

UNIVERSITY OF WISCONSIN-LA CROSSE
Graduate Studies

THE EFFECTS OF SECONDHAND SMOKE EXPOSURE DURING ADOLESCENTS
ON ADULT LUNG FUNCTION

A Manuscript Style Thesis Submitted in Partial Fulfillment of the Requirements for the
Degree of Master of Science

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THE EFFECT OF SECONDHAND SMOKE EXPOSURE DURING ADOLESCENCE ON
ADULT LUNG FUNCTION

By Meghan Michalski

We recommend acceptance of this thesis in partial fulfillment of the candidate's requirements for
the degree of Clinical Exercise Physiology

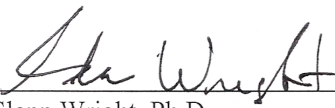
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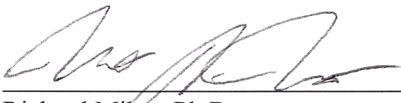
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ABSTRACT

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Mainstream cigarette smoke is known to causes decreases in lung function. This is a potential concern for those subjected to secondhand smoke. The purpose of this study was to compare the effects of secondhand smoke on young adults that either were or were not exposed to secondhand smoke during adolescence. Ninety- four subjects completed a carbon monoxide analysis, pre and post exercise pulmonary function testing and a maximal exercise treadmill test. Forty-four of the subjects were exposed to secondhand smoke during adolescence while the remaining fifty had no history of exposure. Forced vital capacity (FVC), forced expiratory ventilation in one second (FEV₁) and forced expiratory flow 25-75% of FVC were compared pre and post exercise as well as between subject groups. There were no significant differences observed between groups for pulmonary function testing or exercise capacity. Within the limits of this study, there is no evidence suggesting that adolescent secondhand smoke exposure cause deterioration of pulmonary function in young adults.

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Finally, I would like to extend a thank you to all of the subjects in my study, especially my classmates for all of their participation and positive encouragement throughout the process.

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INTRODUCTION

As a child there are few decisions we are able to make on our own. A majority of decisions are made for us by a parent or guardian with our best interests in mind. However, if this is the case, why is secondhand smoke inhalation not viewed as a hazard to our health? Why is it acceptable to smoke in the presence of children? There has been continuous research conducted on the effects of firsthand cigarette exposure since 1950 when Morton Levin published the first study linking cigarette smoke to lung cancer in the *Journal of the American Medical Association* (Caixeta et al., 2011; Elder et al., 1994; Sopori, 2002). With greater than 60 years of substantial research, Levin's findings still are not entrenched in the public mind. Over the last two decades researchers have turned their attention to studying adolescent populations to compare environmental air quality and overall lung function. According to the Centers for Disease Control (CDC) more than 5 million individuals die every year from cigarette smoke and 8 million are projected to die in 2030 with smoking as the attributable cause. A nonsmoker lives an average of 13-14 years longer than a smoker. The years of life reduced by smoking, are attributable to an increased risk of cardiovascular disease, pulmonary diseases and cancer (CDC, 2011).

Cigarette smoke is described as "a complex mixture of particulate and gaseous components" and can enter the lungs in two forms, mainstream or sidestream (e.g. secondhand smoke). Mainstream smoke is directly inhaled from the tobacco source while secondhand smoke is comprised of all elements expired into the air during the

inhalation phase, the burning phase and also the products that are diffused through the paper (Sopori, 2002). There are several factors that effect consumption of secondhand smoke. One factor is the “microenvironment” which consists of the concentration of smoke, volume of the room, the generation rate and the removal rate. Additionally, the time both within a day and the cumulative hours of lifetime exposure affect the net exposure to secondhand smoke. These factors can effect the concentration and volume of secondhand smoke that is inhaled by bystanders. (Moritsugu, 2007)

As the consequences of mainstream smoke became apparent, researchers started to expand the question of how far the effects stretched. Several studies showed a direct relationship with the amount of secondhand smoke exposure and abnormalities of lung function (Maritz & Harding, 2011), especially the forced expiratory flow 25-75% ($FEF_{25-75\%}$) of the forced vital capacity (FVC) curve (Nugoglu et al., 2003; Hofhuis et al., 2003). The more children are exposed to secondhand smoke the more likely they are to have decreased lung function (Gold et al., 1996; Nugoglu et al., 2003; Moshhammer et al., 2006) and have an increased risk for, frequency and severity of infections, such as ear infections or bronchitis (Hofhuis, Jongste, & Merkus, 2003). They are also at a greater risk of developing adult onset asthma and chronic obstructive pulmonary disease (COPD) due to impairment in lung development because of environmental tobacco exposure (Hofhuis, Jongste, & Merkus, 2003).

Along with impaired lung function individuals with a high lifetime exposure to secondhand smoke have an increased risk of cardiovascular mortality and cardiovascular disease (Eisner et al., 2007). There is also an increased risk of developing cancer, especially lung cancer due to the inhalation of secondhand smoke. Spouses of smokers

have a 34% greater risk of developing lung cancer than spouses of nonsmokers, according to a study overviewed by the Surgeon General (Elders et al., 1994).

In addition research has revealed that with one pack per day of secondhand smoke inhalation (ppd) there is a 3.2% decrease in FEF_{25-75%} in girls and a 3.5% decrease in boys. There is also a slight airway obstruction and a slower growth of lung function (Gold et al., 1996). Furthermore there is reduction in forced expiratory volume in one second (FEV₁) in children born to smoking mothers (Moshammer et al., 2006). This evidence suggests that many aspects of respiration are being impaired with in utero and or childhood smoke exposure. In utero exposure results in lower birth weights and premature birth, setting the stage for a lifelong reduction in lung function. There is an adverse effect on newborn tidal flow volume ratios and lung compliance, which reduces maximal expiratory flows in late childhood.

Recently many states have become smoke free by eliminating smoking in public places, with the goal of reducing secondhand smoke exposure being the driving motivator. A 2006 study in Scotland explored the effects of lung function pre and post smoking ban legislation on bartenders. Improvements in the respiratory system as a whole were seen two months post ban with increase in pulmonary function values and decreases in respiratory symptoms and lung cell inflammation (Menzies et al., 2006).

An acute exposure to secondhand smoke, lasting approximately an hour has little effect on long-term lung function. However it does impact short-term lung function to a significant degree and the inflammation of cytokines, which suggest chronic lung disease. Lung function returns to baseline after approximately one hour or non-exposure (Flouris et al., 2009). The question of when does repeated acute exposure become chronic and

when does the respiratory system suffer lasting effects due to secondhand smoke exposure remains unanswered

However what if exposure is chronic, and lasts several hours. A 2012 studies by Arjomandi colleagues looked at the impact of secondhand smoke exposure had on flight attendants prior to the federal smoking ban in 2000 on all flights. This study looked at flight attendant that worked for airlines at least 5 years prior to the ban and the effects on pulmonary function and exercise capacity. The study revealed that flight attendants with 10 plus years of work had a significant effect on lung function and exercise capacity, as well as physiological abnormalities consistent with emphysema and/or COPD (Arjomandi et al., 2012). The influence of an airplanes microenvironment can contribute to theses changes in pulmonary function, small space with poor ventilation and the generation rate can be as high as the number of seats available on the aircraft.

The purpose of this study was to assess the pulmonary function of non-smoking young adults who were either exposed or not exposed to secondhand smoke throughout childhood and adolescence. Pulmonary function testing was conducted at rest and following exercise to compare respiratory function between groups.

METHODS

Subjects

A group of 94 students from the University of Wisconsin - La Crosse, between the ages of 18 to 27 years, were recruited for this study. Table 1 illustrates the subject demographics for the forty-four subjects that were exposed to secondhand smoke during childhood and adolescence and the remaining fifty subjects that were not exposed. The male subjects were 21.2 ± 2.5 years, had a mean height of 179.3 ± 7.6 cm and a mean weight of 81.2 ± 9.3 Kg. The female subjects were 20.3 ± 1.6 years with a mean height of 167.1 ± 5.7 cm and a mean weight of 64.1 ± 7.4 Kg. The majority of subjects reported exercise for at least one day per week for thirty or more minutes of aerobic activity.

Table 1. Subject Demographic

Gender	Exposure	Age (yrs)	Height (cm)	Weight (kg)
Male (n = 17)	Non Exposed	20.5±1.8	182.5±6.6	81.0±10.2
	Exposed	21.7±2.8	176.7±7.5	81.4±8.8
Female(n = 33)	Non Exposed	20.5±1.8	168.2±5.4	63.5±6.1
	Exposed	19.9±1.2	165.5±6.0	64.9±9.0

Procedures

After the approval of the University of Wisconsin-La Crosse Institutional Review Board for the Protection of Human Subjects, participants provided written informed consent prior to participating. They completed a tobacco exposure questionnaire based on

residential environment, parents smoking habits, and personal health. At the beginning of the trial participants completed a carbon monoxide test, verifying that the subjects self-report of non-smoking were accurate. A handheld analyzer was used to provide values, excluding any participants with a value of 10 parts per million (ppm) or greater, suggesting they are a smoker themselves. The values ranged from 0 – 8 with a mean 2.5 ± 1.5 ppm, verifying all subjects as true nonsmokers.

During the trial subjects performed resting pulmonary function testing (PFT) to measure forced vital capacity (FVC), forced expiratory volumes in one second (FEV_1), and forced expiratory flow ($FEF_{25-75\%}$). Subjects completed three trials, with the best measure from each category used as their score. Heart rate was recorded using radio telemetry throughout the trial.

After completion of the resting PFT, each subject completed a maximal treadmill exercise test on a treadmill using the modified Balke protocol. Subjects self selected their speed to a comfortable walk or jogging pace between 2.5mph and 6.5mph. An elevation increase of 2.5% occurred every two minutes until maximal effort was achieved. Measurements of heart rate, rating of perceived exertion (Borg Scale, 0-10) and the “Talk Test” were recorded for data analysis. The exercise intensity at the equivocal stage of the “Talk Test”, a surrogate of ventilatory threshold (Dehart-Beverley et al., 1999, Recalde et al., 2002 & Voelker et al., 2002) and at maximal exercise capacity was estimated from protocol independent equations (Foster et al., 1996). A two-minute active recovery followed the exercise test at a speed of 2.5 mph and a grade of 0%. Repeated pulmonary function testing was performed 15 minutes following the conclusion of the

exercise test. The American Thoracic Society Guidelines were followed for pre, post and exercise pulmonary function testing. (Miller et al., 2010)

A between subjects multivariate analysis of variance (MANOVA) was conducted to assess differences in pulmonary function between the exposure and non-exposure group. Pulmonary function was evaluated for FVC, FEV₁ and FEF_{25%-75%} for the exposed and non-exposed groups and for pre and post maximal exercise. A MANOVA was also conducted to assess diagnosis of chronic ear infections and/or asthma between the two groups.

RESULTS

Exercise capacity at the estimated ventilatory threshold, by the talk test, was 4.76 ± 1.49 METs in the non-exposed and 4.99 ± 1.44 METs in the exposed group. Maximal exercise capacity was 11.02 ± 1.69 METs the non-exposed and 10.68 ± 1.59 METs in the exposed group. The achieved maximal exercise capacity compared to predicted was 77.18 ± 13.05 percent in non-exposed males, 82 ± 8.75 percent in non-exposed females 73.1 ± 9.14 percent in exposed males and 79.04 ± 13.37 percent in exposed females based on the norms for physically active healthy adults (Morris et al., 1993)

There were no significant differences observed between groups for any of the pulmonary function tests. Figure 1 shows the pulmonary function values for the subjects that were exposed to secondhand smoke and those that have not been exposed during the pre exercise measurement. Figure 2 shows the pulmonary function values for the subjects that were exposed to secondhand smoke and those that have not been exposed during the post exercise measurement. There was not a significant difference between groups for either condition or chronic bronchitis or asthma. Figure 3 highlights the relationship between subjects that were exposed and not exposed to secondhand smoke and their prevalence of ear infections and/or asthma.

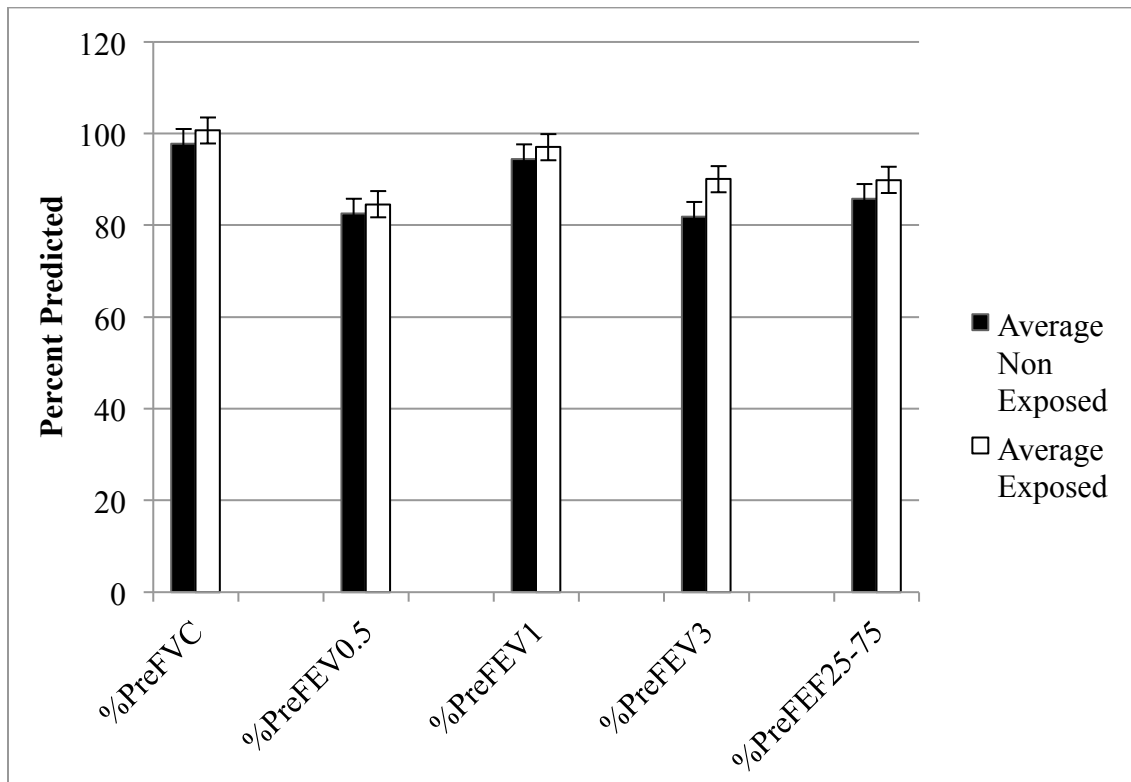


Figure 1. Pulmonary function percentages prior to maximal exercise. There were no significant differences seen between the two groups for any of the lung function values measured.

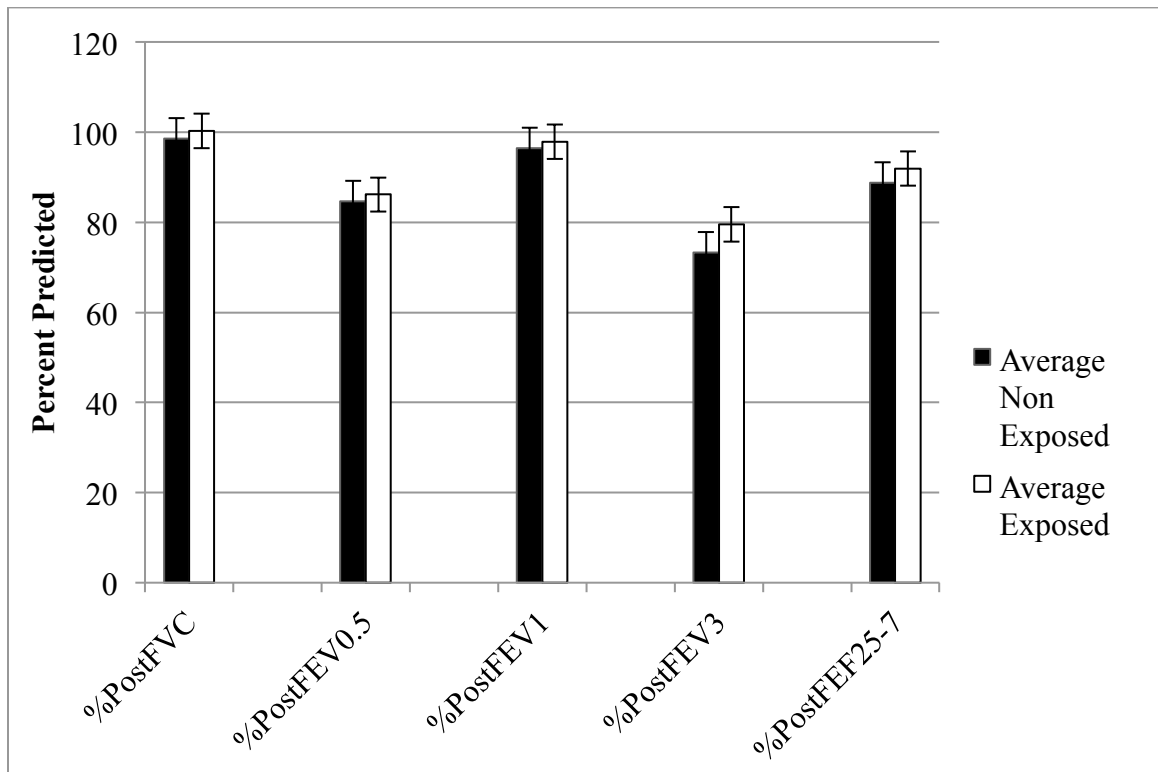


Figure 2. Pulmonary function percentages 15 minutes post maximal exercise. There were no significant differences seen between the two groups for any of the lung function values measured.

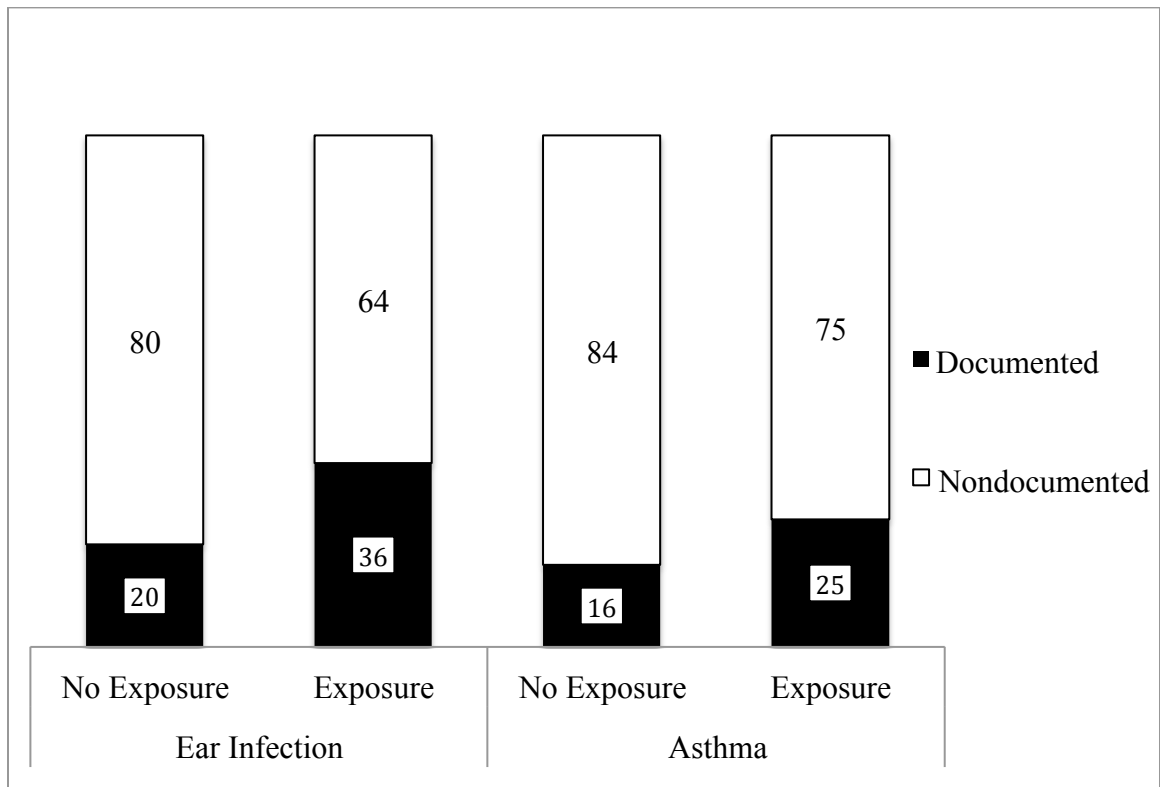


Figure 3. The percentage of ear infections and diagnosed asthma in non-exposed and exposed subjects. There were no significant difference seen between groups for either condition

DISCUSSION

Cigarette smoking causes acute effects in the body. With long term exposure there is an increase for risk for a number of diseases. This is also the case with exposure to secondhand smoke. Acute effects of exposure to secondhand smoke result in known changes in pulmonary function testing (Flouris et al., 2009). The majority of exposed subjects in the present study were exposed to secondhand smoke for most of their childhood. However they have been living away from their previous environment for 1-3 months before participating in the study. Flouris et al. (2009) suggested that the effects of secondhand smoke on lung function normalize after approximately an hour of non-exposure, returning lung function values to pre-exposure levels. This may be one explanation for the lack of significant difference in pulmonary function between the exposed and non-exposed groups.

There were no significant difference between the exposure and non-exposure group relative to pulmonary function testing either pre and post exercise. The majority of participants in this study described themselves as physically active, participating in aerobic activity for at least one day per week for greater than 30 minutes. A high level of aerobic activity and a reduced amount of exposure in the present may be one explanation for the lack of a deficit in the exposed group. However a further study on exposure to secondhand smoke and whether routine aerobic activity can counter the damage delivered from secondhand smoke exposure should be conducted. A 25-year follow up study

suggests that physical activity offers beneficial effects on pulmonary function.

Independent of cigarette smoking, highly fit older subjects who were physically active had better pulmonary function values (Pelkonen et al., 2003). This suggests that physical activity might reduce the predicted negative effects of exposure to secondhand smoke during childhood and adolescence. However in this subject population the mean physical activity and exercise capacity was not high enough to provide a test for this concept.

The self-documentation of asthma and chronic ear infections between the exposure and non-exposure groups were also not significant. Research suggests there is a greater risk of both conditions with exposure to secondhand smoke (Hofhuis, Jongste, & Merkus, 2003; Landau, 2008). However, this study was not consistent with current findings. Increase indoor particulate matter exposure has been shown to elicit asthma related symptoms in very young children (McCormack et al., 2009).

Perhaps general air quality plays a greater role in lung function than just the exposure or non-exposure to secondhand smoke factor. The majority of subjects resided in cities with a population of less than one million. If this study was to be replicated, finding subjects from more densely populated or more systematically polluted areas would be ideal to allow testing for decreases in lung function based on both environmental and secondhand smoke exposure. The concept of microenvironments suggests that the type of exposure results in changes in lung function. Microenvironments take into account the volume of the area, removal rate, generation of consumption and concentration of smoke. Recruiting subjects based on two different types of microenvironments would possibly suggest a greater difference in lung function than simple exposure to secondhand smoke.

In conclusion within the limits of this study, there is no evidence to suggest that adolescence exposure to secondhand smoke causes deterioration of pulmonary function in your adults. However the relationship between the popularity of cigarette smoking and the increased onset of lung disease is not present until 20-30 years post popularity. This time lag may also suggest the reason no differences were observed between the subject groups.

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APPENDIX A
INFORMED CONSENT

Informed Consent

The Effects of Adolescent Secondhand Smoke on Lung Function

I, _____, agree to participate in a research study conducted at the University of Wisconsin-La Crosse

- The purpose of this study is to measure lung function in college students that have or have not been exposed to secondhand smoke throughout adolescence.
- All personal information will be kept confidential, but the research findings of this study may be published or presented however direct information of names will not be included.
- This study will be conducted by Meghan Michalski, a graduate student in the Clinical Exercise Physiology Program. She will be working with Dr. Carl Foster, a professor in the Exercise and Sport Science Department.
- Prior to the trial I will complete a survey based on my personal health, exposure to secondhand smoke, parental habits smoking habits, and hometown air quality.
- Participation in this study will require a completed pre and post pulmonary function test, a carbon monoxide test and a maximal exercise test, recording respiratory gas exchange.
- I will be required to wear a heart rate monitor during testing procedures. I will also be asked to rate my level of perceived exertion, feeling of tiredness, based on the Borg Scale.
- Participation in this study will require no more than one hour of my time. I have the option to withdraw from the study at anytime, for any reason.
- The risk for participating in this study includes muscle and overall body fatigue. The risk of serious complications is less than 1/10,000. The test will be terminated if any indication of complication or request by the participant. Individuals trained and certified in CPR and ACLS will conduct this study. There is also an AED available on site.
- I am aware there are not any direct benefits for me by participating in this study. Participants will be informed on their lung function compared to the norm population but no diagnosis can be declared based on results. The results will benefit the medical community by advancing research on the effects of secondhand smoke.

I have read the above statements and understand in full the test protocol and what participation in this study will require. If there are any questions and/or concerns they can be answered by the investigator Meghan Michalski (608-436-4337) and her research advisor Dr. Carl Foster, Department of Exercise and Sport Science, UW-La Crosse (608-785-8687). If there are any questions and/or concerns involving the protection of human subjects, please contact the Chair of the UW-La Crosse Institutional Review Board for the Protection of Human Subjects at (608-785-8124).

Subject Name: _____ Date: _____

Signature: _____

Investigator Signature: _____ Date: _____

APPENDIX B

TOBACCO SMOKE EXPOSURE QUESTIONNAIRE

TOBACCO SMOKE EXPOSURE QUESTIONNAIRE

1. Demographics

Gender _____ Age (yrs) _____
 Residence (cities lived in >6 months National/International): _____

2. Has a **doctor** ever told you that you have any of the following medical problems?

Medical Condition	Yes	No	Age at Diagnosis
a. High blood pressure			
b. Diabetes			
c. Asthma			
d. Chronic bronchitis			
e. Emphysema			
f. Sleep Apnea			
g. Lung cancer			
h. Sinus problems			
i. Ear Infections			
j. <i>Other:</i>			

3. Do you take any medications? YES NO*

Medication Type	Date Started

4. Do you ever experience chest pain or discomfort with exertion: YES NO
5. Do you ever experience shortness of breath? YES NO*
6. Do you experience shortness of breath in bed at night? YES NO
7. Do you experience shortness of breath with regular activity? YES NO
8. Are you able to perform less physical activity than other healthy people your age?
 YES NO

If YES, reason:

9. Please choose the ONE best description of your usual level of activity:

VERY ACTIVE: Running, fast walking, or other cardiovascular exercise at least once a week for 30 minutes at a time.

ACTIVE: Standing or walking most of the day; lifting groceries, heavy housework, care of young children, or similar activities.

SEDENTARY: Sitting most of the day, without regular physical activity, Except minor household or office tasks.

LIMITED: Often stay in bed for part of the day; perform physical activity only when necessary or require assistance with household tasks.

10. Do you have a cough?

- Daily
- Monthly
- Rarely (2-3 times per year)
- Never

11. Do you have nasal congestion, throat, or eye irritation, not related to a cold or hay fever?

- Daily
- Monthly
- Rarely (2-3 times per year)
- Never

12. Have you been exposed to vapors, dust, gases, or fumes (OTHER than tobacco smoke) at your workplace? YES NO
If yes, what were you exposed to?

If yes, for how many years were you exposed to this agent?

13. Are you currently exposed, for at least one hour daily, to vapors, dust, gas or fumes (other than tobacco smoke) at your workplace? YES NO

SMOKING HISTORY

14. Have you ever smoked cigarettes regularly (at least 1 cigarette per day and a total of 100 cigarettes in your lifetime?) YES*
NO

**If you answered Yes, please do not complete this questionnaire as you are not eligible to participate in this study.*

15. Do you smoke cigarettes now? DAILY SOME DAYS
 NO*

**if you answered NO, please skip to question 20*

16. On average, how many cigarettes per day do you smoke? (One pack = 20 cigarettes)
 _____cigarettes per day

17. On average, how many cigarettes per day did you smoke when you were smoking at your heaviest?
 _____cigarettes per day

18. How old were you when you started to smoke cigarettes regularly?
 _____years old

19. How old were you when you last smoked cigarettes regularly?
 _____years old

SECOND-HAND SMOKE EXPOSURE HISTORY

Childhood Exposure History

20. When your mother was pregnant with you, did either of your parents smoke?

Mother Father Both Neither Don't know

21. Growing up until age 18, did anyone regularly smoke around you? YES NO*

**if you answered NO, please skip to question 22*

If yes, please complete the table below:

Age range (13-16)	Lived with smoker (yes/no)	Confined/ Open Environment/ Both	Who? (mother, father, other)	Hours /week spent time with other smokers? (e.g. babysitter, friends, relatives)	Number of hours/weeks in car with smoker?

How many packs of cigarettes did they smoke per day altogether?			
<u>Less than 1</u>	<u>1</u>	<u>2</u>	<u>More than 2</u>

Adulthood Exposure History

22. After age 18, have you ever lived with anyone who smoked cigarettes?

YES

NO*

**If you answered no, please skip to question 24*

If yes, please complete the table below:

Age Range (19-24)	Confined/ Open Environment/ Both	How many packs of cigarettes did they smoke per day altogether?			
		<u>Less than 1</u>	<u>1</u>	<u>2</u>	<u>More than 2</u>

23. After age 18, approximately how many hours a week did you spend in locations **other than home or work** where smoking occurred around you?

Age Range (e.g., 18-22)	Hours / Week in Each Location					
	friends' home	In a car	Restaurants	Bars, lounges	other locations (name)	other locations (name)

Please circle the best answer for the following questions:

24. Over the past 12 months, how often have you gone to places other than your home or work where people smoked around you indoors, close enough to see or smell the smoke?

More than
once week

More than
once a month

Less than
once a month

Never

25. Have you experienced irritation of your eyes or throat from other people's smoke?

a) At Home: More than once week More than once a month Less than once a month Rarely/ Never

b) At work: More than once week More than once a month Less than once a month Rarely/ Never

c) Other places: More than once week More than once a month Less than once a month Rarely/ Never

APPENDIX C
REVIEW OF LITERATURE

REVIEW OF LITERATURE

The purpose of this literature review is to discuss the effects of secondhand smoke on children that have a parent(s) that smokes and the various health problems that can result from secondhand smoke exposure.

Lung development

Lung development begins around the first month regardless that respiration is not essential until birth. However, lung function is not complete until late adolescences, with 80% of alveoli developing after birth. This development is crucial to feed the increased demand of the growing body. Exposure to toxins or chemicals during the critical stages of development can alter lung function and cause complications in respiration. (Pinkerton & Joad, 2000) Since children have smaller lungs they require an increase in ventilation allowing for a greater exposure to toxins if present.

Exposure to nicotine during pregnancy can cause alterations in lung development. Nicotine crosses the placenta effortlessly and can impact several processes including an elimination of cells, causing enlargement of alveoli producing similar changes seen in emphysema. (Tager, 2007) These changes in lung growth can impact respiration, causing an increased risk of pulmonary disease.

Effect of Secondhand Smoke Inhalation

The popularity of smoking grew in the 1930s along with the knowledge of disease surrounding the habit. Roughly twenty years later the first research based paper linking

cigarette smoke to lung cancer was published in The Journal of the American Medical Association. The article highlighted the risk of developing cancer based on socio-economic status, heredity, percutaneous lesion development, carcinogen exposure and epidemiological factors. Stating that the risk of developing cancer is higher in individuals with a lower socio-economic status, higher exposure to carcinogens, history of cancer and/or percutaneous lesions. Yet risk can vary with epidemiological factors based on the type of cancer. (Levin, 1948)

The gender differences between secondhand smoke exposures in children were explored in 1996 by Gold and colleagues. This study investigated gender differences in the level and rate of growth of pulmonary function from the effects of cigarettes in children ages 10-18 years. Data revealed at one pack per day (ppd) of SHS inhalation there is a 3.2% decrease in FEF_{25-75%} in girls and a 3.5% decrease in boys. There also indicated a slight airway obstruction and a slower growth of lung function. (Gold et al., 1996)

Several studies over the last decade have revealed an inverse relationship with the amount of secondhand smoke exposure and the abnormalities of lung function. Forced expiratory flow 25-75% (FEF_{25-75%}) of the forced vital capacity (FVC) has shown to have a significant decrease in children with parents that smoke. (Nugoglu et al., 2003; Hofhuis et al., 2003; Moshammer et al., 2006). The more smoke children are exposed to the more likely they are to have decreased lung function (Gold et al., 1996; Nugoglu et al., 2003; Moshammer et al., 2006). Along with impaired lung function individuals with a high lifetime exposure to SHS have an increased risk of cardiovascular mortality and cardiovascular disease (Eisner et al., 2007).

In addition, studies have found decreases in adolescent lung function when the mother smoked while pregnant. These children were more likely to be premature and of a low birth weight, implying they are also under developed. An adverse effect is shown in infant tidal volume and lung compliance resulting from maternal smoking. (Landue, 2008). Furthermore a decrease was observed in forced expiratory volume in 1 second (FEV₁) in children of mothers that smoked during their pregnancy (Hofhuis et al., 2003) & (Moshammer et al., 2006).

According to the Surgeon General there are various consequences related to involuntary exposure to tobacco. The current publication summarizes the previous published research while also drawing attention to the environment in which the exposure occurs. The term “microenvironment” is used to describe the location in which exposure occurs. A “microenvironment” is made up of four components, the concentration, room size, rate of production and also the rate at which it is removed. (Moritsugu, 2007) Secondhand smoke inhalation is impacted by the microenvironment present at the time of exposure.

In 2009 Flouris and colleagues advanced SHS exposure research when they developed a research study to measure the acute effects of cigarette exposure to mimic a one hour bar or restaurant experience. This was the first study to look at acute effects of secondhand smoke versus chronic exposure. Subjects were exposed for a total of one hour in a smoke filled room. Over the next three hours subjects’ lung function and cytokine levels were measured to assess the effects of acute exposure. Initially lung function decreased below baseline function but returned to baseline after one hour. However cytokines levels remained elevated over the three-hour data collection.

Overall, exposure to SHS as a child has multiple effects on the development of the lungs and other vital organs. Children are at an increased risk of reduced lung function due to restriction of airflow in small airways. In addition to hyperresponsiveness, asthma and respiratory symptoms such as wheezing, coughing and mucus production. (Maritz & Harding, 2011; Pinkerton & Joad, 2000)

Pulmonary Function Testing (PFT)

Pulmonary lung function testing (PFT) assesses the risk of pulmonary disorders and/or disease. This technique has been used since the 1970s. PFT evaluates diffusion and gas exchange, respiratory muscle function and ventilation capacity while also looking for signs and symptoms such as chest discomfort, pain, wheezing, coughing or dyspnea while testing.

During a PFT several measurement are recorded to calculate pulmonary function. Tidal volume measures normal inhalation and exhalation while at rest. Forced vital capacity (FVC) measures total lung volume minus residual volume remaining in the lungs. Forced expiratory flow measures a percentage of airflow during FVC, usually expressed as a percentage of vital capacity. Forced expiratory volume for 1 second (FEV₁) is used to assess the mechanical lung function. (Crapo, 1994) Each component is essential to evaluate overall lung function along with observed signs and symptoms in order to evaluate lung function.

Summary

In conclusion secondhand smoke exposure worldwide is still high with 40% of children, 33% of nonsmoking males and 35% of nonsmoking females being exposed (Oberger et al., 2011). According to previous studies there is a strong correlation between

increased SHS exposure, pre and postnatal, and a decrease in lung function. It is important for parents to know the effects smoking is having on their child's development. The public needs to be informed of the potential side effects associated with SHS and the life altering implications a pulmonary disorders/disease can have.

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