangerous particulate substances. The use of respirators is an important consideration in healthcare and diagnostic research settings where aerosols pose a high risk of infection by a biological agent (MacIntyre, 2013) to workers. Non-powered, air-purifying particulate-filter respirators must adhere to certain certification requirements. In the United States (U.S.), the National Institute for Occupational Safety and Health (NIOSH) 42 CFR 84 regulation defines nine classes of filtering facepiece (FFP) respirators (three levels of filter efficiency, each with three categories of resistance to filter efficiency degradation). The three levels of filter efficiency are 95%, 99%, and 99.97%. The three categories of resistance to filter efficiency degradation are labeled N (for Not resistant to oil), R (for Resistant to oil), and P (for oil Proof). Therefore, an N95 FFP respirator is not oil-resistant and retains 95% of the penetrating particles. In the European Union (EU), FFP respirators must meet the requirements of the norm EN149:2001 + A1:2009 that defines three categories of respirators (FFP1, FFP2, and FFP3) characterized by maximum filter penetration levels (20%, 6%, and 1%, respectively) and by maximum total inward leakage levels (22%, 8%, and 2%, respectively). Typically, an FFP2 respirator retains 94% of the penetrating particles and shows a total inward leakage of maximally 8%. Since the U.S. and the EU standards are based on different definitions, one could argue that finding a direct equivalence between N-type respirators and FFP-type respirators is difficult. However, one can reasonably interpret the definitions and extrapolate that N95 and N99 respirators are equivalent in performance to FFP2 and FFP3 respirators, respectively. Respirators available on the Swiss market must comply with the EN standards.

The wearing of a respirator should always be based on risk assessment, i.e., on the user’s intended activity. Whenever a biological agent can be aerosolized during a process, and if it poses a risk to human health, the wearing of a respirator should be considered. In general, the wearing of a respirator is not required for activities at biological safety levels 1 and 2 (BSL-1 and BSL-2), but is required for BSL-3 and BSL-4 work and in work environments where a risk of allergen exposure exists (U.S. HHS, 2009). However, FFP3 respirators are intended to be worn for rather short periods of time, less than 2 hours, because the humidity from exhaled breath and thermal burden softens the skin at the contact points and renders the respirator uncomfortable to wear (Roberge et al., 2011; Roberge et al., 2012). In the case of activities longer than 2 hours, switching to a powered air purifying respirator (PAPR) may provide better aerosol protection.

According to research, surgical masks, pre-shaped dust masks, and bandanas offer very little protection (Bowen, 2010) against aerosolized infection. This was also shown in a study in Asia in a health care environment where more than 1,900 hospital workers were asked to wear surgical masks, fit-tested or not fit-tested N95 respirators, or no respirators (MacIntyre, 2011). The authors concluded that surgical masks had no protective effect; that is, the results
were similar to wearing no aerosol protection. N95 respirators were linked to a 56%-75% reduction in influenza infection. Surprisingly, the researchers found that fit-testing of the N95 respirators did not significantly increase protection compared to the non-fit-testing respirator group. However, limited data are available about the value of fit-testing respirators in a laboratory/research environment, although in some countries, like the U.S., requires fit-testing prior to respirator use (OSHA respirator regulations 29 CFR 1910.134).

Fit-testing can be done either in a qualitative or quantitative way. Qualitative fit-testing can be performed in an easy and inexpensive way by testing whether the individual wearing the respirator tastes a sweet or bitter chemical on the tongue. No detection of the chemical on the tongue indicates a proper fit of the respirator. As a drawback, this qualitative test sometimes fails due to a person’s insensitivity to tasting the chemical indicator. Respirator fit can be established quantitatively by comparing particle concentrations inside the respirator to particle concentrations outside the respirator. This can be done using a Condensation Nucleus Counter such as the TSI Portacount® Pro+ Respirator Fit Tester (TSI Incorporated, Shoreview, MN). To quantitatively assess the fit-factors of FFP3 respirators in a laboratory environment and possible other factors determining individual protection, the Institute of Virology and Immunology (IVI) and the Swiss Technological Institute in Lausanne (EPFL) performed a quantitative fit-test study with individuals who normal work in a BSL-3 or BSL-3 Agriculture (BSL-3Ag) laboratory environment and wear these respirators during their work activities. The IVI is a high-containment facility (BSL-3Ag) and is the Swiss Reference Laboratory for the detection and analysis of highly contagious animal diseases. The EPFL is an internationally highly recognized research institution working with many different biological agents at biological safety level 2 and 3. Each individual performed the fit-testing with 10 different commercially available FFP3 respirators.

Materials and Methods

**FFP3 Respirator Test Group**

Fourteen individuals participated in this study: 8 females and 6 males. Workers with prior experience wearing FFP3 respirators in their daily work in BSL-3/BSL-3Ag environments were approached to participate. Individuals without prior FFP3 respirator use were excluded from the study. Fit-testing exercises were performed according to the availability of the personnel; that is, sometimes people performed five fit-tests with five different respirators in succession and sometimes several days elapsed between each fit-test. All study subjects were nonsmokers or were not allowed to smoke 1 hour prior to the test because smoke particles could negatively influence the test results. Study subjects were shown how to put on the respirator, how to position it on the face, how to set strap tension, and how to determine the proper fit of the respirator in accordance with the recommendations of the manufacturer.

**Definitions**

**Filtering facepiece (FFP):** A negative-pressure particulate respirator or filtering facepiece respirator with a filter as an integral part of the facepiece or with the entire facepiece composed of the filtering medium (Bollinger, 2004).

**Fit-factor:** A quantitative measure of the fit of a specific respirator facepiece to a particular individual (Bollinger, 2004) by calculating the ratio of particles inside the respirator to the number of particles outside the respirator, when the respirator is worn.

**Quantitative fit-testing:** An assessment of the adequacy of respirator fit by numerically measuring the amount of leakage into the respirator (Bollinger, 2004).

**Total leakage rate:** According to NIOSH, the maximum total leakage rate of a worn respirator for N95, N99, and N100 type respirators is 10% with a minimal retention of 95%, 99%, and 99.97% for a NaCl test aerosol, respectively. According to “Deutsches Institut für Normung” (DIN) EN149, the maximum total leakage rates for FFP1, FFP2, and FFP3 respirators are 22%, 8%, and 2% with a minimum retention of 80%, 94%, and 99% for a NaCl test aerosol, respectively (Dreller et al., 2006). For a FFP3 respirator, a 2% total allowed leakage rate corresponds to a minimum fit-factor of 50.

**Quantitative Particle Counting**

The detection of particles inside and outside the respirator was performed using a TSI Portacount® Pro+ Respirator Fit Tester Model 8030 (TSI Incorporated, Shoreview, MN). This device grows submicron particles to supermicron alcohol droplets and then measures the concentration of the alcohol droplets. This makes the PortaCount Pro Fit Tester sensitive to particles with diameters as small as 0.015 microns, but insensitive to variations in particle size, shape, composition, and refractive index. Thus, quantitative fit testing can be performed with virtually any aerosol, including ambient air.

Each fit-test exercise consisted of these seven steps:

1. **Normal breathing**
2. **Deep breathing**
3. **Head movement side-to-side**
4. **Head movement up and down**
5. **Loud reading of a text**
6. **Bending over (while standing)**
7. **Normal breathing**

The duration of each step was approximately 60 seconds (20 seconds purging cycle and then 40 seconds measuring particles inside and outside of the respirator). With the exception of step 6, individuals were sitting on a chair in an office during the fit-test exercise.

The overall fit-factor was calculated by the software of the PortaCount Pro Fit Tester (FitPro+™ Fit Test Software) following the OSHA protocol 29 CFR 1910.134 according to the following formula:

\[
\text{Overall fit-factor (FF)} = \frac{1}{\frac{1}{\text{FFP1}} + \frac{1}{\text{FFP2}} + \frac{1}{\text{FFP3}} + \frac{1}{\text{FFP4}} + \frac{1}{\text{FFP5}} + \frac{1}{\text{FFP6}} + \frac{1}{\text{FFP7}}}
\]
Performing this mathematical equation means that low fit-factors influence the outcome of the overall fit-factor much more than high fit-factors.

Measurements had to be performed when >1,000 particles /cm² were available in the room to have a proper quantification of particles and fit-factors (preset level of the PortaCount particle counter). If the number of particles was not present, an aerosol generator (TSI Model 8026 Particle Generator, TSI Incorporated, Shoreview, MN) was used to produce sufficient NaCl aerosol particles. All respirators were worn once in the quantitative fit-test, and a test was considered to be passed if the overall fit-factor was above 50.

**FFP3 Respirators**

FFP3 respirators were purchased according to availability from four different manufacturers in Switzerland (Figure 1). Eight out of 10 respirators had an exhaust valve and 4 out of 10 respirators (respirators 1, 2, 5, and 9) had a rubber seal around the respirator body to improve the fit between the skin and the respirator. In addition, 6 out of 10 respirators had an adjustable headband, and four were specified as reusable, four as non-reusable, and two had neither indication (Table 1).

**Results and Discussion**

To show the importance of fit-testing filtering facepiece respirators in a high-risk laboratory environment, the authors tested 14 BSL-3/BSL-3Ag workers with 10 different FFP3 respirators. The comprehensive data from this study is shown in Table 2, which summarizes the overall fit-factor of all respirators tested by all individuals. Firstly, the table shows that all respirators tested in this study can be used (i.e., had an overall fit-factor >50) by only two individuals (A and J), and that none of the respirators provided a sufficient level of protection to all individuals participating in the study. Secondly, two respirators (respirators 2 and 5) provided a high level of protection (overall fit-factor >500) to a larger group of individuals (A, B, C, E, and G for respirator 2; A, E, H, K, L, and M for respirator 5). However, a series of elevated overall fit-factors does not necessarily imply that the respirator will fit most of the users. For example, in the case of respirator 5, five individuals (B, C, D, I, and N) did not pass the fit-test (i.e., had an overall fit-factor <50).

In 7 out of 10 respirators, an overall factor >500 was observed in at least one of the individuals, with the maximum fit-factor reached for individual E at 5,120 (respirator 5). However, individual E had poor overall fit-factors for other respirators: 37 (respirator 4), 36 (respirator 7), 29 (respirator 8), and 13 (respirator 10), indicating that these respirators are not suitable for this person.

In a second step of the data analysis, individuals with the best and the worst results were the focus. Table 3 shows the two individuals with the best (individuals A and J) and the two individuals with the worst (individuals D and N) overall fit-testing results. Individuals A and J passed the fit-tests with all the respirators, whereas individuals D and N failed in 7 out of 10 fit-tests. Although individuals A and J passed all fit-tests, a considerable differences were evident in the fit-testing results depending on the type of respirator worn and the type of exercise performed. For those two individuals, most of the highest fit-testing values were obtained in the “normal breathing” step, and the highest scores were obtained with respirator 5 for both individual A (with a fit-factor of 4,880) and individual J (with a fit-factor of 32,200). Interestingly, the lowest fit-factor results were obtained in 7 out of 10 tests in the “reading” step in the case of individual A and, also in 7 out of 10 tests, in the “bending over” step in the case of individual J. This indicates that activities like “reading” or “side-to-side” and “up and down” head movements have the highest impact on the efficiency of a respirator.

In the case of individual D, the fit-factors measured during the various steps with the various respirators showed dramatic differences, from as low as 2 (respirator 5) up to 2,460 (respirator 9). In 7 out of 10 respirators, the fit-factors measured were often above 100. However, even in the cases where several steps produced fit-factors exceeding 100, a step that displayed a very low fit-factor was always evident. This low value had a big influence on the resulting overall fit-factor of the tested respirator, reducing it considerably according to the formula applied to calculate this overall fit-factor. This is well illustrated by the results obtained with respirator 7: Four steps generated fit-factors well above 100, but the values measured for the “bending over” step and the final “normal breathing” step strongly affected the overall fit-factor of the respirator, making it unsuitable for individual D.

The fit-factors measured with individual N were even much lower, with the exception of only one outstanding maximum fit-factor of 916 (respirator 6). There were only two respirators (6 and 10) where the fit-factor of some of the exercises exceeded 100. Therefore, the respirators that failed the tests were characterized by low overall fit-factors. Among the three respirators that passed the fit-test, only one (respirator 6) showed an overall fit-factor above 100. In contrast to individuals A and J, the lowest fit-test results did not correlate with the “reading” and “bending over” step. These observations indicate that, when a respirator is fitting correctly on the face of an individual, the fit-test values always decrease during the “reading” and “bending over” steps. Indeed, the stress applied on the respirator by the movement of the facial muscles or by the gross movements of the head affects the fitting. In contrast, when a respirator does not fit properly, the differences between the effects of the quiet exercises (normal breathing, deep breathing, head up and down and left to right) and those of the stress steps (reading and bending over) are small.

A compilation of which respirators gave the best fit-testing results to all the individuals is shown in Table 4. Among all the completed tests, two individuals (A and J) passed the fit-test for all respirators. One individual (F)
Figure 1
Photos of the 10 commercially available respirators used in the study. The brand name of each respirator was covered with a black square. The metal valves seen in most of the pictures were the valves that were added for measuring the particle concentration inside the respirator.
Table 1
Origin and features of FFP3 respirators used in the study. FFP3 respirators were bought from 4 different manufacturers in Switzerland.

<table>
<thead>
<tr>
<th>Mask Number</th>
<th>Manufacturer</th>
<th>Exhaust Valve Present</th>
<th>Special Seal Towards Skin¹</th>
<th>Adjustable Headband</th>
<th>Reusable (R) or Non-reusable (NR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>R</td>
</tr>
<tr>
<td>2</td>
<td>B</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>NR</td>
</tr>
<tr>
<td>3</td>
<td>B</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>R</td>
</tr>
<tr>
<td>4</td>
<td>C</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>NR</td>
</tr>
<tr>
<td>5</td>
<td>B</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>R</td>
</tr>
<tr>
<td>6</td>
<td>B</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>NR</td>
</tr>
<tr>
<td>7</td>
<td>B</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>NR</td>
</tr>
<tr>
<td>8</td>
<td>C</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>R</td>
</tr>
<tr>
<td>9</td>
<td>D</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>NR</td>
</tr>
<tr>
<td>10</td>
<td>A</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>NR</td>
</tr>
</tbody>
</table>

¹Whenever a special plastic material was present around the entire mask to generate a better seal to the skin, it is indicated as “Yes.”
²Feature is not indicated by the manufacturer.
The metric parameter that correlated with a good fit-test clearly fit properly to hollow cheeks. The lack of any clear-cut biological individuals. Others were leaky on the sides because they could not some respirators partially covered the eyes of some individuals with small and thin heads was more difficult. Indeed, a tendency, finding a properly fitting respirator for individuals as a result of the fit-tests (data not shown). However, as a general found between any combination of parameters and the results (e.g., nose to chin, cheek to cheek, nose to ear, etc.). With this limited biometric data, no correlation could be found between any combination of parameters and the result of the fit-tests (data not shown). However, as a general tendency, finding a properly fitting respirator for individuals with small and thin heads was more difficult. Indeed, some respirators partially covered the eyes of some individuals. Others were leaky on the sides because they could not fit properly to hollow cheeks. The lack of any clear-cut biometric parameter that correlated with a good fit-test clearly emphasizes the importance of performing a fit-test with each individual. To give credence to subtle correlations between head shapes and sizes would require a larger number of individuals to be tested and a more sophisticated biometric analysis, which clearly goes beyond the scope of this study. However, this investigation highlighted a few points that need to be considered when these respirators are used: a. The metal band covering the top of the nose is crucial for a good fit along the shape of the cheeks; in other words, the better it can be shaped by hand (soft metal), the better the fit is. In addition, bending this band in the middle before the respirator is donned is advisable so that it is worn symmetrically on the face. Respirators should not be worn by individuals with beards or other facial hair that may inhibit proper contact between facial skin and the respirator.

Table 2
Overall fit-factors for 10 FFP3 respirators worn by 14 BSL-3/BSL-2Ag workers. Not passed fit-tests (fit-factor < 50) are indicated in light grey. Tests with high fit-factor (fit-factor > 1000) are indicated in dark grey. Pass level at fit-factor > 50.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Resp. 1</th>
<th>Resp. 2</th>
<th>Resp. 3</th>
<th>Resp. 4</th>
<th>Resp. 5</th>
<th>Resp. 6</th>
<th>Resp. 7</th>
<th>Resp. 8</th>
<th>Resp. 9</th>
<th>Resp. 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>94</td>
<td>1030</td>
<td>530</td>
<td>125</td>
<td>907</td>
<td>820</td>
<td>547</td>
<td>104</td>
<td>81</td>
<td>519</td>
</tr>
<tr>
<td>B</td>
<td>48</td>
<td>1190</td>
<td>358</td>
<td>22</td>
<td>33</td>
<td>240</td>
<td>205</td>
<td>59</td>
<td>440</td>
<td>178</td>
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<td>C</td>
<td>60</td>
<td>3070</td>
<td>192</td>
<td>305</td>
<td>22</td>
<td>21</td>
<td>61</td>
<td>17</td>
<td>10</td>
<td>58</td>
</tr>
<tr>
<td>D</td>
<td>30</td>
<td>11</td>
<td>45</td>
<td>68</td>
<td>3</td>
<td>54</td>
<td>24</td>
<td>19</td>
<td>64</td>
<td>16</td>
</tr>
<tr>
<td>E</td>
<td>56</td>
<td>1950</td>
<td>166</td>
<td>37</td>
<td>5120</td>
<td>526</td>
<td>36</td>
<td>29</td>
<td>218</td>
<td>13</td>
</tr>
<tr>
<td>F</td>
<td>75</td>
<td>50</td>
<td>123</td>
<td>81</td>
<td>273</td>
<td>838</td>
<td>92</td>
<td>803</td>
<td>56</td>
<td>104</td>
</tr>
<tr>
<td>G</td>
<td>27</td>
<td>1300</td>
<td>12</td>
<td>48</td>
<td>77</td>
<td>12</td>
<td>20</td>
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<td>70</td>
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<tr>
<td>H</td>
<td>13</td>
<td>55</td>
<td>86</td>
<td>25</td>
<td>3430</td>
<td>203</td>
<td>76</td>
<td>14</td>
<td>337</td>
<td>58</td>
</tr>
<tr>
<td>I</td>
<td>45</td>
<td>88</td>
<td>29</td>
<td>113</td>
<td>49</td>
<td>156</td>
<td>60</td>
<td>63</td>
<td>125</td>
<td>83</td>
</tr>
<tr>
<td>J</td>
<td>145</td>
<td>92</td>
<td>108</td>
<td>143</td>
<td>375</td>
<td>366</td>
<td>245</td>
<td>73</td>
<td>139</td>
<td>97</td>
</tr>
<tr>
<td>K</td>
<td>96</td>
<td>247</td>
<td>59</td>
<td>325</td>
<td>842</td>
<td>93</td>
<td>142</td>
<td>29</td>
<td>18</td>
<td>36</td>
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<tr>
<td>L</td>
<td>74</td>
<td>77</td>
<td>18</td>
<td>54</td>
<td>2290</td>
<td>344</td>
<td>105</td>
<td>26</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>M</td>
<td>64</td>
<td>98</td>
<td>90</td>
<td>368</td>
<td>2410</td>
<td>2290</td>
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<td>15</td>
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<td>35</td>
<td>153</td>
<td>8</td>
<td>5</td>
<td>11</td>
<td>91</td>
</tr>
</tbody>
</table>

Passed 9 out of 10 fit-tests. Five individuals (B, H, I, K, and M) passed 7 out of 10 fit-tests. Three individuals (C, E, and L) passed 6 out of 10 fit-tests. Three individuals (D, G, and N) passed 3 out of 10 fit-tests.

These numbers indicate that no clear cut result can be expected when using FFP3 respirators. Also, no correlation between the fit-factor score and the number of respirator tests passed can be observed (e.g., individual J passed 10 out of 10 tests with an averaged overall fit-factor of 178, but individual E passed only 6 out of 10 tests with an averaged overall fit-factor of 1,013). When considering for each individual which respirator that passed the fit-test had the lowest fit-factor, respirator 1 was mentioned three times, respirators 10, 8, and 2 were mentioned twice, and respirators 9, 7, 6, 5, and 4 were mentioned only once, suggesting that respirator 1 is less efficient in its performance in general. With respect to the best fit-factor, respirator 5 was mentioned six times, respirator 2 four times, respirator 6 three times, and respirator 4 was mentioned only once. These results suggest that the respirators 2, 5, and 6 have, in general, a better fit compared to respirators 1, 8, 9, and 10.

In an attempt to correlate respirator efficiency with biometric parameters, the heads of all the participants were photographed (face and profile) to extract various measurements (e.g., nose to chin, cheek to cheek, nose to ear, etc.). With this limited biometric data, no correlation could be found between any combination of parameters and the result of the fit-tests (data not shown). However, as a general tendency, finding a properly fitting respirator for individuals with small and thin heads was more difficult. Indeed, some respirators partially covered the eyes of some individuals. Others were leaky on the sides because they could not fit properly to hollow cheeks. The lack of any clear-cut biometric parameter that correlated with a good fit-test clearly

www.absa.org  Applied Biosafety  Vol. 19, No. 4, 2014  189
## Table 3

Best and worst fit-test results.

<table>
<thead>
<tr>
<th>Individual A</th>
<th>Resp. 1</th>
<th>Resp. 2</th>
<th>Resp. 3</th>
<th>Resp. 4</th>
<th>Resp. 5</th>
<th>Resp. 6</th>
<th>Resp. 7</th>
<th>Resp. 8</th>
<th>Resp. 9</th>
<th>Resp. 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal breathing</td>
<td>111</td>
<td>2070</td>
<td>2100</td>
<td>210</td>
<td>1910</td>
<td>2290</td>
<td>900</td>
<td>141</td>
<td>69</td>
<td>1350</td>
</tr>
<tr>
<td>Deep breathing</td>
<td>105</td>
<td>1940</td>
<td>1300</td>
<td>211</td>
<td>3450</td>
<td>2370</td>
<td>1030</td>
<td>110</td>
<td>96</td>
<td>1290</td>
</tr>
<tr>
<td>Head left to right</td>
<td>115</td>
<td>3510</td>
<td>2340</td>
<td>159</td>
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Table 4

Evaluation of FFP3 respirators that passed the fit-test for the respective individual.

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| e. The rubber seal surrounding some of the respirators in this study improved the sealing of the respirator but, on the other hand, increased the possibility of contact sensitization of the skin in reaction to the rubber material. This occurred because the humidity between the rubber and the skin is much higher compared to respirators that do not have such a seal. |
| f. Lowest fit-factor: Lowest fit-factor of all passed respirator tests and number of respirator. |
| g. Highest fit-factor: Highest fit-factor of a passed test and number of respirator. |

Resp. = Respirator. Overall values were calculated by the software according to Materials and Methods.

The authors could not determine any correlation between the shape of a face and the fit-factor of the different respirators. A much larger number of individual faces would have to be analyzed along with in-depth biometric analysis to get statistically valid data.

Conclusion

This study tested 10 commercially available FFP3 respirators in a quantitative fit-test on 14 individuals who work daily in a laboratory environment in two institutions in Switzerland. Results showed a significant variation in the fit-factor of all 10 respirators for the individuals who performed the fit-test exercises. The authors stressed that the wearing of an FFP3 respirator should always be based on the risk assessment of the activity. Individuals working in BSL-3, BSL3-Ag, and BLS-4 laboratories should never don an FFP3 respirator because “it is nice, inexpensive, and might give a better protection in general” but, rather, because “it is needed.” The data from this study clearly demonstrate that only an empirically performed quantitative fit-test can show if a respirator fits to the face of an individual.

Acknowledgments

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Disclosure

The authors declare no conflict of interest. Urs Pauli and Stephane Karlen contributed equally to this work.

References


