

Advertisement

Hire the best researchers
in any discipline on ResearchGate

Article

Physiologic effects and measurement of carbon dioxide and oxygen levels during qualitative respirator fit testing

September 2006 · *Journal of Chemical Health and Safety* 13(5):22-28

DOI: [10.1016/j.jchas.2005.11.015](https://doi.org/10.1016/j.jchas.2005.11.015)

Authors:



Edward A. Laferty



Roy T. McKay



To read the full-text of this research, you can request a copy directly from the authors.

[Citations \(22\)](#)

[References \(23\)](#)

Abstract

In the United States, two commonly used qualitative respirator fit test methods require the use of a test hood to be placed over the subject's head and shoulders. Workers fit tested by this method have commented on the discomfort of being inside the test hood. This study was designed to quantify some parameters that might lead to these types of comments. For this study, subjects performed a series of four respirator fit tests. A quantitative and a qualitative fit test were performed with a full facepiece respirator. Then a quantitative and a qualitative fit test were performed with an N95 filtering facepiece respirator. Parameters measured include: subjects' height, weight, and age, oxygen and carbon dioxide levels, air temperature, heart rate, arterial oxygen saturation, and Borg Ratio Scale value on breathing exertion. Carbon dioxide levels are significantly higher and oxygen levels are significantly lower in the respirator when the test hood is used during the qualitative fit test. This was especially true when fit testing filtering facepieces where mean carbon dioxide levels rose to 4.2% and mean oxygen levels dropped to 15.5%. Full facepiece respirators had similar changes, but to a lesser magnitude. The temperature inside the test hood rose an average 7.5

ResearchGate

Discover the world of research

- 20+ million members
- 135+ million publications
- 700k+ projects

Join for free

Request full-text

Download citation

Copy link



an extent during a quantitative respirator fit test. Professionals conducting respirator fit tests should be aware of the physiological burdens that may occur during the qualitative respirator fit test. Some groups may be especially sensitive to this test such as the elderly, pregnant women, persons with pulmonary and/or cardiac disease, or persons with psychological disorders such as anxiety, panic disorders, or claustrophobia.

Advertisement



Up To 30% Off At CPAP Direct

The Widest Range With Guaranteed Price Beat Both Online & In Store. Free Delivery.

CPAP Direct



No full-text available



To read the full-text of this research, you can request a copy directly from the authors.

 Request full-text PDF

Citations (22)

References (23)

... In terms of cardiac impact, the nonsignificant difference in heart rate between control and FFR and FFR-with-valve in the current study is congruent with other studies up to 1 hour of FFR use. 8,16,19 One study reported a mild decrease in heart rate with FFR during 4 hours of sedentary activity. 17 FFR-associated increased heart rate relates to breathing resistance, work level, physical fitness, FFR-associated anxiety, and increased retention of CO₂. ...

... The similar S_{pO₂} values between the controls and all the FFR models in the current study mirror a previous report NA is not applicable S_{PO₂} is blood oxygen saturation measured via pulse oximetry P_{tcCO₂} is transcutaneously measured partial pressure of carbon dioxide f is frequency (respiratory rate) V_T is tidal volume V_E is minute ventilation of a 1% difference between controls and subjects wearing N95 FFRs during qualitative respirator-fit testing.

19 A recent study of the impact of a surgical mask on S_{pO₂} in surgeons during surgery found significant S_{pO₂} decreases only during procedures longer than 60 min. 21 Kao et al 17 found a net P_{aO₂} decline of 9 ± 18.5 mm Hg from baseline in approximately 70% of 39 patients wearing N95 FFR after 4 hours of hemodialysis. ...

... That limited prior experience 19,21 and the current study data suggest that S_{pO₂} decrements are possible with N95 FFR or N95 FFR-with-valve, but are likely to be minor for FFR use of 3-1 hour during low energy expenditure, and may not be clinically important. ...

Surgical mask placement over N95 filtering facepiece respirators: Physiological effects on

[Article](#) [Full-text available](#)

Mar 2010 · [Respirology](#)

Raymond J Roberge ·  Aitor Coca · W. Jon Williams · Jeffrey B Powell

[View](#) [Show abstract](#)

... In terms of cardiac impact, the nonsignificant difference in heart rate between control and FFR and FFR-with-valve in the current study is congruent with other studies up to 1 hour of FFR use. 8,16,19 One study reported a mild decrease in heart rate with FFR during 4 hours of sedentary activity. 17 FFR-associated increased heart rate relates to breathing resistance, work level, physical fitness, FFR-associated anxiety, and increased retention of CO₂. ...

... The similar S_{pO₂} values between the controls and all the FFR models in the current study mirror a previous report NA is not applicable S_{PO₂} is blood oxygen saturation measured via pulse oximetry P_tCO₂ is transcutaneously measured partial pressure of carbon dioxide f is frequency (respiratory rate) V_T is tidal volume V_E is minute ventilation of a \approx 1% difference between controls and subjects wearing N95 FFRs during qualitative respirator-fit testing.

19 A recent study of the impact of a surgical mask on S_{pO₂} in surgeons during surgery found significant S_{pO₂} decreases only during procedures longer than 60 min. 21 Kao et al 17 found a net P_{aO₂} decline of 9 \pm 18.5 mm Hg from baseline in approximately 70% of 39 patients wearing N95 FFR after 4 hours of hemodialysis. ...

... That limited prior experience 19,21 and the current study data suggest that S_{pO₂} decrements are possible with N95 FFR or N95 FFR-with-valve, but are likely to be minor for FFR use of \leq 1 hour during low energy expenditure, and may not be clinically important. ...

Physiological impact of the N95 filtering facepiece respirator on healthcare workers

[Article](#) [Full-text available](#)

May 2010 · [RESP CARE](#)

Raymond J Roberge ·  Aitor Coca · W. Jon Williams · Andrew J Palmiero

[View](#) [Show abstract](#)

... The four selected studies that collected objective measures in healthy individuals wearing RPDs (N95 FFRs or full facepiece respirators) revealed some significant respiratory effects, both in those who were experienced with wearing these devices (Laferty and McKay, 2006; Lee and Wang, 2011) and those who were not (Roberge et al., 2010; Smith et al., 2013), and this was also found by (Zhang et al., 2016) using a computational fluid dynamics simulation of full breathing cycles. Table 1 reports a detailed description of the studies, including the sample characteristics, procedures, and main results of interest. ...

... Finally, the increased RPD-related dead space was found to lower the average inhaled O₂ concentration. (Laferty and McKay, 2006) and (Roberge et al., 2010) found O₂ levels inside respirators' cavities ranging from 16.6% to 18.3%, which represent an O₂-deficient space, according to the recommended threshold of the Occupational Health and Safety Administration (O₂ deficiency is an atmosphere that contains <19.5% O₂ by volume) (Table 1). The decreased O₂ levels may result in a faster transition from aerobic to anaerobic respiration, lower tolerance for physical exertion, and decreased working capacity (Laferty and McKay, 2006). ...

... (Laferty and McKay, 2006) and (Roberge et al., 2010) found O₂ levels inside respirators' cavities ranging from 16.6% to 18.3%, which represent an O₂-deficient space, according to the recommended threshold of the Occupational Health and Safety Administration (O₂ deficiency is an atmosphere that contains <19.5% O₂ by volume) (Table 1). The decreased O₂ levels may result in a faster transition from aerobic to anaerobic respiration, lower tolerance for physical exertion, and decreased working capacity (Laferty and McKay, 2006). It should be noted that despite the decrease in O₂ % in the RPD cavity, no impact on blood oxygen saturation (SpO₂), as measured via pulse oximetry, was found in both the abovementioned studies. ...

Impact of respiratory protective devices on respiration: Implications for panic vulnerability

Article

Dec 2020

● Giampaolo Perna · ● Francesco Cuniberti ·
● Silvia Daccò · ● Daniela Caldirola

[View](#) [Show abstract](#)

... Obese individuals and smokers could face more symptoms because of the use of filtering facepiece respirators without valve that brings difficulties in breathing. Laferty and McKay [70] found that filtering facepiece respirators cause breathing resistance resulting on a decrease in SpO₂ and an increase in CO₂ levels. Moreover, isolation gowns cover the entire body causing heavy sweating and continuous dehydration especially among smokers and obese individuals. ...

... Filtering facepiece respirators are more likely to cause adverse events such as breathing difficulties, headaches, panic attacks, and pressure related symptoms especially in case of prolonged use [31,32,37,46,55,70]. Also, Ong et al. [32] found that face shields cause headaches due to pain, pressure or compression from this PPE, while Battista et al. [37] found that face shields cause several symptoms, e.g. ...

Impact of personal protective equipment use on health care workers' physical health during

Article

May 2021 · [AM J INFECT CONTROL](#)

● Petros Galanis · Irene Vraka · ● Despoina Fragkou · ● Daphne Kaitelidou

[View](#) [Show abstract](#)

... They studied the changes in the physiological parameters (an increased HR, decreased SpO₂, and PI). 7, 8 These changes combined with the anxiety and fears related to this pandemic and direct exposure to increased viral loads makes them more vulnerable to infection in PPE or decreased immunity. ...

... All physiological changes related to wearing N95 facemask like tachycardia, hypertension, increased aortic and left ventricular pressure, increased pulmonary artery pressure, decreased SpO₂, headache, fatigue, dizziness, and drowsiness are related to hypoxia and hypercarbia. 5, 8, 9 The study by Chaudhary et al. did not measure the partial pressure of O₂, CO₂, and lactate level that might have given more conclusive evidence for physiological changes, as major limitations. Another limitation was its small sample size. ...

Physiological Effects of N95 FFP and Personal Protective Equipment in Healthcare Workers in

Article

Dec 2020 · [Indian J Crit Care Med](#)

Simant Kumar Jha

[View](#) [Show abstract](#)

... Wearing respirator or mask would affect inhaled gas concentrations and respiratory resistances as well [4]. Particularly, wearing the respirator elevated the carbon dioxide level while decreased oxygen level within the respirator which may be the cause of subjective complaints for wearing respirators [5]. The increased partial carbon dioxide level also tends to affects breathing patterns and heart rate variability [6]. ...

Evaluation of rebreathed air in human nasal cavity with N95 respirator: a CFD study

Article

Jan 2016

Jian Hua Zhu · Shu Jin Lee · De Yun Wang ·
Hp Lee

[View](#)

... mm Hg), despite the EAPR being equipped with an exhalation valve that presumably allows for a smaller proportion of the exhaled breath (and associated carbon dioxide) to be retained in the respirator dead space (all subjects were asymptomatic of hypercapnia). 21 Furthermore, at the 2 work rates, the mean mixed inhalation/exhalation respirator dead space oxygen concentrations (17.85%, 17.81%, respectively) and respirator dead space carbon dioxide concentrations (2.50%, 2.47%, respectively) did not meet Occupational Health and Safety Administration ambient workplace standards (ie, 19.5% is considered oxygen deficient; maximum 0.5% carbon dioxide as an 8-hour time weighted average), 22 although these standards apply to the workplace, not to respirators. Oxygen saturation was not adversely affected. ...

Reusable elastomeric air-purifying respirators: Physiologic impact on health care workers

Article

Full-text available

Feb 2010 · [Am J Infect Contr](#)

Raymond J Roberge · Aitor Coca · W. Jon Williams · Andrew J Palmiero

[View](#) [Show abstract](#)

... This has additional ramifications, above and beyond time and costs associated with fit testing, given that some concern has been raised over the issue of the impact on pregnant women of elevated levels of carbon dioxide in the hoods utilized for respirator qualitative fit testing. (20) It may be that significant increases in Bizygomatic Breadth measurements of pregnant and non-pregnant women who wear RPE could be a useful marker for the consideration of additional fit testing, but this hypothesis would require a study with large numbers of appropriate subjects. Women who exceed the recommended weight gain of pregnancy and those who suffer from pregnancy-associated disorders that result in facial edema (e.g., pre-eclampsia), may experience increases in facial dimensions that could impact respirator fit. ...

Effect of Pregnancy Upon Facial Anthropometrics and Respirator Fit Testing

Article

May 2015 · [J Occup Environ Hyg](#)

Raymond J Roberge ·  Jung-Hyun Kim · Andrew J Palmiero · Jeffrey B Powell

[View](#) [Show abstract](#)



... Some studies show increases of 120% in inspiratory and expiratory flow resistances when N95 respirators are used, and the air exchange volume was reduced by an average of more than 30% [3]. The mean carbon dioxide levels rise and the mean oxygen levels drop in the breathing space inside face masks and respirators [4]. Furthermore, the exhaled carbon dioxide can accumulate, and can subsequently be inhaled during each respiratory cycle. ...

Running with Face Masks or Respirators Can Be Detrimental to the Respiratory and

Article

[Full-text available](#)

Mar 2021

Yidan Wang ·  Gary Tse ·  Guoliang Li

[View](#) [Show abstract](#)

... In non-pregnant subjects, it has been shown that use of N95-respirators can increase CO₂ levels within the masks by 1.8-3 %, suggesting that the increase in expired CO₂ concentration could also be due to the accumulation of expired CO₂ trapped in the dead space of the N95 mask [29, 30]. Our results do not support such a view because FiCO₂ did not increase even with the use of N95 materials and total CO₂ intake was reduced due to the corresponding decrease in V_E. ...

Respiratory consequences of N95-type Mask usage in pregnant healthcare workers-A

[Article](#) [Full-text available](#)

Nov 2015

Pearl Shuang Ye Tong · Anita Sugam Kale · Kai Lyn Ng · Eu-Leong Yong

[View](#) [Show abstract](#)

... Whilst the prolonged use of face mask may not lead to significant hypoxia and hypercapnia under normal use at rest, but can do so during stress [2] or exercise [3], and is associated with increased respiratory efforts, reduced work performance [4], adverse effects such as discomfort [5] and headaches [6], especially in individuals with increased basal metabolic demands such as pregnancy [7]. Such physiological changes can be observed with simple surgical masks [2] but is exacerbated with N95 [8] or full-face respirators [9]. Indeed, computational modelling studies report an increase in carbon dioxide level and a decrease in oxygen level with respiratory use due to rebreathed air [10]. ...

COVID-19: Electrophysiological Mechanisms underlying sudden cardiac death during

[Article](#) [Full-text available](#)

Aug 2020 · [MED HYPOTHESES](#)

Sharen Lee · Guoliang Li · Tong Liu · Gary Tse

[View](#) [Show abstract](#)

... Moreover, hypercapnia-related problems after many hours of wearing these respirators have been a concern to healthcare workers (HCW) and have been studied under in vitro conditions [23] and in vivo studies for respiratory fit tests [24]. Laferty et al. focused on oxygen and carbon dioxide levels of subjects wearing N95 respirators in a test hood and results showed an increase in CO₂ levels and a decrease in O₂ levels due to the important breathing resistance offered by N95 respirators. ...

A Scoping Review of Respirator Literature and a Survey among Dental Professionals

[Article](#) [Full-text available](#)

Aug 2020 · [Int J Environ Res Publ Health](#)

Marco Farronato · Elisa Boccalari · Ettore Del Rosso · Cinzia Maspero

[View](#) [Show abstract](#)

... investigated the oxygen and carbon dioxide levels of participants wearing N95 masks in their study, and the results showed an increase in CO₂ levels and a decrease in SpO₂ levels due to the significant breathing resistance caused by N95 masks. ¹⁹ During the pandemic, increasing stress and anxiety levels were noticed among HCPs. ^{20,21} Increased levels of stress and anxiety may contribute to breathing difficulty and palpitation. ...

Symptoms Associated With Personal Protective Equipment Among Frontline Health

[Article](#) [Full-text available](#)

Nov 2020

Ahmet Çağlar · Ilker Kaçer · Muhammet Hacimustafaoğlu · Kemal Öztürk

[View](#) [Show abstract](#)

... ⁶⁷ Because paper surgical masks and cloth masks are looser fitting and more porous than N95 respirators, there is little likelihood that they meaningfully reduce oxygen saturation when worn in community settings. ⁶⁸ There is some evidence that N95 respirators can increase respirator dead space and transcutaneous CO₂ levels leading to mild hypercapnia, ⁶⁹ but there is little evidence that paper surgical or cloth masks cause CO₂ retention. ⁷⁰ Therefore, there is little evidence that masks cause significant respiratory problems for most people. ...

The Great Mask Debate: A Debate That Shouldn't Be a Debate at All

[Article](#)

Dec 2020

John R Raymond



[View](#) [Show abstract](#)

... Obese individuals and smokers could face more symptoms because of the use of masks without valve that brings difficulties in breathing. Laferty and McKay ^[70] found that N95 masks cause breathing resistance resulting on a decrease in SpO₂ and an increase in CO₂ levels. ...

Impact of personal protective equipment use on health care workers physical health during

[Preprint](#) [Full-text available](#)

Feb 2021




Petros A Galanis · Irene Vraka ·  Despoina Fragkou ·  Daphne Kaitelidou

[View](#) [Show abstract](#)

Exposure of Research Personnel to Carbon Dioxide during Euthanasia Procedures

[Article](#)

Sep 2014 · [J AM ASSOC LAB ANIM](#)

Ashlee A Amparan ·  Meen Momo ·  Beverly K Grunden ·  Gregory P Boivin

[View](#) [Show abstract](#)

Are Exhalation Valves on N95 Filtering Facepiece Respirators Beneficial at Low-

[Article](#)

Nov 2012 · [J Occup Environ Hyg](#)

Raymond J Roberge

[View](#) [Show abstract](#)

Effect of Respirator Resistance on Tolerant Capacity during Graded Load Exercise

[Article](#)

Jun 2012 · [J HUAZHONG U SCI-MED](#)

Man Qiu ·  Sheng Wang

[View](#) [Show abstract](#)

Facemask Use by Children During Infectious Disease Outbreaks

[Article](#)

Aug 2011

Raymond J Roberge




[View](#) [Show abstract](#)

Investigating the Effects of Protective Face Masks on the Respiratory Parameters of

[Article](#)

[Full-text available](#)

Feb 2021

 Burhan Dost ·  Özgür Kömürcü ·  Sezgin Bilgin · Sibel Baris

[View](#) [Show abstract](#)

Physiological Burden Associated with the Use of Filtering Facepiece Respirators (N95 Masks)

[Article](#)

Jul 2009

Raymond J Roberge

[View](#) [Show abstract](#)

Effect of Surgical Masks Worn Concurrently Over N95 Filtering Facepiece Respirators:

[Article](#)

Mar 2008

Raymond J Roberge

[View](#) [Show abstract](#)

Recommended publications [Discover more](#)

Article

Oxygen and Carbon Dioxide Levels During Qualitative Respirator Fit Testing

June 2004

Edward A. Laferty

Approved Occupational Safety and Health Administration qualitative respirator fit test methods require the use of a test hood about the subject's head and shoulders. Workers fit tested by this method have commented on the discomfort of being inside the test enclosure. This study was designed to quantify some parameters that might lead to these types of comments. For this study, subjects performed ... [\[Show full abstract\]](#)

[Read more](#)

Last Updated: 21 Nov 2020



Company

[About us](#)

[News](#)

[Careers](#)

Support

[Help Center](#)

Business solutions

[Advertising](#)

[Recruiting](#)