



# Effect of Mean Inspiratory Flow, Heart Rate and Breath Rate on the Efficiency of Respirators



**Kyungmin Jacob Cho**

Department of Environmental Health, University of Cincinnati, Cincinnati, OH, USA

# Introduction

- More than 3 million workers wear respirators
- Exposure to high concentration of aerosols
- Efficiency of respirators
  - Faceseal leakage and Filter penetration
- Faceseal leakage
  - Level of activity

# Definition

Protection Factor =  $\frac{\text{Concentration outside the respirator}}{\text{Concentration inside the respirator}}$

- **Workplace Protection Factor (WPF)**

: Measured when worker is using properly fitted respirator during usual work activities

- **Simulated Workplace Protection Factor (SWPF)**

: Workplace environment simulated in the laboratory

- **Most of WPF or SWPF studies**

- Have not taken into account the effect of human activity

# Objective

Assess the effect of human activity on efficiency of respirator

## Strategies

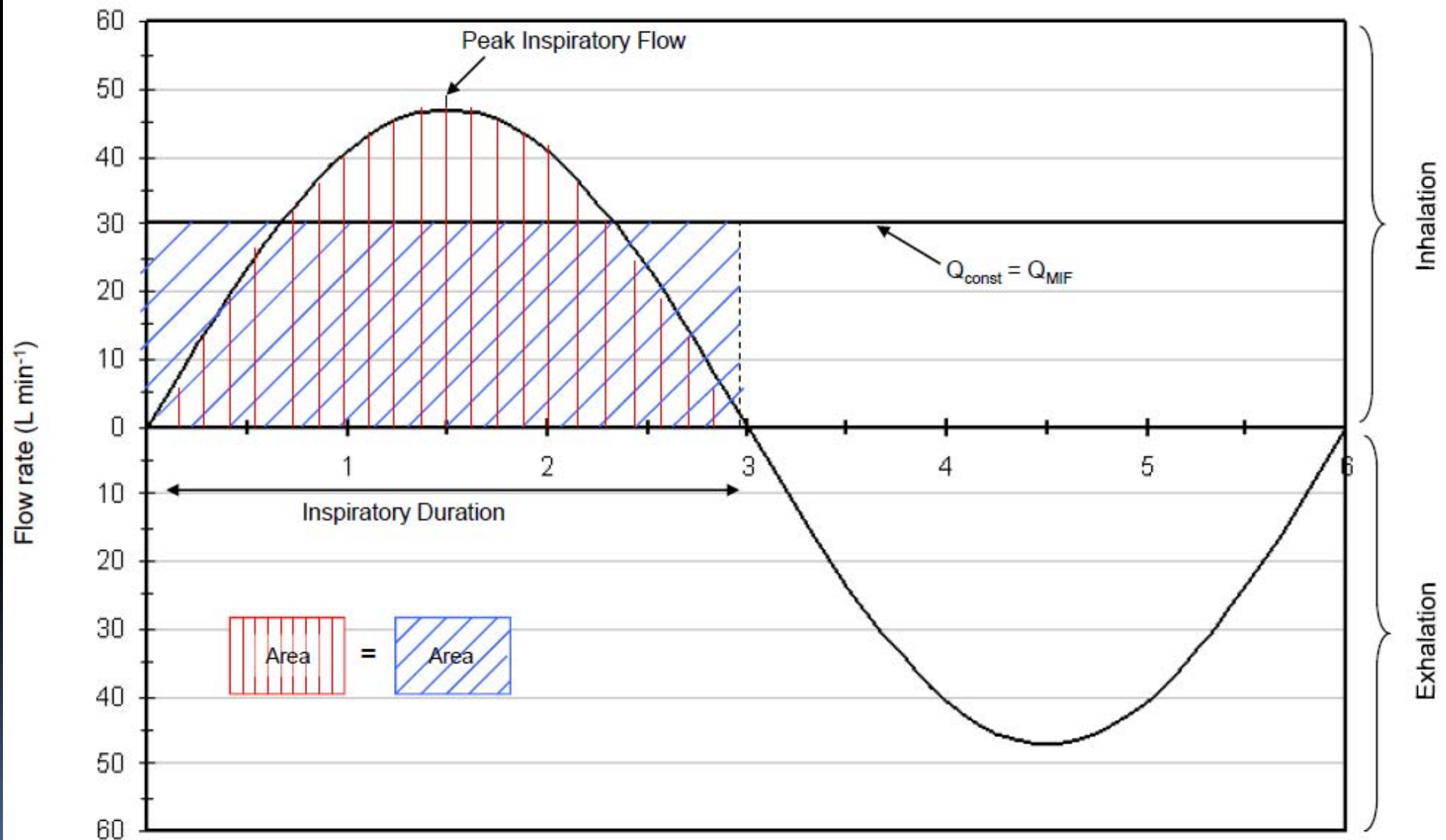
- Activity indicators
  - Mean Inspiratory Flow
  - Heart Rate
  - Breath Rate
- Efficiency of respirator
  - SWPF

Compare SWPFs based on:

Respirator types

Penetration vs. Different activities

# Representative sinusoidal breathing pattern



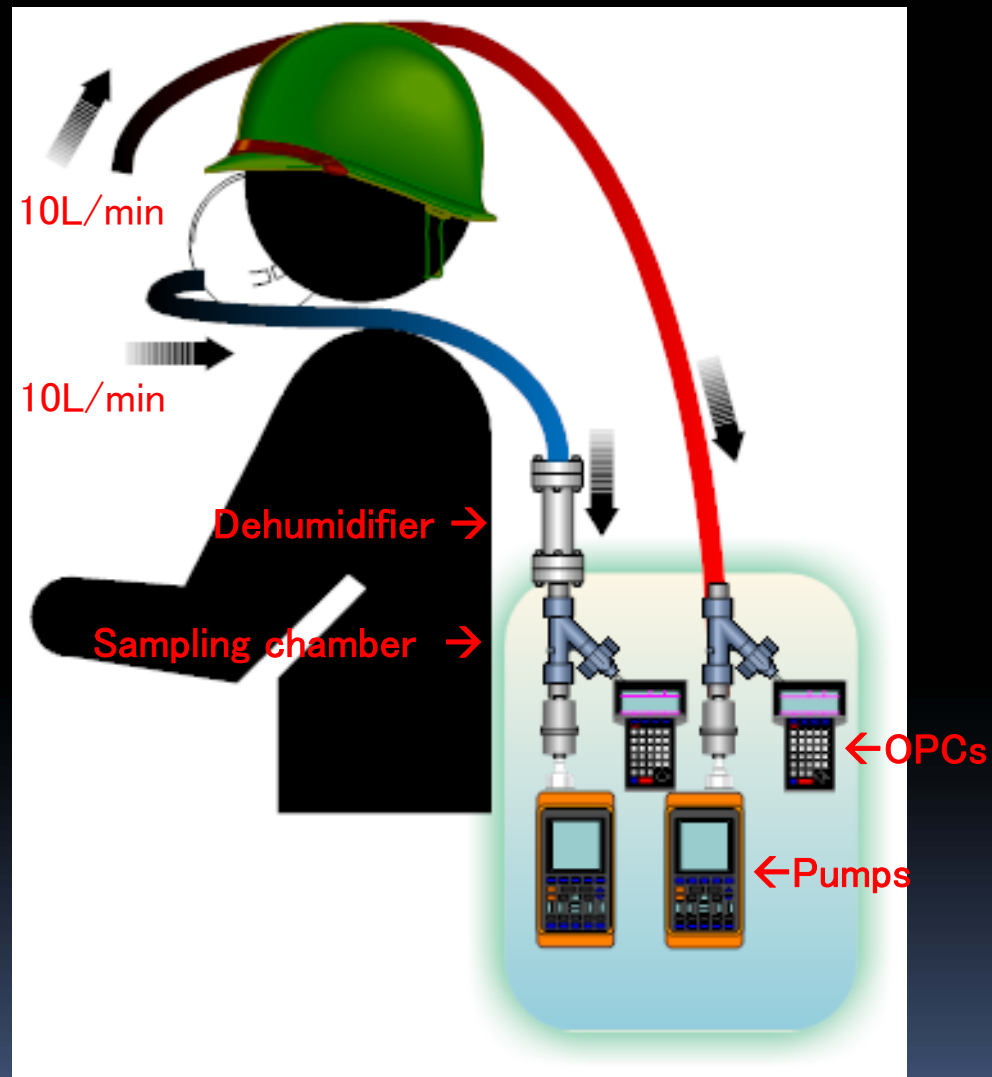
# Method

## *Laboratory experiment*

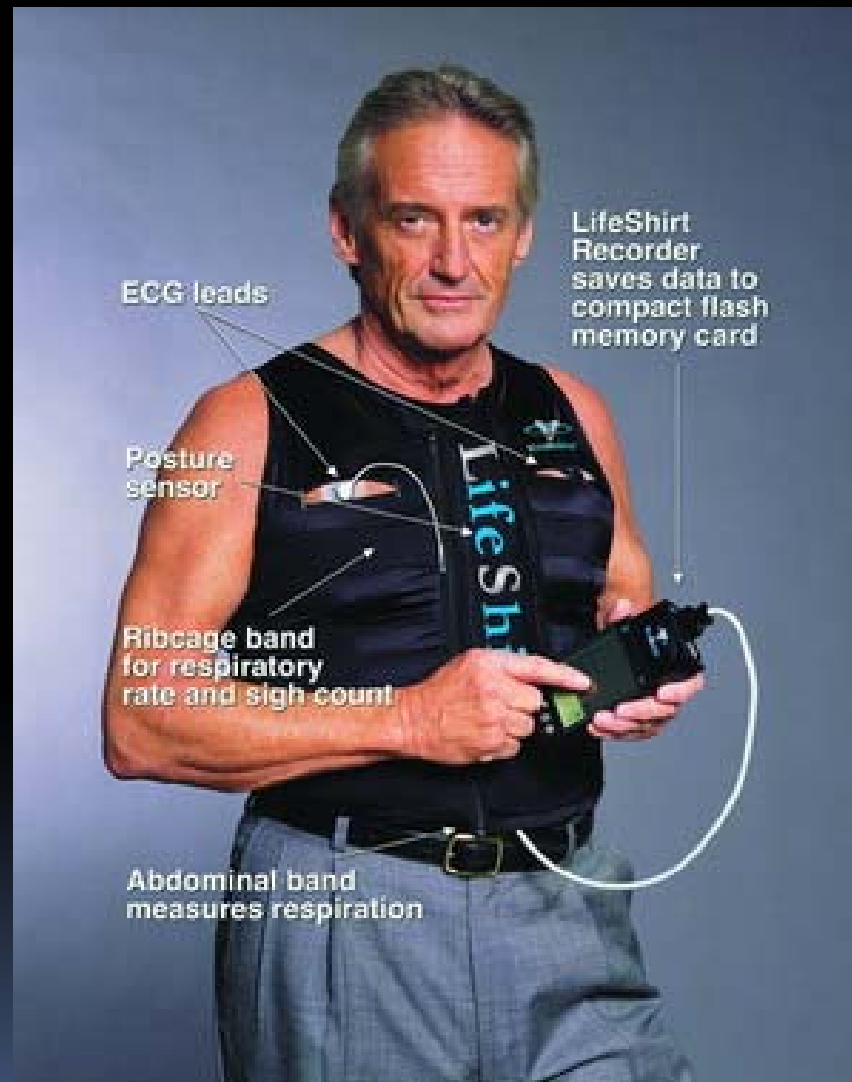
- 8 human subjects in simulated workplace
  - Standing, Walking and Stepping up & down
- Personal sampling set-up developed earlier (Lee et al. 2005)
  - Two identical sampling lines
    - Sampling chamber, filter, OPC, and pump
- LifeShirt (REA Systems Inc.)
  - Heart Rate, Breath Rate and MIF
- N95 filtering facepiece respirator / N95 elastomeric respirator



# Personal sampling system



# LifeShirt





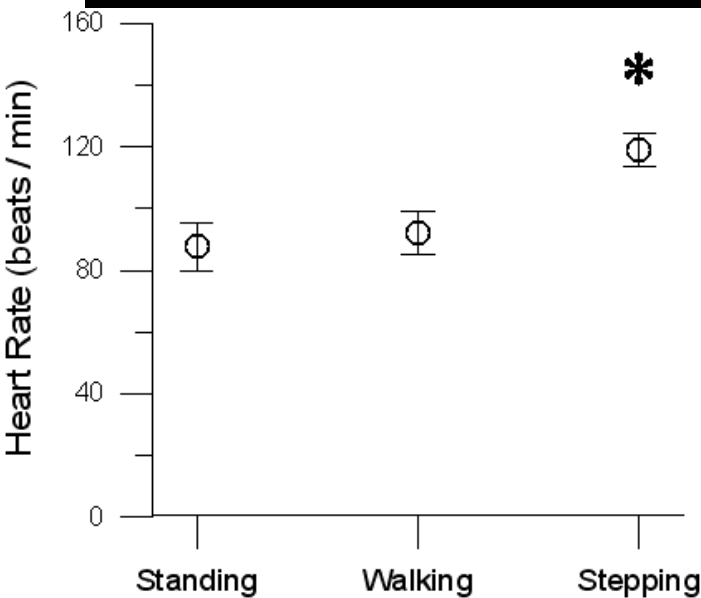
# Method

## *Lab experiment protocols*

- Randomly assign testing order for two respirator types
  - N95 elastomeric / N95 filtering facepiece respirator
- Select proper respirator size
  - Small, Medium or Large
- Fit test with 1<sup>st</sup> selected respirator
- Begin 1<sup>st</sup> lab experiment (max 1hr)
- Fit test with 2<sup>nd</sup> respirator
- Begin 2<sup>nd</sup> lab experiment (max 1hr)

# Activity indicators at three different activities

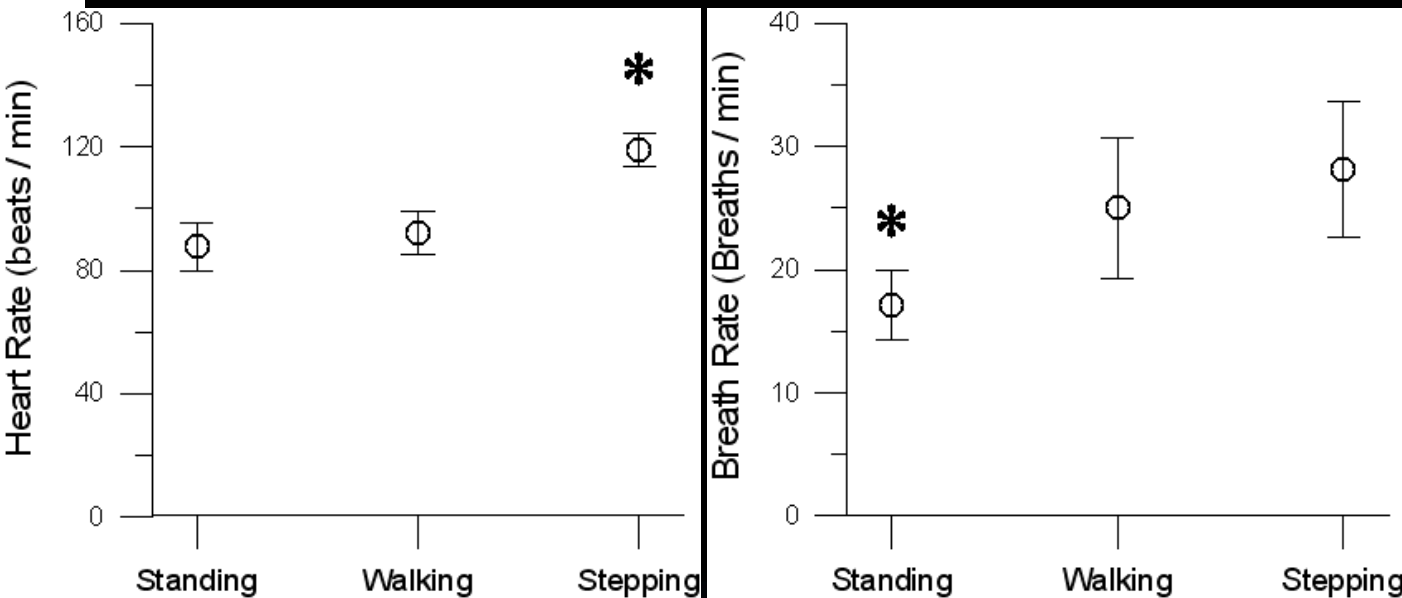
## Filtering Facepiece Respirator



\*ANOVA was used to test the difference between three activities (standing, walking, stepping up & down).

# Activity indicators at three different activities

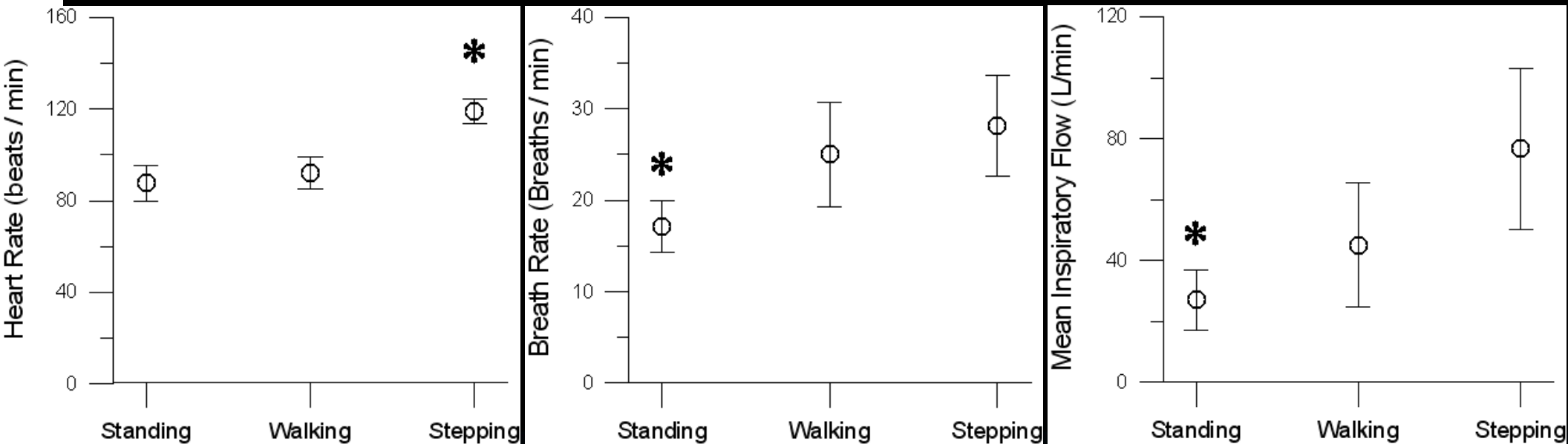
## Filtering Facepiece Respirator



\*ANOVA was used to test the difference between three activities (standing, walking, stepping up & down).

# Activity indicators at three different activities

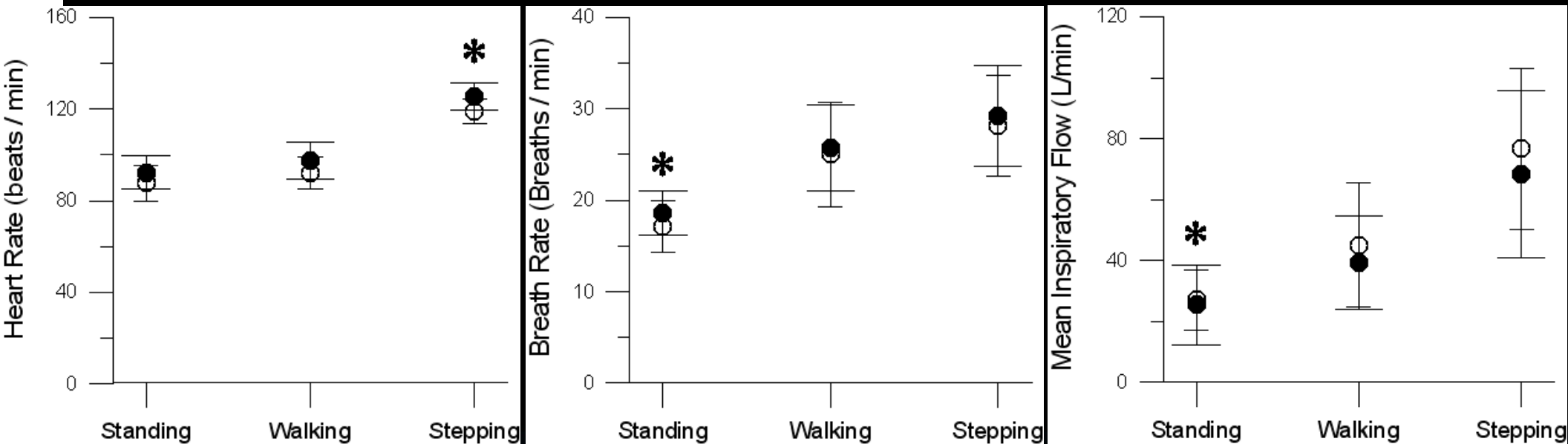
## Filtering Facepiece Respirator



\*ANOVA was used to test the difference between three activities (standing, walking, stepping up & down).

# Activity indicators at three different activities

○ Filtering facepiece respirator  
● Elastomeric respirator

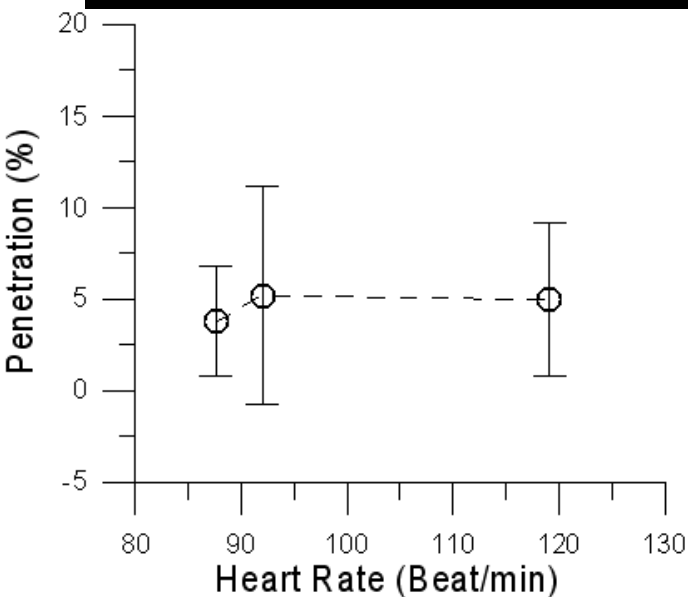


\*ANOVA was used to test the difference between three activities (standing, walking, stepping up & down).

# Penetration vs. Activity indicators

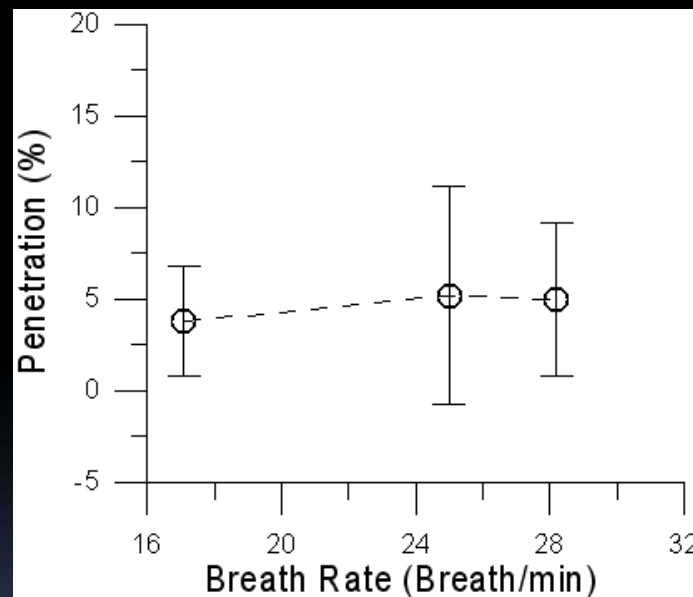
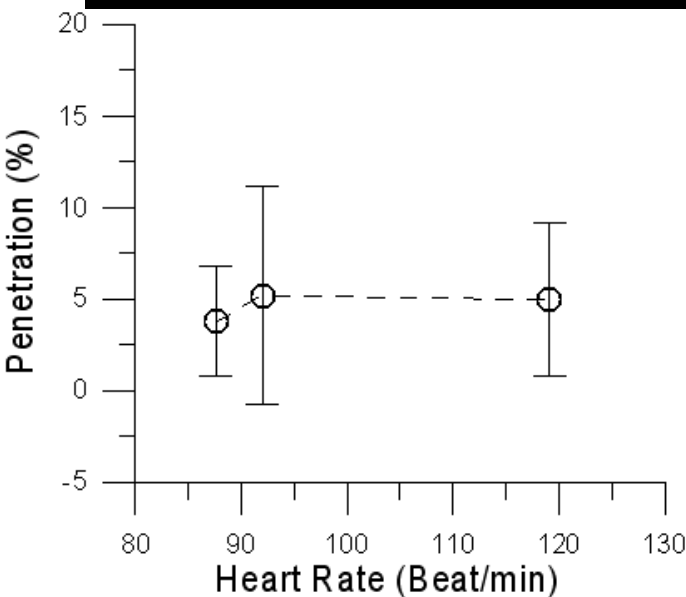
## at three different activities

### Filtering Facepiece Respirator



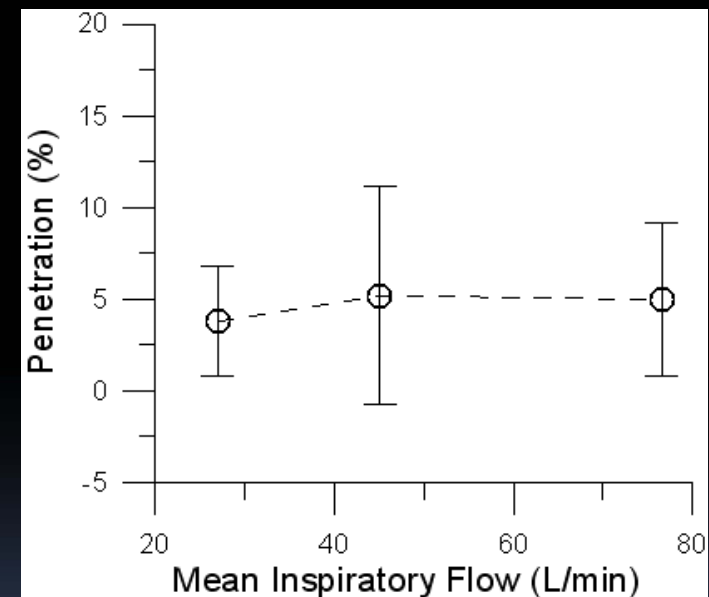
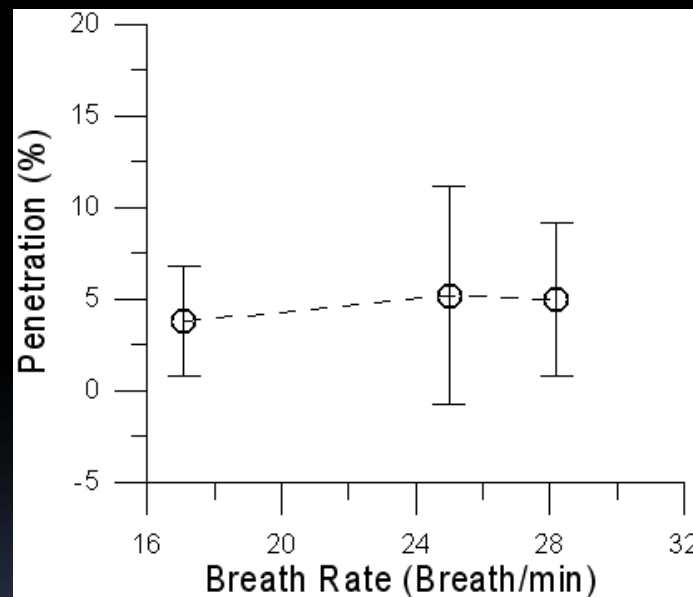
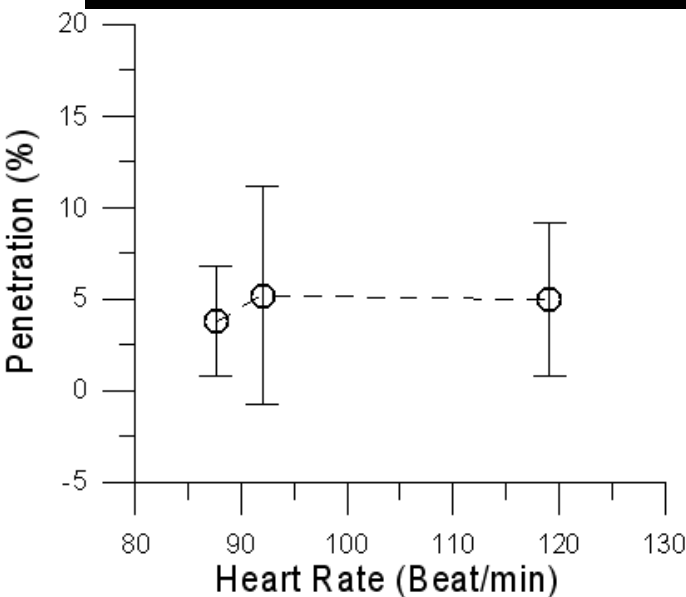
: Total concentration of particles in the size range of 0.7-5  $\mu\text{m}$

# Penetration vs. Activity indicators at three different activities Filtering Facepiece Respirator



: Total concentration of particles in the size range of 0.7-5  $\mu\text{m}$

# Penetration vs. Activity indicators at three different activities Filtering Facepiece Respirator

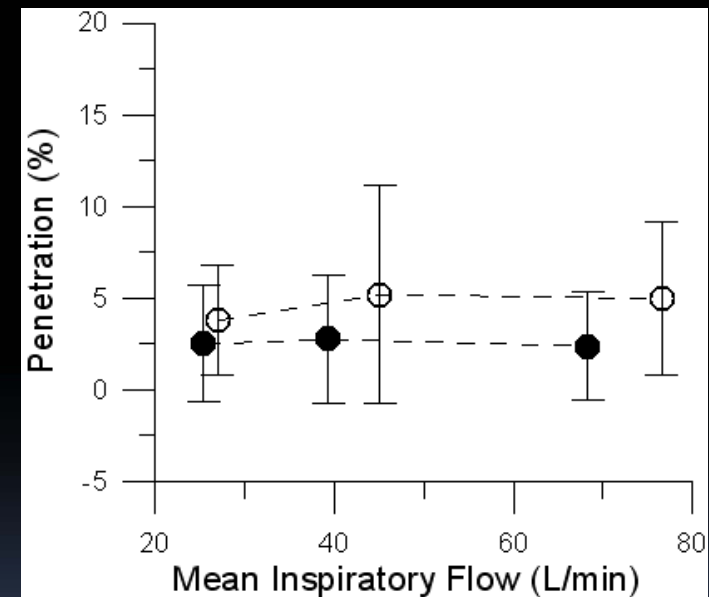
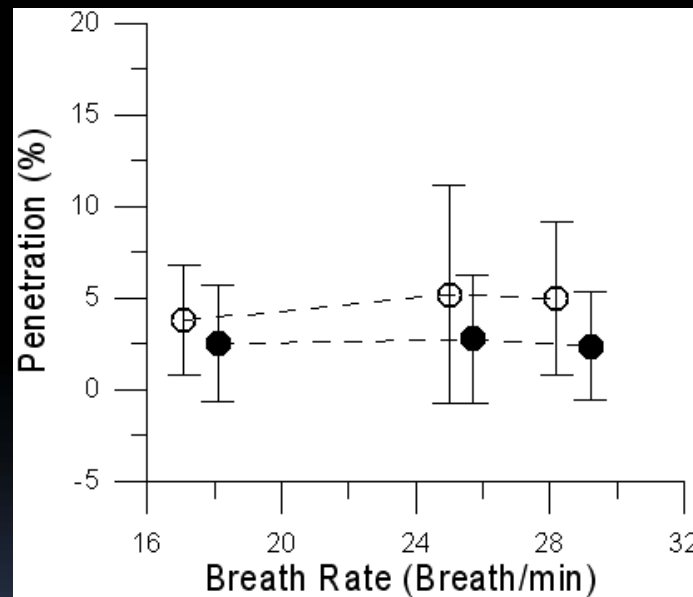
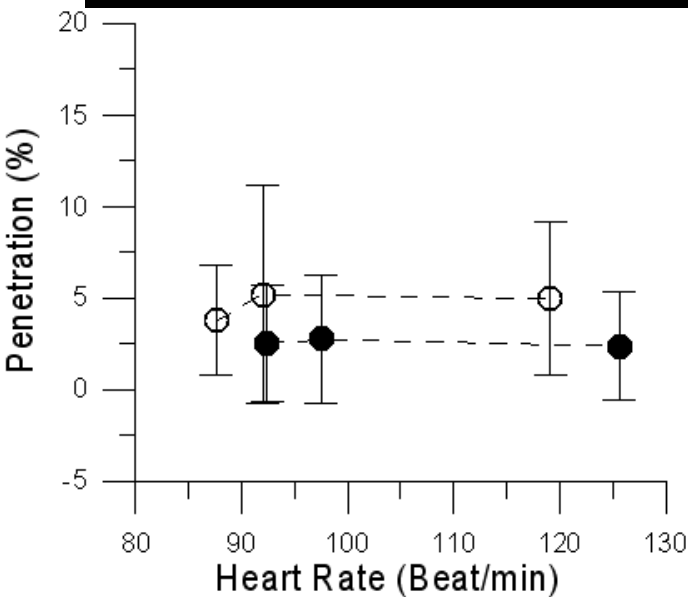


: Total concentration of particles in the size range of 0.7-5  $\mu\text{m}$



# Penetration vs. Activity indicators at three different activities

- Filtering facepiece respirator
- Elastomeric respirator



: Total concentration of particles in the size range of 0.7-5  $\mu\text{m}$

# Conclusions

- Novel experimental protocol was developed to quantitatively characterize the level of activity on respirator efficiency
- Particle penetration was affected more by the variability between subjects than by the level of activity

# Acknowledgement

- This research study was supported by the National Institute for Occupational Safety and Health Pilot Research Project Training Program of the University of Cincinnati Education and Research Center Grant #T42/OH008432-04.
- **University of Cincinnati**
  - Dr. Tiina Reponen
  - Dr. Roy McKay
  - Dr. Sergey Grinshpun
- **Clarkson University**
  - Dr. Stephanie Schuckers
  - Dr. Alan Rossner



# University of Cincinnati 10th Annual Pilot Research Project Symposium October 1-2, 2009

## Main Menu

Hosted by: The University of Cincinnati Education and Research Center Supported by: The National  
Institute for Occupational Safety and Health.  
(NIOSH) Grant #: T42/OH008432-05

- ◆ Welcome and Opening Remarks
- ◆ Keynote Speakers
- ◆ Podium Presentations
- ◆ Poster Presentations
- ◆ Video Montage of the 10th Annual PRP Symposium
- ◆ Participating Universities
- ◆ Steering Committee Members
- ◆ Acknowledgements
- ◆ Problems Viewing the Videos

Produced by Kurt Roberts Department of Environmental Health  
Copyright 2009, University of Cincinnati