Reproductive health among tactical athletes: An examination of physical activity and occupational concerns

by

Ainslie Kathryn Kehler

B.S., University of Victoria, 2006
M.Kin., University of British Columbia, 2014

AN ABSTRACT OF A DISSERTATION

submitted in partial fulfillment of the requirements for the degree

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Abstract

Tactical athletes (e.g., law enforcement, military, firefighters) require a proportionate fitness level, along with specific technical and tactical skills, to achieve short-term objectives and disable various threats. Although these professions have unique job duties and workplace exposures, tactical athletes share many commonalities. A tactical athlete's occupation requires her to be physically prepared for the unknown to protect the public. So what happens when the tactical athlete becomes pregnant? Benefits of physical activity throughout pregnancy for athletes, non-athletes, and baby have been well-documented. However, certain common tactical occupational conditions may result in adverse birth outcomes. These include shift work, high job stress, and exposures such as lead handling or high ambient temperatures. Additionally, extreme physical exertion around the implantation period may harm the developing embryo. In an unpredictable, potentially extremely physically demanding and stressful job environment, the pregnant tactical athlete may have higher risk for adverse birth outcomes compared to other women. The purpose of this dissertation was to examine the reproductive health of physically active females with specific focus on tactical athletes. First, we wanted to determine any exercise limits for pregnant athletes. We were also interested whether reproductive health was an important concern for this population, and if their adverse birth outcomes were higher compared to the United States national average. Chapter one reviews the literature, examining the female athlete and tactical athlete, the physical and occupational demands of tactical professions, and the reproductive health concerns among law enforcement officers (LEOs) and firefighters. Chapter two is a comprehensive review on prenatal exercise. It

highlights the lack of scientific rigor presented in earlier guidelines, and states the need for more research on the upper limits of exercise intensity for athletes. Female athletes can usually maintain regular exercise training during pregnancy. Chapter three uses grounded-theory to investigate reproductive health concerns among firefighters. Results indicate that reproductive health is unquestionably a large concern, with four resulting themes (i.e., decision-making, recruitment and retention, policy variation, and lack of research). Chapter four investigates adverse reproductive health outcomes in female LEOs. Miscarriage rates are compared with a large prospective linkage study, preterm birth rates are compared to a large systematic US review study, and links are explored between specific job exposures and pregnancy loss. Miscarriage rate for our population are 19.1%, and preterm birth rates are 16.4%, both significantly higher than US averages. Physical activity, including strenuous occupational demands during pregnancy, is not associated with pregnancy loss among female LEOs. Chapter five presents a findings summary and future research directions. Miscarriage and preterm birth appear to be higher than average for both female firefighters and LEOs. Exercise did not play a large role in the concerns of female firefighters, or findings from female LEOs. Future research should be conducted specifically on females working in tactical occupations, with an emphasis on reproductive health concerns. More education should be provided at the organization level on the potential occupational exposures that can cause increased risk of adverse birth outcomes in female tactical athletes.

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Dedication

For Jenny, who was taken too soon from this earth. Your friendship and shortened life pushed me to step out of my comfort zone, take a big chance, and view life and its many obstacles as a privilege. I miss you.

For Kathryn, whose remarkable strength and resilience shines brighter than any scars or injury. You are a warrior. Thank you for reaching out to me during the hard times, even though it was you fighting the real battles. Grateful we are family.

For all the women who are killing it in male-dominated professions – especially the firefighters and the police officers. This research is for you.

For Nick. My rock. For always believing in me when I didn't always believe in myself. We did it!

Chapter 1 - Introduction

Terminology

This dissertation is focused primarily on miscarriage as the adverse birth outcome of interest since it is the most common type of pregnancy loss (Cunningham et al., 2014). Miscarriage, also referred to in the literature as spontaneous abortion or pregnancy loss, is the loss of a pregnancy during the first 20 weeks (Bø et al., 2016). In addition to a consensus statement from the American College of Obstetricians and Gynecologists (ACOG), several studies have reported that miscarriages occur in approximately 10% of all pregnancies (ACOG, 2015; Wang et al., 2003; Wilcox et al., 1988; Zinaman et al., 1996); 80% of which occur in the first trimester due to chromosomal abnormalities (Alijotas-Reig & Garrido-Gimenez, 2013; Stephenson, Awartani, & Robinson, 2002). The World Health Organization (WHO, 2018) defines preterm birth as any live birth before 37 weeks gestation. It is the leading cause of death among children under five years of age, and survivors often face learning disabilities, and vision and hearing problems (WHO, 2018). The research in this dissertation uncovers that, similar to female firefighters, miscarriage and preterm birth among female LEOs appear to occur at higher rates compared to the US average.

Exercise, physical activity, and physical fitness are sometimes used interchangeably, however, their meanings are distinctly different from one another. Physical activity is any bodily movement created by skeletal muscle that results in expenditure of energy (Caspersen, Powell, & Christenson, 1985). Exercise is a subset of physical activity, and refers to planned, structured and repetitive movement whose objective is the improvement or maintenance of physical fitness (Caspersen et al.,

1985). Physical fitness is defined as “the ability to carry out daily tasks with vigor and alertness, without undue fatigue and with ample energy to enjoy leisure-time pursuits and to respond to unforeseen emergencies” (CDC, 2015, p. 1). One of the goals of this dissertation is to examine exercise and its potential relationship to adverse birth outcomes such as miscarriage and preterm birth.

The Female Athlete

The numerous maternal benefits of exercise throughout pregnancy for both athletes and women alike have been well documented (Bø et al., 2016; Clapp & Little, 1995; Kardel, 2005; Kardel, Johansen, Voldner, Iverson, & Henriksen, 2009; Pennick & Young, 2007). However, there is still apprehension concerning exercise intensity and volume on the developing fetus and birth outcomes. The trepidation lies in the fear that exercise could lead to selective blood flow redistribution to maternal exercising muscles, and the redistribution could result in inadequate fetal oxygenation (Kruger, Murphy, & Thompson, 2006). Insufficient fetal oxygenation could lead to threatening changes in fetal heart rate (FHR) and possibly miscarriage (Kruger et al. 2006). Despite concerns over miscarriage and other adverse outcomes including low birth weight (<2500 g) babies (Leet & Flick, 2003), congenital deformities and premature labor, there is no documentation that regular exercise has increased the occurrence of maternal or fetal injury in an uncomplicated pregnancy (Hammer et al., 2000). Kardel’s research (2005) indicated that female athletes could safely train at high intensities with an uncomplicated pregnancy. In fact, she reported that well-trained athletes benefit from exercising at high volumes during pregnancy, as it did not threaten the health of mother or fetus, and could help sustain pre-pregnancy fitness levels (Kardel, 2005). Additional research

reported that well-trained pregnant athletes also had a significantly shorter first stage of labor compared to women who ceased exercise before the end of the first trimester (Clapp & Little, 1995).

In 2011, the International Olympic Committee Medical Commission made the following statement about female athletes performing in the Olympics: “No female athlete should be denied the opportunity to participate in any Olympic sport on the basis that she might sustain an injury to her reproductive organs. A survey of injury data has failed to find any evidence of an increased risk for acute or chronic damage to the female reproductive organs occurring as a direct result from participation in sport” (p.1). In support of this statement, Sports Medicine Australia found no reports of fetal death or injury related to contact or trauma during sports (Brown et al., 2002). The most recent guidelines from the ACOG (2015) summed their stance on exercise intensity by stating, “Although an upper level of safe exercise intensity has not been established, women who were regular exercisers before pregnancy and who have uncomplicated, healthy pregnancies should be able to engage in high-intensity exercise programs… with no adverse effects” (p.1).

The Tactical Athlete

The term “tactical athlete” refers to law enforcement, military, and rescue professions. Tactical athletes have also been referred to in the literature as tactical professionals, emergency responders and first responders. This dissertation will use the term tactical athlete and will specifically focus on female firefighters and female law enforcement officers (LEOs). Although tactical athletes have unique job requirements and workplace exposures, they share many common conditions relevant to their

emergency services and duties. These professionals require unique physical training strategies that are focused on elevating their occupational physical performance (Scofield & Kardouni, 2015). In particular, cardiovascular fitness is one of the most common physical demands required for emergency response among all professions (Kales, Tsismenakis, Zhang, & Soteriades, 2009). In addition to specific technical and tactical skills, tactical athletes require a proportionate fitness level for their occupational requirements of successfully achieving short-term objectives and disabling various human or environmental threats (Jetté, Kimick, & Sidney, 1989; Pawlak, Clasey, Palmer, Symons, & Abel, 2015; Sothmann, Gebhardt, Baker, Kastello, & Sheppard, 2004). Day-to-day job duties can require explosive strength, repeating strenuous tasks, working in awkward positions, or requiring great cardiovascular endurance (Alver, Sell, & Deuster, 2017). Scofield and Kardouni (2015) sum up the unpredictable physical nature of these occupations by stating, “Tactical athletes are expected to effectively respond to a myriad of unpredictable, physically and psychologically stressful events; tasks only accomplished by continual physical readiness” (p.5).

There is a need for new research and prevention efforts to improve the health and safety of tactical athletes (Reichard & Jackson, 2010). Research in this field continues to be predominantly conducted with males, since the majority of personnel in tactical occupations are male (Kales et al., 2009). Despite goals of having females represent 16-22% of the fire service (iWomen, 1995), only 3.7% of career firefighters (n = 12,850) are estimated to be female (Haynes & Stein, 2017). Similarly, despite efforts to increase the recruitment and retention of females in law enforcement, there has been limited success and slow growth (Harrington, 2003). Female law enforcement officers

(LEOs) are grossly under-represented, and make up approximately 16% (n=96,900) of the total US sworn police force (Langton, 2010).

There has been limited research conducted on the job-specific health of female firefighters or female LEOs. However, it was recently found that miscarriage rates among a large sample of female firefighters (n=674) were at least 2.3 times higher than the US national average (Jahnke et al., 2018). Additionally, rates of preterm birth (<37 weeks) appeared to be higher in the sample (12.3%), compared to the 9.8% US national average (March of Dimes, 2017).

Exercise and Occupational Reproductive Concerns

Light to moderate exercise does not increase risk of miscarriage, but rather, may decrease it (Schlüssel et al., 2008). In addition, females working in occupations that provide light or medium physical activity have a lower risk of miscarriage compared to sedentary occupations (Bø et al., 2016). In support of these findings, two large pregnancy cohort studies did not find that work-related heavy lifting was associated with miscarriage (Ahlborg, Bodin, & Hogstedt, 1990; Fenster, Hubbard, Windham, Waller, & Swan, 1997). Contrary to these findings, more recent research reported that females engaged in occupational lifting were more likely to have a miscarriage compared to those with no lifting, and this risk increased with total number of kilos lifted per day and with lifting frequency (Juhl et al., 2013). In addition, those who worked in repeatedly crouched positions also had an increased risk of miscarriage (Hagan & Wong, 2010). There is also evidence that miscarriage risk is increased when there is highly strenuous exercise right around the time of embryo implantation (Hjollund et al., 2000). From an occupational standpoint, this finding may have the most relevancy for tactical athletes.

Typically, the nature of tactical occupations involve long stretches of relative inactivity that are interspersed with unpredictable and incredibly stressful bursts of high intensity activity (Kales et al., 2009).

Job Exposures and Reproductive Health Concerns

Various workplace exposures and hazards can have an adverse impact on females' reproductive health. Various exposures and hazards can have consequences on both fertility and fetal health and development (NIOSH, 2015). For example, pregnant females absorb certain chemicals faster than non-pregnant females (NIOSH, 2015). In addition, due to the rapid development and small size of the fetus, certain chemical exposures are considered riskier for pregnant females (NIOSH, 2015).

In firefighting, exposure to carbon monoxide and high temperatures may increase the risk of birth defects (McDiarmid et al., 1991). Early research suggests that certain toxic exposures could also increase birth defects among the offspring of male firefighters (no information was collected on female firefighters) (Olshan, Teschke, & Baird, 1990). Exposure to loud noises during pregnancy may result in lower fetal weight and increase chances of fetal mortality (Olshan et al., 1990).

In law enforcement occupations, lead exposure, such as handling lead-based ammunition, poses a threat to reproductive health (Czarnecki, 2003). It is associated with miscarriage, preterm delivery, premature membrane rupture, and neurobehavioral effects in infants (Gardella, 2001). For female LEOs in investigatory roles involving arson, bombs and drugs, there is the potential to be exposed to poisonous chemicals and vapors (Mentzer, 1997). Toxic chemicals and high concentrations of toxic vapors

such as those in illicit drug labs can be absorbed residually through skin and eyes (Hargreaves, 2000).

Shift work negatively impacts physiological function through a disruption of individuals' circadian rhythms (Knutsson, 2003). This appears to be accompanied by changes in hormonal concentrations that can affect both conception and normal fetal development (Figà-Talamanca, 2006). For females, this type of work schedule may also increase the incidence of miscarriage, low birth weight in infants, and preterm delivery (Amani & Gill, 2013; Knutsson, 2003; Mozurkewich, 2000; Nurminen, 1998; Puttonen, Harma, & Hublin, 2010).

High job stress is a well-known factor affecting tactical occupations. Female LEOs experience even greater levels of job stress than males due to added discrimination, harassment and the need to adapt to a male-dominated profession (Swan 1990). Female firefighters also report more job stress compared to their male counterparts (Rosell & Miller, 1995) and have shown higher levels of depression, PTSD and suicidal ideation in addition to higher stress levels (Pao, Tran, & Arbona, 2017). This is concerning since high job stress for females has been positively associated with increased risk of miscarriage and low birth weight infants (Brandt & Nielsen, 1992).

Purpose of Dissertation

The overarching goal of this research is to highlight the importance of reproductive health issues for female tactical athletes. Reproductive health, as it relates to exercise, occupational demands, and occupational exposures is an understudied but important aspect of female tactical athlete health. The findings of this research have practical implications for not only for the health and well-being of the female tactical

athlete, but also from an organization standpoint. This dissertation along with the emergence of more female-specific tactical athletes research has practical implications for policy change, as well as recruitment and retention strategies. This dissertation adds to the limited literature on the topic of reproductive health and tactical athletes. It appears there is a genuine concern for reproductive health among female firefighters, and this concern is warranted given that miscarriage and preterm birth both appear to occur at higher rates in LEOs and firefighters compared to the US averages.

In addition to the overarching goal, this dissertation has several objectives: 1) provide an overview of female tactical athletes and discuss their physical and occupational demands along with the reasons for reproductive health concerns; 2) summarize the prenatal exercise literature with focus on the scientific rigor behind previous guidelines and explore the limitations of exercise during pregnancy; 3) determine the reproductive health concerns among female firefighters; 4) determine if adverse reproductive outcomes are greater than average among female law enforcement officers; and 5) provide a brief summary of the dissertation findings in addition to future recommendations on further directions for research on female tactical athletes and reproductive health.

Chapter 2 - A Comprehensive Review of Prenatal Exercise Guidelines since the 1950s until present: Written for Women, Health Care Professionals, and Female Athletes

Introduction

The foundation of this paper is a comprehensive literature review of prenatal exercise guidelines from the 1950s until the present. The trends and changes in medical opinion on this topic are reviewed for each decade. The shifts in thought over time are compared and related to the salient socio-cultural trends and notions of power and control over the female body. Following the historical review, current guidelines for prenatal exercise are outlined for active women, sedentary women, and athletes. Next, the issues and controversies in research are discussed. The goal of this review is to bring awareness to the idea that most of the notions regarding safe exercise during pregnancy are hypersensitive and dated. The majority of the early published guidelines for pregnant women were unscientific and reinforced the notion that females were weak and frail (Bruser, 1968). The current guidelines for prenatal exercise are missing information about vigorous and high intensity training in addition to defining what those terms mean. Scientifically valid experimentation through randomized controlled trials may not be feasible or ethical for studying this special population. This review was written for any physically active woman or athlete who is or plans to become pregnant, and for health care professionals advising pregnant women.

It is difficult to find clear exercise guidelines with regard to specific intensity and frequency for pregnant women among the scientific literature, particularly for highly

active women and athletes. However, popular sports magazines have produced anecdotal stories of Olympians and other fit women who have successfully trained under their typical intense training regime as well as successfully competed throughout their pregnancy without issue (Court 2002; Rose, 2013). Despite these stories, there is a lack of peer-reviewed research to support or refute this type of training.

Most current literature states that women should be encouraged to exercise in the same manner they did prior to their pregnancy (Brown, 2002; Hammer, Perkins & Parr, 2000; Martens, Hernandez, Sports Medicine Australia, 2002; Strickland & Boatwright, 2006; Zavorsky & Longo, 2011). High-intensity interval training (HIIT) is a proven modality of fitness that has been shown to significantly reduce subcutaneous fat, reduce total body mass, and improve maximal aerobic capacity (VO2 max), all the while requiring minimal time commitment compared to traditional endurance training (Zavorsky & Longo, 2011; Shiraev & Barclay, 2012; Heinrich et al. 2015). High intensity functional training (HIFT) is a version of HIIT and incorporates resistance training with varied, multiple joint movements, but differs from traditional HIIT because of its lack of prescribed rest periods (Heinrich et al. 2015). CrossFit™ is a variation of HIFT and has recently gained great popularity (Heinrich et al. 2015). If pregnant women participate in HIIT or HIFT and are encouraged to exercise in the same manner as they did prior to pregnancy, this would contradict current exercise guidelines which encourage moderate-intensity, low-impact aerobic exercise (Artal & O'Toole, 2003).

Method

Search strategy

A comprehensive review of scholarly journals was conducted to identify the prevailing research, guidelines and perceived limits of prenatal exercise throughout the 1950's, 1960's, 1970's, 1980's, 1990's, 2000's, and present day. Position statements from government and health agencies such as the American College of Obstetricians and Gynecologists, Society of Obstetricians and Gynecologists of Canada, Canadian Sport and Exercise Physiology, and Sports Medicine Australia, as well as research leaders in the area of prenatal exercise were identified.

Databases searched

The databases searched included PubMed Central, ProQuest Central, and ScienceDirect. The date limits applied were literature written from 1950 until present. The other restrictions were that the articles were published in English. With the exception of two magazine articles used as examples (Court, 2002; Rose, 2013), all other content was retrieved from scholarly journals and provided information about the research, attitude towards, or guidelines regarding pregnant women and exercise.

A variety of key words were used across the searched databases. They included: pregnancy, pregnant women, prenatal, exercise, fitness, weight training, strength training, intensity, high-intensity training, high-intensity functional training, high-intensity power training, CrossFit™, health professional, guidelines, effect, safety, limitations, and frequency. The bibliographies and reference lists of the relevant journal articles were also examined to identify additional relevant studies.

Review

1950s

Popular medical opinion from the late nineteenth century and into the first decades of the 20th century was that pregnant women should use extreme caution to avoid fatigue and overexertion (Bruser, 1968; Browne, 1939; Vertinsky, 1987). Many pregnancy guidelines surrounding exercise and pregnancy during the 1950s (and 1960s) had little scientific basis, and were predominately vague, cautionary, and reinforced the notion that pregnant women were frail (Bruser, 1968). The deeply rooted mentality of most medical professionals was anxiety-ridden surrounding the female reproductive body (Jette, 2011). Medical texts, such as “Antenatal and Postnatal Care” (Browne 1939) discouraged violent exercise during the last two trimesters of pregnancy. Examples of violent exercise to avoid were tennis, horse riding, swimming and cycling. “Gentle” physical activities such as light housework and easy walking were prescribed instead (Vertinsky, 1987). These exercise guidelines not only remained unquestioned for decades, but they also reinforced normative gender roles of women in the domestic field.

1960s

It was not until the late 60s that some physicians began speaking out about these previously unquestioned and long-held notions regarding prenatal exercise (Jette, 2011). In 1968, physician Michael Bruser critiqued the way Western medicine viewed exercise during pregnancy (Bruser, 1968). He noted that medical texts failed to address sports during pregnancy besides warnings that caution and common sense were emphasized; yet those same texts did not offer an operational definition of common

sense. Bruser also noted that the specific sports previously deemed “violent” such as swimming, cycling, and tennis did not have to be violent in any way and pointed out that many women participated in such sports until the end of their pregnancy.

Bruser also questioned why it was so heavily stressed that fatigue and overexertion were so important to avoid during pregnancy. He referred to research done by Jokl in 1964 who studied fatigue in pregnant and non-pregnant women. It was found that pregnancy did not affect a woman’s ability to ventilate and pregnant women were just as efficient when exercising as non-pregnant women (Jokl, 1964). Jokl concluded that there were no identified physiological limitations during exercise for pregnant women. The exception to the researcher’s findings was women who were in the last few weeks of their pregnancy (Jokl, 1964).

The rise of second wave feminism in the late 1960s along with Bruser’s critique began to unravel the standard way of thinking, and began to revolutionize the way medical and health professionals started thinking about physical capabilities of pregnant women (Jette 2011).

1970s

The 1970s marked the era of the health and fitness boom. There was a growing shift and greater sense of freedom on the general discourse of pregnancy and exercise. Not only was exercise during pregnancy deemed safer, but some of the benefits of exercise during pregnancy began to appear in the literature. This was achieved through advancements in government health promotion texts, sports medicine literature, and the consumer culture (Jette, 2011). The 70s also marked a time when women were recognized in the fitness industry as an important niche (Bordo, 1993). In the growing

field of sports medicine during the 1970s, there was also an increasing sense of permissiveness for sports activities among women. At the same time, the health care system in Western society began to pressure individuals to take greater ownership of their personal health. This included awareness of weight, food intake, and the inclusion of regular, moderate exercise (Jette, 2011).

The 1970s represented a time where the benefits and popularity of prenatal exercise training emerged. Examples of this include Jane Fonda's workout program entitled "*Jane Fonda's Pregnancy, Birth, and Recovery Program*" and the Canadian government controlled *ParticipACTION's* book entitled "*Fitness and Pregnancy*" (Jette, 2011). Advice on prenatal aerobic exercise and encouragement for pregnant women to maintain their pre-pregnancy fitness levels were popular topics aimed at this niche fitness market. These factors combined with a growing number of women seeking equality in sport led to the emergence of a more liberal stream of thought regarding exercise and pregnancy.

1980s

The rise and advocacy for the promotion of exercise for pregnant women during the 1970s raised new questions within the medical community and pregnant women alike. This seemingly contradictory information and growing interest in the specialized areas of fitness was met with a rapid increase in research as exercise scientists and health professionals tried to produce information that could clearly define the limits of safety for pregnant women (Jette, 2009). There was a better understanding of the changes in respiratory and cardiovascular demands of the pregnant women, yet it still remained uncertain which underlying mechanisms caused these changes (Wallace,

Wiswell & Artal, 1991). There was a concern that exercise had possible interactive effects on pregnancy since it affected many of the same variables that were altered during pregnancy, such as changes in ventilation rate, heart rate, and substrate utilization. This doubling of physiological events was reasoned to potentially negatively affect the growing fetus (Mullinax & Dale, 1986).

Considering what medical professionals knew about pregnancy and the growing theories behind the possible doubling interaction between the physiology of exercise and pregnancy, prenatal exercise was an area of concern for some (Snyder & Carruth, 1984). Other theories were developed during this time; however, none were ever proven. Such theories included the idea that prenatal exercise could redistribute blood flow away from the uterus and into working muscles during exercise. This redistribution would force the fetus to compete with skeletal muscles for oxygenated blood, energy substrates, and heat dissipation (Clapp, 1994). It was theorized that such competition for these essential elements could potentially lead to fetal hypoxia, restricted fetal growth, fetal hyperthermia, and potential birth defects (Clapp, 1994). Certain activities such as running or aerobics were hypothesized to negatively affect the pregnant woman's uterus and could potentially cause membrane rupture, premature labour, fetal injury, placental separation, or umbilical cord entanglement. In addition, it was thought possible that strenuous prenatal exercise could lead to premature labour and lower birth weights (Clapp, 1994).

Contrary to what some of the theories proposed, research conducted by Uzendoski, Latin, Berg, and Moshier, (1989) hypothesized that healthy women could exercise at a moderate intensity during pregnancy without risk to themselves or the

fetus. They stated that although stroke volume, cardiac output and oxygen consumption typically increased as a result of pregnancy, thermal balance was still maintained during exercise. In addition, Uzendoski et al. (1989) also noted that fitness levels had the potential to be improved or maintained during pregnancy.

1990s

The 1990s marked an era where exercise physiologists and obstetricians and gynecologists started teaming up and sharing similar messages. It became mutually agreed upon that moderate exercise was safe as long as the pregnant woman was healthy and free of health complications (Jette, 2011). Professional organizations such as the American Congress of Obstetricians and Gynecologists, the Canadian Society of Exercise Physiology, and the Canadian Academy of Sport Medicine created their own specialized area in the prenatal fitness field complete with their own guidelines and checklists (Jette, 2011). While many of these guidelines were some of the first-ever to be quantified using the evaluation of evidence-based guidelines, there was still agreement that large gaps in knowledge remained (Davies, Wolfe, Mottola & MacKinnon, 2003). These gaps and limitations in the research methodology still exist today.

Bung, Huch, and Huch (1991) were some of the first researchers to publish a case study on the maternal and fetal heart rates of a professional athlete under rigorous training conditions. They noted that while there was a rise in popularity of physical fitness programs throughout pregnancy, there were still no standards available for female athletes with regards to intensity and frequency of training sessions or sports. The athlete they monitored was a professional runner who trained throughout her

pregnancy as many as six times per week. Her workouts included sprint work, submaximal testing, strength training, and endurance training. The result? She had an uncomplicated, healthy birth. The subject resumed her training weeks after delivery, and was reported to have set records over various short-distance runs in the following years. A noteworthy observation in this study was that immediately following a sprint training session, the subject's heart rate rose to above 170 beats per minute (bpm), while the fetal heart rate showed signs of bradycardia, at a rate of 70 bpm. It quickly recovered to 120 bpm within 3 minutes, however, the athlete experienced dizziness and symptoms of pre-collapse (Bung, Huch & Huch, 1991). While this was the only recorded incident throughout the study, it would be valuable to see more studies of this nature carried out in the future.

2000s

Researchers who have studied the change in discourse over prenatal exercise have noted the consistent conflict between proposed risks and benefits. As a result of the contradictory nature and lack of scientific rigor of many studies carried out in the 1980s, there was still uncertainty on the quantity, quality, and type of exercise that was optimal for pregnant women (Bell, 2002; Wolfe & Davies, 2003). This inconclusiveness has led to many different opinions and viewpoints from different types of professionals including general practitioners, sports medicine professionals, and obstetricians (Jette, 2009). There is still variation on the types of exercise deemed appropriate, the stage at which exercise should begin and cease, the frequency of exercise sessions, as well as the optimal level of intensity during prenatal exercise (Jette, 2009).

Artal and O'Toole (2003) recommended that healthy pregnant women follow the guidelines put forth by the American College of Sports Medicine-Centers for Disease Control and Prevention. These included thirty minutes or more of moderate physical activity per day in the majority or preferably every day of the week.

Brown and colleagues (2002) stated that many benefits were incurred with prenatal exercise. These included a reduced risk of gestational diabetes mellitus in the mother, as well as improved psychological functioning (Brown, Finch, Robinson, Torode, & White, 2002). Brown (2002) found that physically active women during pregnancy had more energy, gained less subcutaneous fat, and delivered fewer large-for-gestational-age (LGA) infants. It was also found that prenatal exercise was related to fewer complications in delivery and resistance training in particular, provided benefits to the pregnant woman that included faster recovery from labor, and increased bone mineral density (Brown, 2002). In the postpartum period, research has shown that women experienced a lactation-induced loss of bone density. Therefore, consistent resistance training before and during pregnancy helped women build bone density that helped off-set this loss as well as helped reduce future risk of osteoporosis (Brown, 2002).

On the other hand, it was also suggested during the 2000s that prenatal exercise could promote neural tube defects due to exercise-induced hyperthermia. However, Brown and colleagues (2002) stated that this was not likely due to effective heat dissipation mechanisms in humans. It was also suggested that moderate intensity prenatal exercise might enhance birth weight, however, it was possible that more frequent or severe exercise might have resulted in lighter infants (Brown et al., 2002).

Contradictory to this literature was a meta-analyses done by Bell (2002), who found no evidence to support the hypothesis that vigorous exercise reduced birth weight. Clearly, there were still gaps and contradictions in the literature specifically with regards to pregnant women who chose to participate in vigorous and frequent exercise.

2010-present day

The most current recommendations obtained from the Society of Obstetricians and Gynecologists of Canada (SOGC) (2013) support exercise during pregnancy, and furthermore, emphasize risks of not exercising. These guidelines stress the importance of not gaining too much weight during the pregnancy, as this can create a higher risk of caesarean section, gestational hypertension, and high or low birth weight (SOGC, 2013). There is legitimate fear of the uprising obesity epidemic within North America, and pregnant women are no exception to this. This may be a reason why more women are expressing an interest in pushing their physical limits throughout pregnancy (Jette, 2009). The SOGC guidelines are still relatively vague. Although this medical organization positively promotes prenatal exercise, their recommendations for active women are to initially consult with their healthcare professional about whether they should continue their activities (SOGC 2013). This dodges responsibility of the issue and puts the duty back on the woman to seek out another opinion from healthcare professionals who may lack knowledge of current recommendations. In support of this statement, Bauman and Finch (2000) reported that only one third of survey responders who were attendees at the 5th IOC world congress sports medicine/sports science conference reported familiarity with the United States Surgeon General's report on physical activity and health, and only 43% had familiarity with the Active Australia

initiative. This suggests a strong need for further physical activity education for professionals in this sector, especially if they are counseling pregnant women.

A recent, systematic review of prenatal exercise found no association with low birth rates or preterm birth rates (Nascimento, Surita & Cecatti, 2012). Based on the research reviewed, the authors concluded that exercise intensity for previously sedentary pregnant women should be mild or moderate. Currently active pregnant women should engage in moderate to high intensity exercise, at least three times per week (Nascimento et al., 2012). In addition, strength training and muscle conditioning should be incorporated into new guidelines (Zavorsky & Longo, 2011). It is also recommended that guidelines should increase the amount of vigorous intensity exercise and weekly physical activity expenditure (Zavorsky & Longo, 2011). In further support of strength training, exercising pregnant women can expect to reduce low back pain, prevent urinary incontinence, control gestational weight gain and control gestational diabetes (Nascimento et al., 2012).

Prenatal Exercise Considerations for Female Athletes

In 2011, the International Olympic Committee Medical Commission (2011) made the following statement about female athletes performing in the Olympics:

"*No female athlete should be denied the opportunity to participate in any Olympic sport on the basis that she might sustain an injury to her reproductive organs. A survey of injury data has failed to find any evidence of an increased risk for acute or chronic damage to the female reproductive organs occurring as a direct result from participation in sport"* (p. 1).

In support of this statement, Sports Medicine Australia has found no reports of fetal death or injury related to contact or trauma during sports (Brown et al., 2002). However, they stress that although pregnant women may still participate in competitive sports during pregnancy, highly active athletes should discuss the benefits and risks of doing so with their healthcare provider. While studies are limited, trained athletes may exercise at a higher level than what is recommended by the American College of Obstetricians and Gynecologists (Brown et al., 2002).

One of the few researchers in the field of high-intensity training during pregnancy is Kardel (2005). Her research has indicated that female athletes can safely train at high intensities throughout uncomplicated pregnancies. In fact, well-trained women can benefit from training at high volumes during pregnancy, as high-volume training did not threaten the health of the mother or the fetus and has even sustained initial fitness levels in pregnancy athletes (Kardel, 2005). Additional research found that well-trained pregnant women had a significant shorter first stage of labour by 118 minutes compared to the group that ceased exercise before the end of the first trimester (Clapp & Little, 1995).

Leet & Flick (2003) noted that female endurance athletes who trained vigorously tended to have smaller infants (200-400g lighter on average) compared to control groups. However, it is important to note that even though these trained athletes delivered smaller infants, a 200-400g decrease in birth weight is not clinically meaningful. More recent research data that had a larger sample size found no clinical difference in the birth weight of infants born whose mothers exercised for 5 hours or more per week compared to women who did not exercise. It was found that the

physically active women delivered infants weighing on average only 11g less than non-exercisers (Juhl et al, 2010).

Kardel (2005) found that high volume training at moderate and high intensities for pregnant women was beneficial not only for maintenance of fitness levels, but also for quickly returning to sport after birth. When compared with a medium-volume of exercise, pregnant women who participated in the high-volume exercise group indicated a quicker return to athletics and a physically active lifestyle (Kardel, 2005). The study provided excellent support for pregnant women who would like to continue training at high intensity or volume. However, it is important to note that the specific training program used in this study might not be appropriate for all pregnant athletes, since different sports require different types of training.

The Issues and Controversy in Research

Both methodological and ethical barriers exist for sound scientific prenatal exercise research. In order to avoid confounding variables and to achieve maximum validity, studies need to be large-scale and well controlled. The effects of single variables such as exercise are hard to separate out due the wide variation of fetal outcomes that can be caused by genetics, socioeconomic factors, nutrition, stress, and environmental factors (Lotgering, Gilbert, & Longo, 1984).

Most studies on prenatal exercise fail to produce satisfactory control groups. In order for a study to have high validity, researchers need to randomly assign participants into experimental and control groups (Wallace & Engstrom, 1987). It is unethical to prevent women from doing exercise during their pregnancies, as well as unethical to

test pregnant women under strenuous exercise conditions when little research has measured strenuous exercise and fetal outcomes (Lotgering et al., 1984).

The anecdotal observational and case studies carried out on women who have exercised vigorously during their pregnancies are perceived to be even more methodologically unsound due to the small sample size and lack of a control group. Anecdotal evidence is also viewed under an evidence-based medicine lens as the lowest form of reliability and validity (Lambert, Gordon & Bogdan-Lovis, 2006). The inconsistent exercise protocols of each of these anecdotal observations and case studies also make it difficult to cross-compare data, resulting in decreased validity (Wallace & Engstrom, 1987).

Final Prenatal Exercise Recommendations

Pregnancy is often a time where women become highly motivated to implement positive behavioral changes such as exercise (Nascimento et al., 2012). These changes could have long-term positive impacts and should be encouraged. Exercise for a pregnant woman without contraindications is considered safe and beneficial for both herself and the fetus (Nascimento et al., 2012).

Current exercise recommendations are vague and general, but this is mostly due to individual differences in fitness level, health status, and pregnancy status (Hammer et al., 2000). There should not be a “one-size-fits-all” exercise prescription for pregnant women; exercise prescription should be specific to the woman and her exercise preferences and consider whether she is new to exercise, experienced, or a competitive athlete. Regardless of experience level, medical clearance should be obtained. It is recommended that all pregnant women fill out the Physical Activity

Readiness Medical Examination (PARmed-X) for Pregnancy form with their healthcare practitioner in order to screen for potential contraindications (Hammer et al., 2000).

It should be noted that competitive athletes and fitness beginners in particular should obtain the most detailed screening and on-going evaluation during their training program. It would be ideal for beginners to commence a training program at least six weeks before conceiving (Hammer et al., 2000). Again, it is not necessary for healthy women to change their regular training regime once they become pregnant, unless they wish to. It should also be noted that during the second half of pregnancy, most physically active pregnant women should avoid moves requiring the supine position in order to prevent hypotension (Wolfe & Davies 2003). Exercises or sports where there is risk of fall or trauma to the abdomen should be avoided. As with other exercise programs, a warm-up and cool-down period should also be incorporated into each session (Artal & O'Toole, 2003; Browne, 1939; Wolfe & Davies, 2003).

Continued participation in high intensity workouts such as HIIT, HIFT, or other competitive sports should still be considered by pregnant women, especially if this is their preferred mode of exercise. Labor duration has been found to be inversely associated with a woman's aerobic capacity after adjusting for birthweight (Kardel, Johansen, Voldner, Iverson & Henriksen, 2009). Since these methods of training have been shown to significantly improve maximal aerobic capacity (V02max) (Heinrich et al., 2015), this is just one more reason why active pregnant women should be encouraged to perform vigorous exercise as tolerated.

Light strength training (no data other than anecdotal has been found on heavy strength training) suggests that there is no effect on newborn size or overall health of

the infant (Pennick & Young, 2007). In fact, the potential benefits of strength training during pregnancy include overall body strength, improved core strengthening and improved posture. Strength training during pregnancy may also positively address labour and birth discomforts (Pennick & Young, 2007). Pelvic floor strengthening in addition to strength training should also be considered for pregnant women; the more intense the program for pelvic floor strengthening, the greater the treatment effect (Boyle, Hay-Smith, Cody, & Mørkved, 2012).

One of the largest issues regarding prenatal exercise, especially high-intensity training, is that there is still a lack of evidence that suggests it is harmful to the growing fetus. Physician Bruser highlighted this controversial topic in the late 1960s. He stressed that it has generally been suggested that conditions such as abortion, premature labor, and abruption placentae may take place without physical activity or stress as factors (Vertinsky, 1987). Until it is proven that any unsafe or unhealthy conditions occur as a result of physical activity, disapproval of participation in sport or high intensity exercise because of fear is unjustified. In congruence with this, Bell (2005) suggests that we remain open-minded on this issue until sufficient evidence becomes available for which to base exercise intensity recommendations.

Medicine and culture are impossible to separate from one another, especially when it comes to exercise and health. Medicine shapes how people understand their bodies and mind as well as the way we act in the world (Jette, 2011). Culture shapes the sociocultural milieu including opinions of medical professionals, and therefore scientific inquiry. In other words, culture influences the types of questions that are asked and consequently the research that is then carried out (Jette, 2011). Prenatal exercise

participation is one of those areas where there has been a shift in the social and cultural norms, and we need science and medicine to catch up. It is hard to ignore the growing participation of pregnant women in sports and fitness activities (both competitive and recreational). This challenges long-held notions regarding the general physical capabilities of pregnant women. More research is needed on this topic, but not just empirical studies. Observational, case study, and anecdotal evidence should continue to be reviewed and considered as methods for study.

Conclusion

It is generally known and accepted that exercise during pregnancy can provide positive physical and physiological effects (Clapp & Little, 1995). However, a large research gap remains for the upper limits of exercise frequency as well as the upper level of exercise intensity needed to potentially render a negative effect, if any. More research is also needed within the specific field of athletes and pregnancy, along with recreationally fit women. Even today, there still remains the opinion that exercise during pregnancy can cause abortion, congenital deformities, and premature labor despite no documentation that regular exercise has increased the occurrence of maternal nor fetal injury in an uncomplicated pregnancy (Hammer et al, 2000).

The goal of this paper was to raise awareness about the contingent nature of what we know regarding exercise during pregnancy. The information received by a pregnant woman about exercise depends on the practitioner. The research is limited and has not been particularly neutral or purely objective (Jette, 2011). Despite what Western society knows and does not know concerning exercise intensity during pregnancy, one factor has remained constant. The pregnant woman is still construed to

be a risk to the fetus and is solely responsible for controlling this risk to ensure a healthy pregnancy (Jette, 2011). We should to continue to ask ourselves: what counts as knowledge? With so many varying opinions on this highly debatable topic, what type of knowledge should be used as the primary source of information? It is hoped that this paper will assist pregnant women and those who work with physically active pregnant women be able make informed judgments on their participation in exercise training.

Chapter 3 - Reproductive Health Concerns among Female Firefighters

Introduction

Females make up 50.9% of the workforce (Hulett, Bendick, & Moccio, 2008), and this number continues to rise (Bureau of Labor Statistics, 2003). Traditional male-dominated occupations such as military and law enforcement have female employment rates of approximately 14% (Women in Military Service for America Memorial Foundation, 2010) and 13% (US Department of Labor, 2009), respectively. Despite a target of 16-22% representation by females in the fire service (iWomen, 1995), only 3.7% of career firefighters (n = 12,850) are estimated to be female (Haynes & Stein, 2017). This representation is remarkably low, especially when compared to other tactical careers or occupations that have similar requirements in strength, endurance, and hazardous work conditions like logging and roofing (Hulett et al., 2008). Questions remain as to why female representation is so low in the fire service.

Background

Female representation in the fire department

The firefighter workplace culture has been traditionally unaccepting of females (Bielby & Reskin, 2005). On top of this, the psychological and physical strain of firefighting are cited as possible explanations for the low proportion of female firefighters (Hulett et al., 2008). Gender-based harassment has also been suggested as an explanation and is suspected to account for issues in female firefighter recruitment and retention (Hulett et al., 2008; Rosell, Miller, & Barber, 1995).

While these explanations may account for some of the representation disparity, similar concerns have been raised in other tactical occupations that employ higher percentages of females (Women in Military Service for America Memorial Foundation, 2010; US Department of Labor, 2009). It is possible that the lack of information about the impact of firefighting on reproductive health may be partially responsible for the small numbers. There has been little research conducted on the job-specific health of female firefighters (Jahnke et al., 2012). Early firefighter research suggests that certain toxic exposures could increase birth defects among the offspring of male firefighters (Olshan, Teschke, & Baird, 1990). Exposure to carbon monoxide and high temperatures may also increase the risk of birth defects among female firefighters (McDiarmid et al., 1991). Exposure to loud noises during pregnancy may result in lower fetal weight and increase chances of fetal mortality (Olshan et al., 1990).

Recent research conducted by Jahnke and associates (2018) attempted to quantify birth outcomes among female firefighters. They noted that miscarriage rates amongst female firefighters were at least 2.3 times higher among firefighters compared to the U.S. National average of 10% (ACOG 2015). They also found that history of preterm birth was higher among female firefighters than the general population (Jahnke et al., 2018). Thus, in addition to firefighter workplace culture, gender-based harassment and the psychological and physical strain of firefighting, it is hypothesized reproductive health concerns may play a contributing role in explaining poor female representation in firefighting.

Despite early findings that suggested certain exposures may negatively impact the reproductive health firefighters, there is very little literature on the subject (Jahnke et

al., 2012; McDiarmid et al., 1991; Olshan, Teschke, & Baird, 1990). A survey conducted by the International Association of Women in Fire & Emergency Services (iWomen), the largest organization of female firefighters in the United States, found that 58% reported ill-fitting personal protective ensemble (PPE) (iWomen, 1995). Fourteen percent of those females specifically cited ill-fitting self-contained breathing apparatus (SCBA); the face piece that protects firefighters against potential toxic particles in the air. Many female firefighters also reported that they were unable to get an adequate seal with their SCBA face piece (iWomen, 1995), which could dramatically increase exposure risk to potentially harmful chemicals and toxins (Jahnke et al., 2012).

Occupational reproductive health

Various workplace exposures and hazards can affect the reproductive health of females. Certain exposures and hazards can have consequences not only on the ability to become pregnant, but also fetal health and development (NIOSH, 2015). Workplace health and safety laws do not always protect a woman's reproductive health. Hazards encountered in the workplace can lead to reproductive health problems such as infertility/reduced fertility, menstrual/ovulatory cycle disorders, sex hormone imbalances, miscarriage, stillbirth, birth defects, child developmental disorders, premature birth, or lower birth weight babies (NIOSH, 2015). Although the National Institute of Occupational Safety and Health (2015) states that most pregnant employees can still safely perform their jobs, they admit that pregnancy can sometimes negatively affect worker safety.

Reproductive health of female firefighters

Female firefighters' reproductive health concerns were first documented over 20 years ago (FEMA, 1996). Improper fit of PPE and its possible effect on reproductive health was female firefighters' second largest concern about their occupation (their first reported concern was the stress of fitting into a nontraditional occupation) (FEMA, 1996). Despite these early concerns, very little has been done to address them and, not surprisingly, firefighting continues to struggle with near stagnant growth and representation rates of females compared to law enforcement or military occupations.

It has also been posited that shift-work has a connection to miscarriage and preterm delivery (Amani & Gill, 2013; Mozurkewich, 2000; Nurminen, 1995; Puttonen, Harma, & Hublin, 2010). It is well documented that shift work negatively impacts physiological function through disruption of circadian rhythms (Knutsson, 2003). An in-depth review of health disorders among shift workers summarized the findings of the effects of shift work while pregnant and reported a strong association between shift work and miscarriage, low birth weight, and preterm birth (Knutsson, 2003).

The National Fire Protection Association (NFPA) is the governing body for fire departments or organizations that provide rescue, fire suppression, emergency medical services, hazardous materials mitigation, special operation, and other emergency services and specifies the minimum requirements for occupational safety (NFPA, 2018). The NFPA 1582 is the policy standard on fire department comprehensive occupational medical programs (NFPA, 2018). The Essential Job Tasks outlined by the NFPA Standard 1582 (2018) contains 14 essential job duties that have the potential to result in

negative birth outcomes for the pregnant firefighter. (See Appendix A for NFPA's Essential Job Tasks). For example, the first listed essential job task states:

While wearing personal protective ensembles and self-contained breathing apparatus (SCBA), performing firefighting tasks (e.g., hoseline operations, extensive crawling, lifting and carrying heavy objects, ventilating roofs or walls using power or hand tools, forcible entry), rescue operations, and other emergency response actions under stressful conditions including working in extremely hot or cold environments for prolonged time periods. (p.12-13)

In this first essential job task, there are several potential risks to the pregnant firefighter. PPE may not adequately fit the firefighter over the course of a pregnancy, and poor-fitting turnout jackets and pants may increase exposure to toxic air particles and harmful chemicals (iWomen, 1995). Certain chemicals and metals may be absorbed faster by pregnant females compared to non-pregnant females and certain chemical exposures are riskier for a fetus than the pregnant woman because of its rapid development and size (NIOSH, 2015). Second, high ambient temperatures are associated with shorter gestation periods and greater occurrence of still birth (Strand, Barnett & Tong 2011). In addition, maternal hyperthermia is associated with neural tube defects during early pregnancy (Moretti, Bar-Oz, Fried, & Koren, 2005). Both El-Metwalli et al. (2001) and Wong et al. (2001) report that extensive bending/crouching is associated with elevated risk of miscarriage. Despite the well-documented associations between specific job duties and increased risk of negative reproductive health outcomes, there is still a major lack of research within this field.

Pregnancy policy in the fire department

According to iWomen, pregnancy policy existence and language varies among departments. Some departments do not even have a policy in place for pregnant firefighters (Sprenger & Bates, 2003). Fire departments should educate all firefighters on potential job risks on reproductive health associated with job duties.

The purpose of the current study is to identify perceptions and concerns about the occupational impact of firefighting on reproductive health for females.

Methods

Study design and participants

This qualitative study included a national sample of 46 female firefighters, 27 female fire service leaders, and 14 male fire service leaders. Participants were recruited via national conferences, fire departments where the research team had access to large groups of female firefighters, and recommendations from fire service advisors. The female firefighters participated in one of eight focus groups. Based on recommendations from fire service advisors, individual interviews were conducted with the fire service leaders. Participants ranged in age from 25-66 years and years of service ranged from 3-30 years.

Procedure

Once the purpose and operating procedures of the study were explained, all participants were given the opportunity to ask questions. An informed consent document was then signed, and participants completed a demographic questionnaire.

The guided discussion on reproductive health generally began with the question, “What concerns exist related to reproductive health among women in the fire service?”

In addition to the responses collected from the reproductive health domain, other questions were asked surrounding reproductive health education, recruitment and retention, leave, and policy such as “What policies are you aware of that are most common concerning pregnancy?” All focus groups and interviews were transcribed verbatim, and responses from the resulting discussions that were relevant to reproductive health were analyzed.

Data analysis

Focus groups transcriptions were uploaded into QSR International’s NVivo 10. Three trained qualitative researchers analyzed the data through the process of grounded theory. Through developing, checking, and integrating theoretical categories, emerging key words and ideas were drawn from the data. Gradually, codes and themes were created so that inferences could be made from the data and form conceptualizations (Miles & Huberman, 1994). One research team member read and re-read each transcript to develop initial codes and subsequent themes. Then, the second researcher read and re-read each transcript to create, refine and add further codes and themes. The researchers then discussed discrepancies until a consensus was achieved. After this process, a third trained researcher read the coded data for final confirmation of the overall themes.

Grounded theory is a qualitative research method procedure that flows from one inductive inference to another through selective data collection (Glaser, Strauss, & Strutzel, 1968). Using grounded theory involves a systematic collection and data analyzing process that leads to creation of theories on patterns of human behavior in social contexts. This research method can increase our understanding of social

phenomena (Clamp, Gough, & Land, 2005), but also enables a solid generation of theories that are informed by the data, as opposed to using the data to test an existing theory (Haris, 2015). This study adhered to the RATS guidelines for reporting qualitative research (Clark, 2003).

Results

The following results are centered around five key themes that emerged. The key themes were as follows: 1) Department variation regarding pregnancy policy; 2) Decision-making by firefighters for disclosure of a pregnancy; 3) Lack of education, research, and information for firefighters on reproductive health; 4) Reproductive health concerns impact female recruitment and retention; and 5) Innovation within the fire service.

1) Department variation regarding pregnancy policy

There is no single policy in place for a firefighter who becomes pregnant. It was unanimously agreed that departments should have a policy in place for when a firefighter becomes pregnant. Most participants reported their respective departments either had no policy, or that their policy was unfavorable for females in some way. The departments with no set pregnancy policies usually had few female firefighters. This also resulted in a scramble to find a policy and confusion within the department when a pregnancy was announced.

> Female fire service leader: *"…it was a scramble to find a policy that- that could – that they could use to protect both the firefighter and the department and the baby. It was interesting, you know, it was almost like wait until you're walking through the door and now I got to come up with something? Never a good move*."

Female firefighter: *"A lot of places don't have policies…And we still don't have a policy."*

Female fire service leader: *"No policies for like, when we're pregnant or anything like that. Um, we had two females in the past that neither one of them had kids while they were working, so it was never an issue."*

Pregnancy policies that were viewed as unfavorable occurred when firefighters had to use sick time, vacation time, or a combination of both when they were no longer able to work during a pregnancy. This happened in smaller departments that did not have light duty assignments, or had budgetary constraints.

Female firefighter: *"Mine is you use up your sick time, vacation time, and you go on unpaid leave."*

For the participants that knew of their department's pregnancy policy, it was typical that the firefighter was given a light duty assignment for the remainder of their pregnancy. A light duty assignment is typically clerical day work and also means that they do not respond to emergency calls. One large difference noted in light duty assignments was that some firefighters had a policy that let them and/or their health care practitioner decide when to go on light duty, and some departments had a policy that immediately removed pregnant firefighters from active duty. The statements below highlight these issues:

Female firefighter: *"Our folks all have a light duty or a temporary modified work assignment option. So, if they choose, if they choose, as soon as they find out, um, that they're pregnant, they go on temporary modified."*

Male fire service leader: *"The moment that a female firefighter notifies the fire department that she is pregnant, um, we bring her off line. Um, we put her on day work…. She remains on day work, um, in a non-operational capacity until she delivers."*

Female fire service leader: *"We have a policy that once you become pregnant, you have to tell our administration, and they take you off-line. So our administration is pretty proactive in that. And we've actually taken some heat from that."*

2) Decision-making by firefighters for disclosure of a pregnancy

Disclosure of pregnancy by firefighters greatly varied, and reasons for choosing when to do so also varied. Some females chose to disclose their pregnancy to their department right away, while some chose to wait as long as possible before letting their department know in order to stay working on active duty. The most cited reason for early disclosure of pregnancy included concern for fetal and/or maternal health while responding to calls.

Female firefighter: *I would never want to have to make a choice between somebody in the – a firefighter in a house, or my child. I don't want to make that choice. And so I – I made the choice to go to days and to go to limited duty, off shift. And I – I feel it was a good choice."*

Female firefighter: *"When I got pregnant, um, I – I was very careful not to let anyone know for a – a good period of time. Because one, I was afraid I was going to be forced to go off shift or there would be other decisions to make."*

Few participants reported disclosing a pregnancy then staying on active duty. In these cases, judgement and criticism from coworkers were received, along with unnecessary

protective treatment. Firefighters who disclosed a pregnancy but chose to continue to "ride the engine" reported being accused by coworkers of being irresponsible and negligent of their unborn children.

Female firefighter: *"But he's like, '… doesn't she risk… the fetus? And then won't the coworkers feel responsible to have to, you know, watch her a little bit more closer?"*

Female firefighter: *"There's a perception that a woman, once she becomes pregnant, has a handicap."*

Many participants reported they decided to stay on active duty as long as possible until their pregnancy prevented them from continuing. Some firefighters reported coming off the line once their turnout gear no longer fit, or when they felt they could not perform their duties adequately.

Female firefighter: *"I didn't tell anybody… as soon as… I felt like that I was going to be, um, harmful to the crew or I wasn't pulling- able to pull my own weight, well then it was time for me to try to find some light duty. Somewhere you know, you know, not to be a hindrance. Um, so I just didn't tell anybody…for me, at six months it was, you know, it was time to go."*

One of the most cited reasons for choosing to stay on active duty while pregnant was to avoid being placed in a light duty assignment. This type of work was reported to involve a position that was mainly clerical day work, and was generally viewed as a boring or meaningless job. It was also sometimes viewed by coworkers as an excuse for the pregnant firefighter to choose light duty as a way to "slack off" but still be paid.

Female firefighter: *"…light duty is a punishment. It's the worst."*

Female firefighter: *"I don't want to sit there and do desk stuff and menial job, I want to work my shift 24 hours. You know, Monday through Friday sucks for people that aren't used to that kind of shift."*

Female firefighter: *"They think that 'Oh, you want light duty for pregnancy, oh you just want to get paid to do nothing."*

In some cases, the decision to stay on active duty was a financial issue since other assignments were not available for the firefighter. Other reasons reported for staying on active duty included believing that their pregnancy had no impact on being a firefighter so long as they could perform their job, or to prove a point to the men that pregnancy was not a handicap.

Female fire service leader: *"Boy, it is a heated, heated issue… you got the people that don't think you should be working and endangering your child"*

Some participants noted that their decision to disclose a pregnancy or not had to do with promotional or seniority factors. One participant recounted disclosing a pregnancy early and going off active duty only to lose a promotion because of it. The same participant chose to keep their pregnancy a secret with her second pregnancy so she did not lose her seniority again. Other firefighters reported not disclosing a pregnancy and staying on active duty because they did not want to use up their sick time and vacation time.

3) Lack of education, research, and information for firefighters on reproductive health

It was unanimously agreed that the firefighting industry lacked education, research, and general knowledge about female firefighters' reproductive health. Participants reported

that there were limited informational resources to guide or counsel a firefighter if they become pregnant.

> Female firefighter: *"We really need to have some… kind of guidelines for women that – that they can look at and whether there's an impact on – on their, uh their children long term, uh, or not. Or you know, something that is solid to be able to look to for information."*
>
> Female firefighter: *"It would be nice if somebody had, you know, some rhyme or reason to when is a good time to go and when's not, you know? But it seems like we're all on our own."*

Extreme heat, hazmat incidents, exposure risk (hydrogen cyanide, smoke, sick people, carcinogens, byproducts of combustion, chemicals, and blood borne pathogens), poor fit of personal protective ensembles, and carrying/transporting heavy victims were cited as possible and questionable threats to firefighter and fetal safety.

> Male fire service leader: *"We've had some people who have gotten pregnant recently, and I don't think they realized what the risk is, because some of them have stayed on duty six, seven months into their pregnancy."*
>
> Female fire service leader: *"There should be more, um, information out there for women who are planning to be pregnant while they're in the fire service as to know when it is safe for them to be in combat and then not, you know, and then have to go on light duty."*
>
> Female firefighter: *"When the baby's making, you know, the critical time in the first trimester… you're going in a heated environment and things like that. Isn't that bad?'"*

Lack of knowledge, specifically from health care practitioners and fire service leaders, was also reported by participants. Several firefighters reported that when they asked for information or counsel regarding the risks involved with firefighting while pregnant, they were not given satisfactory answers.

> Female firefighter: *"Even my doctor, my OB had no idea. She's like, 'So what do you want to do?' I'm like, 'Well, I thought you could answer that for me.'*
>
> Female firefighter: *"My chief at the time comes up to me and goes, 'Now what do I do with you?' Like I said, nobody has a clue."*

Although research and education for pregnancy while working active duty was the primary concern from participants, other areas that needed more research and information for firefighters included breastmilk contamination, reproductive cancers, fertility, long-term health of the child conceived by a working firefighter, and the overall long-term impacts on female firefighters' reproductive health.

4) Reproductive health concerns impact female recruitment and retention

Many firefighters reported delaying becoming pregnant during their careers. Reasons for delaying pregnancy were trying to save up or "bank" sick time so that they could accrue time off in the pregnancy or post-partum period, to get past their probationary period, or because they were trying to get promoted. These planned delays in pregnancy were reported to cause fertility issues in some cases, especially for those firefighters who waited until their 30s to try and conceive. This was said to have caused additional stress, uncovered fertility treatment bills, and questioning by females whether a career in the fire service was "worth it."

Female firefighter: *"I understand some of the issues, but when – I'm like, when you look at the big picture of, I'm here for this entire career." '*

Female firefighter: *"…we've lost women who've become pregnant and because of the policy."*

It was also reported that when firefighters declared pregnancy and could no longer work active duty, they were unfairly treated. Some departments, due to budget restrictions and department size, forced pregnant firefighters to use sick time, vacation time, or take unpaid leave during the rest of their pregnancy.

Female firefighter: *"You're kind of penalized for being female."*

Female firefighter: *"And so I think if pregnancy leave and return isn't really well done, that could be a big black hole as to why women fall out of the fire service after getting, uh, after becoming mothers."*

Female fire service leader: *"Out of the four ladies that I can tell you left the fire service three of them left because they became mothers."*

It was reported by participants that pregnancy and managing a family were sometimes treated like inconveniences for the department. It was mentioned multiple times that firefighters felt as though they had to choose between starting a family and their career because doing both did not benefit the department.

Female firefighter: *"You chose to have this family. You know what the rules are."*

Female firefighter: *"You chose this. You want to be one of us."*

Many female firefighters also pointed out that their departments or unions often chose to ignore their reproductive health concerns and pregnancy leave options because there

were so few females overall. Also, their gender was a discriminatory factor in making departmental decisions.

> Female firefighter: *"The unions are like, 'Well, that only, you know, we're here to protect the greater – the majority.' … I'm stuck being a woman."*
>
> Female firefighter: *"They're just like, 'Well we can only bring so many things to the table, and you're one person. So, you know, are we going to sacrifice one of our important things for just helping one person?'"*

It was generally agreed that many female firefighters had to battle to find their place within the male-dominated profession of firefighting. In certain cases, firefighters reported not wanting to recruit or convince other females to join the fire service because they did not want other females to experience what they went through with regards to having fertility issues, taking leave due to starting a family, or receiving judgement from other firefighters for taking leave due to pregnancy.

> Female firefighter: *"… yesterday their big thing was the recruitment drive and we have to get more women involved. And I struggle with that because I have a hard time going and recommending this to any woman. I'm like 'Why would you put yourself through what I did?'"*

Family building and pregnancy were also framed by one firefighter as being a relatively short amount of time in context of a 30-year career. She reported it was unfair for females to have so few options when pregnant, or to feel as though females were penalized by less pay, leave options, or opportunity for promotion because they wanted to start a family. Others felt as though being a firefighter and female forced them to

choose between having a family or to continue to be a firefighter, because having both was not an option.

> Female firefighter: *"It was such an inconvenience to everybody that I had a child and it was such a big deal."*

A lot of females agreed unanimously that they felt uncomfortable being the person who spoke up to say that things were unfair for female firefighters. They did not want to be a person who was viewed as a trouble-maker or a whistle-blower as this would reflect negatively upon them. Participants also felt that while fire departments had gotten better in recent years with respect to how they treated females and their specific issues in the fire workplace, there was still a long way to go with females and reproduction within the fire service.

5) Innovation within the fire service

A minority of participants reported successful and positive policies implemented by departments with regards to female firefighter reproductive health. These innovations are presented in Table 3.1.

Table 3.1

Innovations Within Departments

Department Strategy	Example
Create an opportunity to take paid leave during pregnancy	*"They instituted…a short-term disability you could opt into. And so that was what the… females…would utilize once they couldn't work anymore. They would … take the short-term disability and then… maternity leave after that."* - Male fire service leader
Female firefighters are given options to decide	*"Our folks all have a light duty or temporary modified work assignment option. So if they choose… as soon as they find out that they're pregnant, they go on temporary modified."* - Female fire service leader
Female firefighters have job security	*"when you got pregnant, there was a spot for you to go to continue working… they either put them at the chief's office answering phones, at fire prevention, … they have worked in applicant processing, recruiting."* – Female firefighter
Creating modified work assignments that do not feel like punishment	*"take people's talents and find someplace to…have them productive and giving back… I never realized how exciting it could be and how I can make a bigger influence being in a staff assignment as opposed to just being an operations battalion chief."*- Female fire service leader
Offering female firefighters longer than 12 weeks of FMLA leave	*"I get 70% of my pay…for one year."* – Female firefighter *"We have a year maternity leave from the time that the baby's born. And then from there…if we require additional time, um, it's something that we have to coordinate with the fire chief."* – Female firefighter

Discussion

The purpose of this study was to identify if female reproductive health is a concern in the fire service, and what those specific concerns were. Without doubt, it is a significant, although often under recognized, area of concern, and these data emphasize the large gap in the literature for investigating firefighter reproductive health.

We identified five themes total; four of which represented the major areas of reproductive health concerns in addition to one theme where innovation among some departments was highlighted. The four themes of reproductive health concern included department variation regarding pregnancy policy, decision-making by firefighters for pregnancy disclosure, general lack of education, research, and information for firefighters on reproductive health, and the negative impact on female recruitment/retention.

Implement appropriate pregnancy policy

Within the NFPA Standard 1582, Comprehensive Occupational Medical Programs for Fire Departments, there is a recommended policy for the treatment and care of pregnant firefighters in section 9.18 (see Appendix B) (NFPA, 2013). Although the standard offers policy recommendations for fire departments, it is important to note that they are not mandatory, enforced, nor monitored within fire departments (NFPA, 2018). However, the recommended policy language addresses many of the concerns highlighted by this research. The recommendations include immediate report to the department physician once a pregnancy is known, full disclosure to the firefighter of fire related hazards that can affect the pregnancy and fetus, provision of an alternative duty assignment that is safe, and on-going medical evaluation to determine any restrictions from activities which the woman is not able to perform in a safe manner (NFPA, 2013). The standard also states that educational materials should be provided highlighting reproductive health risks for both male and female firefighters (NFPA, 2013). It is also noted that certain essential job tasks will eventually become unsafe for the pregnant firefighter due to diminished aerobic capacity, speed, balance, and agility, and that the

firefighter will need to be restricted from those job tasks upon medical evaluation from the fire department physician. Additionally, the pregnant firefighter may also request an alternative duty assignment at any stage of pregnancy (NFPA, 2013). Departments need to have a pregnancy policy in place. It is not acceptable nor fair to the female firefighter to have to figure out what to do in the event of a pregnancy. As noted from our results, the majority of departments either lacked a policy altogether, or had a limited pregnancy policy in place that did not satisfy the needs of the firefighters interviewed.

Informed decision-making through increased awareness and education

While the NFPA pregnancy policy (2013) is a strong starting point, especially for departments that have nothing in place, it is important to point out that some of the largest concerns highlighted from this research appear to be the overall lack of knowledge and education of health care providers and fire service leadership. Subsequently, this has led to a lack of educational materials for firefighters. In support of our findings, FEMA (1996) has also stated that physicians needed to be better updated on the demands of first responder duties.

There is adequate occupational health research (though the majority is not firefighter specific) associating certain firefighter job duties and adverse reproductive health outcomes (American Pregnancy Association, 2018; Bhatt, 2000; El-Metwalli et al., 2001; Fabian et al., 2010; iWomen 2012; McDiarmid & Agnew 1995; McDiarmid et al., 1991; McDonald et al., 1988; Moretti, Bar-Oz, Fried, & Koren, 2005; NIOSH, 2015; NIOSH, 1999; Strand, Barnett, & Tong, 2011; Taskinen et al., 1990; Treitman, Burgess,

& Gold, 1980; Wong et al., 2010). This is a good starting point and at least should be shared with as many fire departments as possible.

Providing information and education to health care providers about the essential job tasks of firefighting could help close this knowledge gap (FEMA, 1996). Although our research has focused on the female firefighter, much of this evidence is not limited to females. Toxic exposures may also increase risk of birth defects among children of male firefighters (Olshan, Teschke, & Baird, 1990).

In response to our findings of concern over lack of information/education on reproductive health, it is proposed that the pregnant firefighter bring a copy of Table 2 to discuss with her primary care physician do help her decide whether she should continue working active duty. Under Title VII of the Civil Rights Act, a department cannot forbid a female firefighter from performing certain job tasks, otherwise they will face liability for violation of the sex discrimination prohibition (Miller, 1966). Table 2 outlines the NFPA Standard 1582 Essential Job Tasks (2018) and specifically highlights the potential reproductive health risks for a pregnant firefighter so that an informed decision on working active duty can be made. We also recommend reproductive health education for all firefighters in order to decrease stigma or negative judgement that may follow a pregnant firefighter going off active duty.

Table 3.2

Reproductive Health Concerns Within Essential Firefighter Job Tasks

NFPA Essential Job Tasks (2018)	Reproductive Health Concern
(1)*"While wearing personal protective ensembles (PPE) and self-contained breathing apparatus (SCBA), performing firefighting tasks (e.g.,*	• Maternal hyperthermia is associated with neural tube defects during early pregnancy (Moretti, Bar-Oz, Fried & Koren 2005)

hoseline operations, extensive crawling, lifting and carrying heavy objects, ventilating roofs or walls using power or hand tools, forcible entry), rescue operations, and other emergency response actions under stressful conditions including working in extremely hot or cold environments for prolonged time periods"	• PPE may not adequately fit the female firefighter over the course of a pregnancy, and poorly fitted turnout jackets and pants may increase workplace exposure to toxic air particles and harmful chemicals (iWomen 2012) • High ambient temperatures are associated with shorter gestation periods and greater occurrence of still birth (Strand, Barnett & Tong 2011) • Bending/crouching have been associated with elevated risk of miscarriage (El-Metwalli et al. 2001; Wong et al. 2010)
(3)"*Exposure to toxic fumes, irritants, particulates, biological (infectious) and nonbiological hazards, and heated gases, despite the use of personal protective ensembles and SCBA"*	• Certain chemicals and metals are absorbed faster by pregnant females compared to non-pregnant females and certain chemical exposures are riskier for a fetus than the pregnant woman because of its rapid development and size (NIOSH, 2015) • Lead exposure: found in smoke particles, (Fabian et al. 2010) can lead miscarriage, low birth weight, infertility, or developmental disorders (NIOSH 1999) • Lead can cross placental barrier at 12 weeks of gestation, which could lead to issues brain development (Bhatt 2000; NIOSH 1999) • Carbon disulfide exposure: (found in personal air sampling devices among firefighters) (Treitman, Burgess & Gold 1980) can lead to menstrual cycle changes which can lead to fertility issues (NIOSH 1999) • Carbon monoxide exposure (a gas created when fuels burn incompletely) (NFPA 2008) likely increases risk of birth defects in pregnant female firefighters (McDiarmid & Agnew 1995) • Other products of combustion: aldehydes (e.g. acetaldehyde, formaldehyde, acrolein), benzene, carbon dioxide, chloroform,

	dichlorofluoromethane, hydrogen chloride, hydrogen cyanide, methylene chloride, nitrogen dioxide, nitrogen oxide, perchloroethylene, sulfur dioxide, toluene, trichloroethylene, and trichlorophenol have been found to be of concern for reproductive health in either animals or humans (McDiarmid et al. 1991)
(4) "*Depending on the local jurisdiction, climbing six or more flights of stairs while wearing a fire protective ensemble, including SCBA, weighing at least 50 lb. (22.6 kg) or more and carrying equipment/tools weighing an additional 20 to 40 lb. (9 to 18 kg)"*	• Heavy occupational lifting has an observed effect of miscarriage late in pregnancy, or premature delivery (McDonald et al. 1988; NIOSH 1999; Taskinen et al. 1990)* • Excessive occupational physical activity (PA) (reported high intensity, high fatigue, unfavorable working hours) (El-Metwalli et al. 2001), and bending or crouching have been associated with elevated risk of miscarriage (El-Metwalli et al. 2001; Wong et al. 2010)*
(5*) "Wearing a fire protective ensemble, including SCBA, that is encapsulating and insulated, which will result in significant fluid loss that frequently progresses to clinical dehydration and can elevate core temperature to levels exceeding 102.2°F (39°C)"*	• Maternal hyperthermia is associated with neural tube defects during early pregnancy (Moretti, Bar-Oz, Fried & Koren 2005) • Maternal dehydration can lead to pregnancy complications like neural tube defects, low amniotic fluid, inadequate milk production, premature labor, and birth defects (American Pregnancy Association 2018)
(6*) "While wearing personal protective ensembles and SCBA, searching, finding, and rescue-dragging or carrying victims ranging from newborns to adults weighing over 200 lb. (90kg) to safety despite hazardous conditions and low visibility"*	• Heavy occupational lifting has an observed effect of miscarriage late in pregnancy, or premature delivery (McDonald et al. 1988; NIOSH 1999; Taskinen et al. 1990)*
(7) "*While wearing personal protective ensembles and SCBA, advancing water-filled hoselines up to 2 $^{1/2}$ in. (65 mm) in diameter from fire apparatus to occupancy [approximately 150 ft. (50 m)],*	• Excessive occupational PA (reported high intensity, high fatigue, unfavorable working hours) has been associated with elevated risk of miscarriage (El-Metwalli et al. 2001)

which can involve negotiating multiple flights of stairs, ladders, and other obstacles"	
(8) *"While wearing personal protective ensembles and SCBA, climbing ladders, operating from heights, walking or crawling in the dark along narrow and uneven surfaces that might be wet or icy, and operating in proximity to electrical power lines or other hazards"*	• Bending/crouching have been associated with elevated risk of miscarriage (El-Metwalli et al. 2001; Wong et al. 2010)
(9) *"Unpredictable emergency requirements for prolonged periods of extreme physical exertion without benefit of warmup, scheduled rest periods, meals, access to medication(s), or hydration"*	• Excessive occupational PA (reported high intensity, high fatigue, unfavorable working hours) has been associated with elevated risk of miscarriage (El-Metwalli et al. 2001)
(11) "Critical, time-sensitive, complex problem solving during physical exertion in stressful, hazardous environments, including hot, dark, tightly enclosed spaces, that is further aggravated by fatigue, flashing lights, sirens, and other distractions"	• High job stress is associated with increased risk of miscarriage and low birth weight in females (Brandt & Nielsen 1992) • Bending/crouching have been associated with elevated risk of miscarriage (El-Metwalli et al. 2001; Wong et al. 2010)
(12) *"Ability to communicate (give and comprehend verbal order) while wearing personal protective ensembles and SCBA under conditions of high background noise, poor visibility, and drenching from hoselines and/or fixed protection systems (sprinklers)"*	• Textile workers exposed to more than 85 decibels from a wide range of noise exposures were found to have significantly increased rates of miscarriage (Zhan et al. 1991)**
(13) "*Functioning as an integral component of a team, where sudden incapacitation of a member can result in mission failure or in risk of injury or death to civilians or other team members"*	

(14) *"Working in shifts, including during nighttime, that can extend beyond 12 hours"*	• Evidence strongly suggests shift-work is associated with higher rates of miscarriage, preterm birth (Amani & Gill, 2013; Knuttson 2003; Mozurkewich 2000; Nurminen 1995; Puttonen, Harma & Hublin, 2010) and low birth weight • Working long working hours has a strong association with miscarriage (Schenker, Eaton, Green, & Samuels 1997)

* Epidemiologic evidence for physical activity has not been consistent (Wong et al. 2010) Occupational heavy lifting has been previously associated with both risk reductions and elevations (McDonald et al. 1986; McDonald et aI. 1988; Taskinen et al. 1990). Occupational physical exertion research has been mixed with some null studies (Axelsson, Rylander & Molin 1989; Fenster et al. 1997; John, Savitz & Shy 1994).
** Epidemiologic evidence for noise exposure has not been consistent (no elevations in miscarriage risk were identified for females holding jobs considered to have moderate or loud noise levels) (Wong et al. 2010)

Female firefighter recruitment and retention

Evidence suggest that showing your employees that you value their health and safety and the health of their families improves employee morale and retention (NIOSH, 2015). Pregnancy among female firefighters tends to be treated as a sickness and not a condition, and many female firefighters are forced to save up sick time and vacation time to use once they become pregnant due to a lack of or poor policy provisions. This has obvious negative retention and recruitment implications, since this means that the ability to utilize sick time for its actual purpose is impacted, and taking vacation time to have a child loses its designation and purpose. Our findings suggest this negatively impacts firefighter recruitment and retention, as it makes more traditional jobs with clear maternity and pregnancy leave policies more appealing than working for the fire service. Female firefighter retention may be improved if better policies regarding pregnancy and maternity leave are implemented. In addition to potentially increased retention,

departments may also benefit financially. Research suggests that implementing successful health systems (such as a pregnancy policy) could reduce injury and illness costs and have a high return on investment (NIOSH, 2015).

Limitations

As with any study, there are limitations to be considered including that results may be specific to our participants. However, our findings align with previous research and bolster the suggestion that reproductive health is a warranted firefighter concern and should be researched further for this population. For example, our study supports previous findings that female firefighters experienced gender-based harassment from coworkers, and this was heightened once they announced a pregnancy. It also supports previous research (FEMA 1996) that found reproductive health was a large concern among female firefighters. The focus group and interview questions aimed to gather insight into the experiences surrounding reproductive health of female firefighters. Although participants were drawn from a national sample of mostly female firefighters (with several key male leaders), it is possible that some attitudes and experiences may have been missed in this study.

Conclusion & future recommendations

The concern and call for more research on firefighters' reproductive health highlighted by this study are the same issues identified more than 20 years ago by the Federal Emergency Management Agency (1996). Yet, little focus has been placed on female firefighters' reproductive health needs. This highlights a huge gap in the research and possibly exposes some of the problems with recruitment and retention of

females in the fire service. Our findings reinforce the need for further research and lay a foundation for identification of key issues.

Whether females make up a small percentage of a fire department or even in departments where females have yet to be employed, it is imperative that every department has a clear pregnancy policy in place. Employers are required to provide a safe workplace for employees (NIOSH, 2015). This includes educating employees about safe work practices and providing appropriate equipment in order to safely perform their job (NIOSH, 2015). The pregnancy policy set by departments should involve the department's physician, and should clearly communicate the risks involved (iWomen, 2012) as outlined here (see Table 2). Implementation of a sound policy should also include guidelines for the firefighter to report her condition. Once a firefighter has disclosed her condition, ideally, her department's physician administer a medical release form that complies with NFPA 1582: Comprehensive Occupational Medical Programs for Fire Departments so that her ability to perform essential job tasks can be assessed and a guideline can be given to the firefighter as to when those duties should be modified. One of the larger concerns is the possibility of exposure during the early stages of pregnancy. The first 12 weeks of a pregnancy is a particularly vulnerable time for the fetus, as it is a critical developmental stage (NIOSH, 1999). Even small exposures can elicit lasting adverse fetal health outcomes (Grandjean et al. 2008). Education for the firefighter, the department and any health care practitioners working with firefighters should be acknowledge potential negative implications of firefighting and pregnancy.

Sharing successful program information between departments is also a simple strategy that may lead to a more uniform approach and could also avoid false starts, where a department tries an unsuccessful attempt to implement something new (FEMA, 1996). (See Table 1 for examples of departments that have championed reproductive health in various ways.) Sharing successful policy creation, reproductive health education, recruitment and retention tactics, and connecting fellow departments with informed departmental physicians are some of the areas where departments could support one another. A successful program sharing option could be done via firefighter publications (NFPA, Fire Engineering, etc.) or through national firefighter conferences. The military, who boast a much higher representation of females, have invested in research for adjustments that make their equipment more accessible to men and women (FEMA, 1996). A centralized focus on proper fitting PPE for a female firefighter could be an important next step for decreasing reproductive health concerns due to poor fitting clothing and breathing apparatus.

A combination of an appropriate pregnancy policy, dissemination of what is known regarding occupational health, and further research on the maternal and fetal risks firefighting while pregnant is the recommended starting point. A strong implemented pregnancy policy could lead to safer pregnancy outcomes, healthier firefighters, and better retention and recruitment for current and future female firefighters. Further research and subsequent dissemination to departments and health care practitioners that work with this population is desperately needed. Pregnant firefighters deserve to make an informed decision when it comes to working active duty. In order to make an informed decision, the repercussions of firefighting while pregnant

needs further research. Staying on active duty because of poor or lacking pregnancy policy, fear of harassment, avoidance of light duty, or loss of promotion/seniority should not be deciding factors for the female firefighter. The implications of this research benefit not just the current female firefighter, but could pave the way for better reproductive health protection for future firefighters and their children.

Chapter 4 - An Epidemiological Examination of Reproductive Health among Female Law Enforcement Officers

Significance

There is a need for new research and prevention efforts to improve first responder health and safety (Reichard & Jackson, 2010). While there is evidence that various occupational exposures, shift work, and a high stress job can individually pose threats to maternal and fetal health, there is little literature to date that has examined the reproductive health of female law enforcement officers (LEOs). To our knowledge, no published literature has investigated or quantified birth outcomes in this population. Such research could affect policy decisions for departments and decision-making for the female LEO; thus, further investigation is warranted.

This study used a cross-sectional epidemiological survey with snowball sampling of US female LEOs to determine the incidence of adverse maternal and fetal outcomes for each pregnancy. This study helps begin to address occupational health needs of this underrepresented and understudied group of women.

Background

Law enforcement is an inherently stressful occupation (Berg et al., 2006) and a high-risk job compared to other careers (Driscoll et al., 1999; NOHSC, 1999). LEOs are responsible for protecting the public and maintaining order (Bureau of Justice Statistics, 2016). They are first responders to any type of event that poses a threat to safety, involving regular and ongoing exposure to confrontation, potential harm, and violence (Maguen et al., 2009). LEOs are tactical athletes since they are expected to be combat-

ready at all times (Violanti, 1999). Because this occupation is the first line of defense to any public threat of safety, there is little disagreement that LEOs' overall health is vitally important.

Female LEOs are an asset to law enforcement. While they have been found to use similar amounts of force during an arrest (Hoffman & Hickey, 2005), women are less likely than male LEOs to use extreme controlling behaviors such as threats, and physical restraint (Rabe-Hemp, 2008). Nationwide, one of the single largest police call categories is violence against women, and female LEOs are more effective responding to these calls than males (Harrington, 1998).

Despite efforts to increase the recruitment and retention of females in the police force, there has been limited success and slow growth (Harrington, 2003). Women LEOs are grossly under-represented and understudied, and make up approximately 16% of the total sworn force (Langton, 2010). This percentage represents 96,900 women nationwide at federal, state, and local law enforcement agencies (Langton, 2010).

Independently, shiftwork, high stress, and various environmental exposures have been reported as factors that could result in increased risk of adverse fetal outcomes (Amani & Gill, 2013; Brandt & Nielsen, 1992; Figà-Talamanca, 2006; Gardella, 2001; Knutsson, 2003; Mentzer, 1997; Mozurkewich, 2000; NIOSH, 2015; Nurminen, 1998; Puttonen, Harma, & Hublin, 2010). While these conditions are common within law enforcement, adverse birth outcomes have never been quantified in this population. To date, few studies have looked specifically at the reproductive health of female LEOs. Based on a recent study featuring a similar tactical occupation (firefighters) with high

rates of reported miscarriage (27%) (Jahnke, Poston, Jitnarin, & Haddock, 2018), the lack of published literature regarding tactical athletes' reproductive health is unsettling.

Shiftwork

The US Bureau of Labor Statistics Standard Occupational Classifications (2018) lists law enforcement as a shift work occupation falling under the protective services branch. Shift work affects approximately one-half of all law enforcement personnel (McMenamin, Holden, & Bahls 2007). Shift work negatively impacts physiological function through a disruption of individual's circadian rhythms (Knutsson, 2003). This appears to be accompanied by changes in hormonal concentrations that can affect both conception and normal fetal development (Figà-Talamanca, 2006).

The ill-effects of shift work have been well documented in the literature. Negative repercussions of shift work include increased anxiety, depression, neuroticism, gastrointestinal disorders, weight gain, type II diabetes, and coronary heart disease (Barbadoro et al., 2013; Harrington, 2001). For females, this type of work schedule may also increase the incidence of miscarriage, low birth weight in infants, and preterm delivery (Amani & Gill, 2013; Knutsson, 2003; Mozurkewich, 2000; Nurminen, 1998; Puttonen, Harma, & Hublin, 2010).

Occupational stress

Law enforcement is considered one of the Nation's most stressful occupations compared to other careers (Anshel, Robertson & Caputi, 1997). Law enforcement includes regular and on-going exposure to potential harm, confrontation, and violence (Maguen et al., 2009). It is well-documented that LEOs suffer from very high stress levels due to their physically and emotionally draining occupation (Dick, 2000; Gershon,

Barocas, Canton, Li, & Vlahov, 2009; He, Zhao, & Ren, 2005). Physical symptoms often experienced among law enforcement officers include cardiovascular, musculoskeletal, and gastrointestinal disorders, while psychological symptoms include posttraumatic stress disorder, depression, and anxiety (Berg, Hem, Lau, & Ekeberg, 2006). Female LEOs experience even greater levels of stress than males due to added discrimination, harassment and the need to adapt to a male-dominated profession (Swan, 1990). High job stress has also been associated with increased risk of miscarriage and low birth weight among women (Brandt & Nielsen, 1992).

Chemical exposure

Various workplace exposures to chemicals and disease-causing agents can affect the reproductive health of female LEOs. Certain exposures can have consequences not only on the ability to become pregnant, but also on fetal health and development (NIOSH, 2015). This can lead to reproductive health problems such as infertility/reduced fertility, menstrual/ovulatory cycle disorders, sex hormone imbalances, miscarriage, stillbirth, birth defects, child developmental disorders, premature birth, or lower birth weight babies (NIOSH, 2015). During the first three months, exposure to harmful substances risks a birth defect or miscarriage, while exposure during the last six months of pregnancy could result in delayed growth of the fetus, premature birth, or impact brain development (NIOSH, 1999). Certain chemicals and metals may be absorbed faster by pregnant females compared to non-pregnant females and certain chemical exposures are riskier for a fetus than the pregnant woman because of its rapid development and small size (NIOSH, 2015). Because of their constant contact with the public, LEOs risk coming into contact with people carrying various disease-causing

agents that are known reproductive hazards including, but not limited to, cytomegalo-virus (CMV), hepatitis B, human immune-deficiency virus (HIV), Human parvovirus B19, and varicella-zostervirus (chicken pox) (NIOSH, 1999). LEOs in investigatory roles involving arson, bombs and drugs have the potential to be exposed to poisonous chemicals and vapors (Mentzer, 1997). There has been an exponential increase in illicit drug labs in the US manufacturing illegal drugs that contain toxic chemicals and high concentrations of toxic vapors which can be absorbed residually through the skin and eyes (Hargreaves, 2000). LEOs also have the potential for lead exposure, primarily via handling lead-based ammunition (Czarnecki, 2003). Lead exposure is associated with negative birth outcomes such as miscarriage, preterm delivery, premature membrane rupture, and neurobehavioral effects in infants (Gardella, 2001).

The purpose of this study is to provide preliminary data on birth outcomes among this tactical population. We hypothesize that adverse birth outcomes such as miscarriage and preterm birth will be significantly higher among female LEOs compared to two large general population birth outcome studies (Andersen et al., 2000, & Blencowe et al., 2012); similar to the findings reported in female firefighters by Jahnke and colleagues (2018).

Methods

Design

Study design was a cross-sectional epidemiological survey that used snowball sampling techniques (Cook, Campbell & Shadish, 2002) to garner participation.

Participants

There is no national organization that acts as a unifying body for law enforcement. This means there is no single registry of law enforcement officers that exists from which we could identify female law enforcement officers for random sampling. Due to privacy and protection policies, police departments will not provide personal contact information for their members. Primary sample recruitment began with survey distribution from several organizations including the International Association of Women Police, the National Strength and Conditioning Association Tactical facilitators email list, and social media sites such as LinkedIn, and female law enforcement organizations and groups on Facebook. Secondary recruitment was solicited through the survey itself. One of the final sections of the survey requested participating LEOs to input the emails of any female colleagues who might also be interested in participating. Those females were then emailed and directed with a link to the web-based survey.

A total of 275 individual responses were collected. Of the 275 who indicated a willingness to participate in the survey, 200 (73%) met the criteria of currently serving in US law enforcement, being 18 years of age or older, under the age of 66, and had had at least one pregnancy during their career in law enforcement. Not all questions were answered by all participants. The first page of the survey served as the informed consent document. It also described both the scope and purpose of the study, the anonymous nature of the survey, and provided the contact information for the principal investigator. Approval was received from Kansas State University's Institutional Review Board (IRB).

Exclusions

Current female US law enforcement officers who had not experienced at least one pregnancy during their law enforcement careers or those under age 18 or older than age 66 were excluded from participation.

Study variables

The self-report survey was formatted similarly to Jahnke and colleagues (2018), who collected self-reported data on reproductive health from female firefighters. Data were collected on pregnancy outcome, duration of pregnancy, maternal age at time of conception, and if the pregnancy occurred while employed in law enforcement. Participants answered detailed questions about each pregnancy outcome. For pregnancies occurring while employed in law enforcement, participants indicated specific job exposures encountered (e.g. strenuous physical demands, shiftwork, stress, lead handling). We categorized birth outcomes into live birth, miscarriage, still birth, intended termination, still pregnant, or other. The “other” category allowed participants to describe their pregnancy outcome, which were collapsed and manually classified. Ectopic pregnancies (n=7) or anembryonic pregnancies (n=1) were classified as miscarriage since these pregnancies resulted in a loss before 20 weeks. Any pregnancy loss that occurred after 20 weeks of gestation was defined as still birth and was not used in our miscarriage calculation. Each reported live birth was followed with yes/no questions that determined if the baby was born light for gestational age (5lbs 8oz or less), if the baby was preterm (born at 37 weeks or less of gestational age), if the baby was diagnosed as jaundiced, or if the baby had failure to thrive, a diagnosis of inadequate growth based on anthropometrical parameters (Olsen, 2006).

Statistical analysis

Participants provided general demographic information such as marital status, ethnicity, income, and education attainment, along with occupational information such as rank and years of service.

The frequency of all pregnancy outcomes were calculated. Miscarriage rates were also calculated for those who reported working active duty during time of pregnancy. After all pregnancy outcomes were calculated for the entire sample, trends in maternal age were then examined. Maternal age at pregnancy onset was categorized into 2 groups: <35 years, and ≥35 years, since 35 years and older is considered "advanced maternal age", and is often used as a factor in determining prenatal screening protocols (Society for Maternal-Fetal Medicine, 2014).

To compare our sample's miscarriage rates with the literature, definitions and classifications of miscarriage were aligned and age standardized to Andersen et al. (2000), a prospective linkage study that included data on maternal age and fetal outcomes of over 1 million pregnancies. Ectopic pregnancies were counted in miscarriage data, but still births were not due their definition in gestational age (pregnancy loss occurring at 20 weeks or more). The same definition of miscarriage was used for comparison in the Andersen et al. (2000) sample. Definitions of preterm birth were standardized and compared with Blencowe et al. (2012), a systematic review study with a large U.S. sample as the comparison group. Differences in these estimates were both assessed using chi square analysis and 95% confidence intervals. Logistic regression was used to determine if specific job exposures were associated with pregnancy loss (miscarriage or still birth) among the sample of female LEOs. Subjects

that reported currently being pregnant, and intentionally terminated pregnancies were excluded in the analysis for that pregnancy due to unknown reproductive outcome.

Results

Law enforcement sample characteristics

More than 90% of the sample was Caucasian, and the largest group of respondents was between 31 and 40 years of age (see Table 4.1). The sample had an average BMI of 28.4 ± 5.5 kg/m^2. The average number of pregnancies for each female LEO was 2.7 ± 1.5. The majority of the sample (75.8%) reported being married or with a partner, had incomes of $100,000 or more (59.7%), and had college degrees or advanced degrees (64.0%); only 2% had a high school education or less. The 200 participants who fit the inclusion criteria were from across the U.S.; with representation from 32 of 50 states. The states with the largest response rates were New York (14%), Nebraska (10%), California (8%), Kansas (8%), and Wisconsin (8%).

Table 4.1

Participant Demographics

Domain	M (SD)	n (%)
Age (in years) (n=153)		
18-30		15 (9.8)
31-40		69 (45.1)
41-49		49 (32.0)
50-60		20 (13.1)
BMI (n=187)	28.4 (5.5)	
Number of pregnancies (n=437)	2.7 (1.47)	
Marital Status (n=153)		
Married/Partnered		116 (75.8)
Divorced/Separated		25 (16.3)
Never Married		9 (5.9)
Race Classification (n=153)		
White		239 (90.9)
Black or African American		8 (5.2)
Asian		0
Native or other Pacific Islander		0
Other		3 (2.0)
Hispanic, Latina or Spanish origin (n=153)		13 (8.5)
Income (n=153)		
$75,000 or less		24 (15.4)
$75,000 to $100,000		33 (21.5)
Greater than $100,000		91 (59.7)
Prefer not to answer		5 (3.4)
Education (n=150)		
Some High School		1 (0.7)
High School graduate or GED		2 (1.3)
Some College or Technical School		51 (34.0)
College Graduate		70 (46.7)
Advanced Degree		26 (17.3)

Sample occupational information

The average number of years served in law enforcement for the sample was 13.2 ± 5.6 (see Table 4.2), and the largest respondent group (36.8%) reported their job title was officer (police, patrol), constable, or deputy sheriff; followed by Sergeants,

Detectives, or Investigators (34.4%). Half of the sample (50.3%) described their department as urban, compared to suburban (28.9%) or rural (17.1%). A large proportion of the sample (45.1%) reported having a spouse that also worked in law enforcement.

Table 4.2

Job specific demographics (n = 187)

Characteristic	**Mean (SD)**	**n (%)**
Years of law enforcement service	13.2 (5.59)	
5 years or less		20 (10.7)
6-10 years		40 (21.4)
11-15 years		51 (27.3)
16-19 years		27 (14.4)
20 + years		49 (26.2)
Rank		
Officer (Including Police Officer, Patrol Officer, Constable, or Deputy Sheriff)		69 (36.8)
Corporal		9 (4.8)
Sergeant		31 (17.0)
Lieutenant		20 (11.0)
Captain		4 (1.9)
Detective/Investigator		33 (17.5)
Staff Sergeant		2 (1.0)
Chief/Sheriff		4 (1.9)
Other		15 (7.8)
Department Classification		
Urban		94 (50.3)
Suburban		54 (28.9)
Rural		32 (17.1)
Don’t know		7 (3.7)
Spouse employed by the police department (n=111)		
Yes		50 (45)
No		61 (55)

Career outlook

The majority of the sample (63.1%) either agreed or strongly agreed that they were optimistic about their future career success (see Table 4.3). Similarly, 66.3%

agreed or strongly agreed that they were satisfied with their law enforcement career. More than half of the sample (58.8%) said they would recommend a career in law enforcement to other women.

Table 4.3

Career satisfaction for participants (n = 187)

Statement and Level of Agreement	**n (%)**
I am optimistic about my future success with my police department	
Very much disagree	10 (5.4)
Disagree	18 (9.6)
Neutral	41 (21.9)
Agree	75 (40.1)
Strongly agree	43 (23.0)
I am satisfied with my job in the police department	
Very much disagree	10 (5.4)
Disagree	14 (7.5)
Neutral	39 (20.9)
Agree	87 (46.5)
Strongly agree	37 (19.8)
I would recommend being a law enforcement officer to other women	
Very much disagree	10 (5.4)
Disagree	22 (11.8)
Neutral	45 (24.1)
Agree	83 (44.4)
Strongly agree	27 (14.4)

Mental health

Just over 6% of the sample had struggled with some sort of alcohol abuse or dependency (see Table 4.4). A quarter of the sample (25.1%) was diagnosed with an anxiety disorder and 23.5% had been diagnosed with a depressive disorder.

Table 4.4

Participant Self-Reported Mental Health

Characteristic	n (%)
Diagnosed w/ anxiety disorder (n=187)	
Yes	47 (25.1)
No	139 (74.3)
Prefer not to answer	1 (0.5)
Diagnosed w/ a depressive disorder (n=187)	
Yes	44 (23.5)
No	138 (73.8)
Prefer not to answer	5 (2.7)

Pregnancy outcomes

Pregnancy outcome data were provided by 200 women, and a total of 437 pregnancies were reported (see Table 4.5). Of those, five female LEOs were currently pregnant and 35 pregnancies were elected terminations, so those pregnancies were removed from outcome calculations. This resulted in 397 intended pregnancies from our sample. Live birth resulted from 80% of intended pregnancies. The crude overall miscarriage rate across all pregnancies and ages was 19.1%. Three cases of still birth were reported in our sample (0.8%), which did not allow for statistical comparison. The age-adjusted miscarriage rate for our sample of female LEOs under 35 years was 17.9% (see Table 4.6), and 24.7% when adjusted for LEOs aged 35 years and older (see Table 4.7). The age-adjusted LEO miscarriage rates were both higher compared to the Andersen sample, whom reported a miscarriage rate of 12.0% in females under 35 and 28.3% in females 35 and older.

The Chi-Square test of independence revealed that the proportion of overall miscarriage rates compared to live births among the female LEO sample was higher than the proportion of overall miscarriage rates compared to live births in the Andersen

et al. (2000) sample. The difference in proportions was significant at, χ^2 (1, N = 912,000) = 22.01, $p < 0.001$. However, only female LEOs under 35 had significantly higher miscarriage rates compared to the Andersen sample, at χ^2 (1, N = 865,472) = 10.72, $p < 0.001$.

Table 4.5

Pregnancy Outcome Data All Ages (n = 200)

	*P1	P2	P3	P4	P5 (or more)	Total **n (%)**
Total Pregnancies	184	130	69	30	24	437 (100)
Intended Pregnancies with known outcome (n=397)	169	124	63	26	15	397 (100)
Live Birth	85.1%	84.7%	79.4%	76.9%	80.0.%	318 (80.1)
Miscarriage**	21.3%	17.1%	20.6%	23.1%	20.0%	76 (19.1)
Still Birth	1.2%	0.8%	0%	0%	0%	3 (0.8)
Terminated***	8.2%	3.1%	5.8%	13.3%	33.3 %	35 (8.0)
Still Pregnant***	0%	1.5%	2.9%	0%	7.7%	5 (1.1)

* P = pregnancy
** Includes ectopic pregnancies and one case of anembryonic miscarriage
*** Not counted in pregnancy outcome calculations

Table 4.6

Intended Pregnancy Outcomes LESS than 35 years

	*P1	P2	P3	P4	P5 (or more)	Total **n (%)**
Total Pregnancies (n=324)	156	104	41	15	8	324 (100)
Live Birth	80.8%	86.5%	75.6%	73.3%	87.5%	265 (81.8)
Miscarriage**	18.6%	13.5%	24.4%	26.7%	25.0%	58 (17.9)
Still Birth	0.6%	0%	0%	0%	0%	1 (0.3)

* P = pregnancy
** Includes ectopic pregnancies and one case of anembryonic miscarriage

Table 4.7

Intended Pregnancy Outcomes 35 years & Older

	*P1	P2	P3	P4	P5 (or more)	Total **n (%)**
Total Pregnancies (n=73)	13	20	22	11	7	73 (100)
Live Birth	38.5%	75.0%	86.4%	81.8%	83.3%	53 (72.6)
Miscarriage**	53.9%	20.0%	13.6%	18.2%	28.6%	18 (24.7)
Still Birth	7.7%	5.0%	0%	0%	0%	2 (2.7)

* P = pregnancy
** Includes ectopic pregnancies and one case of anembryonic miscarriage

Maternal and fetal health

Out of 317 live births, 6.3% of babies were considered light for gestational age (see Table 4.8). Almost one-third (30.3%) of babies had jaundice, and only 2.5% of babies had failure to thrive. It was reported that 16.4% of the sample had preterm babies (born 3 or more weeks prior to due date). The proportion of preterm births in the female LEO sample was over 4% higher than the proportion of preterm births in the Blencowe et al. (2012) comparison sample (16.4% vs. 12.0%). The Chi-Square test of independence revealed that self-reported preterm birth occurred at significantly higher proportions in the female LEO sample in comparison to the comparison group at, χ^2 (1, N = 4,300,935) = 5.15, p = 0.02.

On the maternal side, 11.1% of female LEOs were diagnosed with some form of gestational hypertension, and 7.6% were diagnosed with gestational diabetes (see Table 4.9).

Table 4.8

Live Birth Outcomes: Baby Complications

	*P1	P2	P3	P4	P5 (or more)	Total **n (%)**
Baby Condition	130	105	50	20	12	317 (100)
Baby weighed less than 5 lbs.,8 oz.	9.2%	3.8%	6.0%	5.0%	0%	20 (6.3)
Baby born more than 3 weeks before due date	19.2%	12.4%	24.0%	10.0%	0%	52 (16.4)
Baby had jaundice at birth	32.3%	29.5%	28.0%	30.0%	25.0%	96 (30.3)
Baby had failure to thrive	1.5%	2.9%	6.0%	0%	0%	8 (2.5)

* P = pregnancy

Table 4.9

Live Birth Outcomes: Maternal complications

	*P1	P2	P3	P4	P5 (or more)	Total **n (%)**
Pregnancies	182	128	68	30	24	432 (100)
Diagnosed with gestational hypertension	9.3%	10.9%	11.8%	16.7%	20.8%	48 (11.1)
Diagnosed with gestational diabetes	5.5%	6.3%	11.8%	10.0%	16.7%	33 (7.64)

* P = pregnancy

Pregnancy practices in law enforcement

Of the 437 reported pregnancies, more than three quarters (77.6%) occurred while participants were actively serving in law enforcement. Over 70% reported they were actively responding to emergency calls when they learned of their pregnancy (see Table 4.10). The adjusted miscarriage rate for these LEOs was a slight increase from 19.6% to 20.4%, and the adjusted preterm birth rate was slightly decreased from to 16.4% to 14%. The most widely reported job exposure reported by participants (19.9%)

was shift work (see Figure 4.1). The second most common job exposure was high job stress (18.6%). The third most common job exposure selected by female LEOs during the onset of their pregnancy was working shifts longer than 10 hours (14.1%). Extreme or dangerous job physicality (e.g. violence, wrestling, assault, apprehension) was only reported by 9.6% of the sample, and high intensity exercise was only reported by 8.1%.

For female LEOs that reported a pregnancy loss (miscarriage or still birth) while on the job, logistic regression found that no reported specific job exposures were significantly associated ($p > 0.05$) with pregnancy loss (see Table 4.11).

Table 4.10

Pregnancy Practices on the Job (n = 225)

	*P1	P2	P3	P4	P5	Total **n (%)**
Pregnancies	128	105	60	24	22	339 (100)
Actively responding to emergency calls at onset of pregnancy	75.8%	69.5%	63.3%	58.3%	86.4%	241 (71.1)

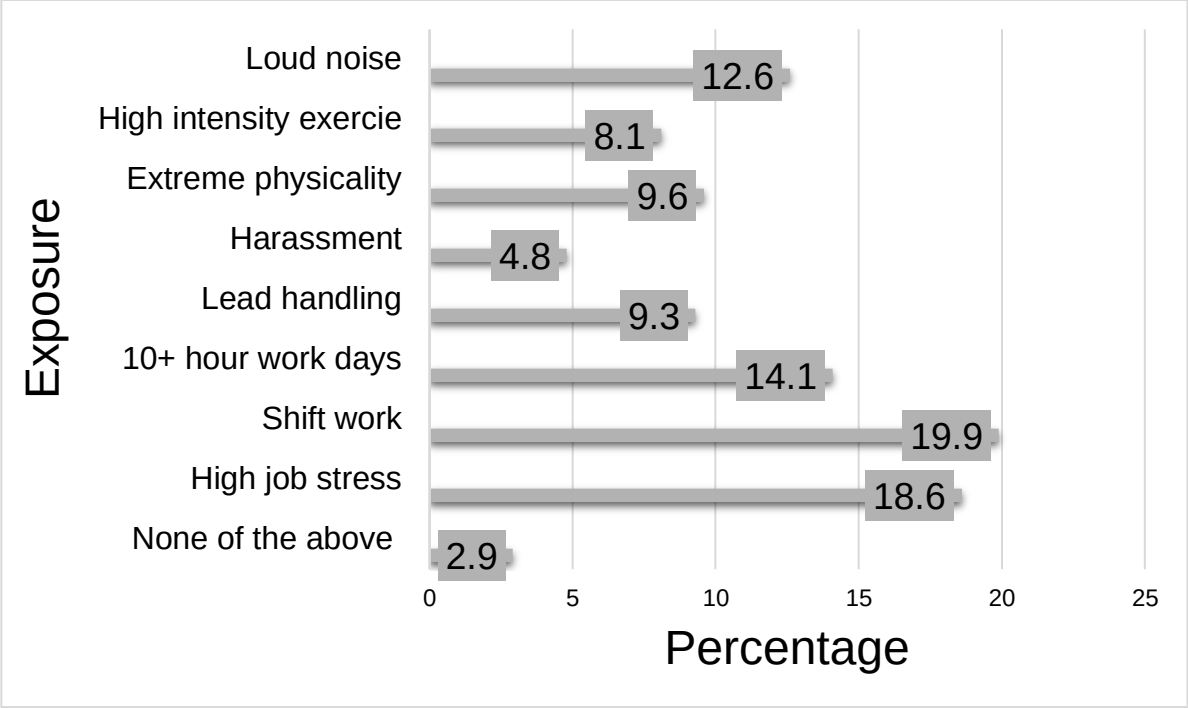

Figure 4.1**.** Self-reported job exposures during pregnancy (n = 225)

Table 4.11

Association between Job Exposures and Pregnancy Loss

	Standardized Coefficients		Significance
Job Tasks	**Beta**	**t**	**p**
Exceptionally loud noise (e.g. Discharge from a firearm)	.030	.465	.642
High job stress	-.001	-.012	.990
Shift work	.010	.152	.879
Regular work days exceeding 10 hours	.040	.652	.515
Handling lead or lead-based products (e.g. Lead based ammunition)	.017	.285	.775
Work place harassment (verbal, emotional, physical, sexual)	.035	.648	.517
Extreme or dangerous job physicality (e.g. Violence, wrestling, assault, apprehension)	-.074	-1.259	.209
High-intensity exercise (e.g. Sprinting, jumping, lifting, carrying)	-.003	-.047	.963
I did not experience any of the above during this pregnancy	-.013	-.246	.806

Discussion

The purpose of this study was to provide preliminary data on birth outcomes among female LEOs. Our hypothesis was supported; miscarriage and preterm birth were significantly higher among female LEOs compared to two large control groups (Andersen et al., 2000, & Blencowe et al., 2012). Additionally, miscarriage and preterm birth both appear to be higher among US female law enforcement officers compared to the ACOG statements that miscarriage tends to occur in 10% of pregnancies (see ACOG, 2015 and ACOG, 2017). Since age is the strongest predictor of miscarriage (Andersen et al., 2000; Maconochie, Doyle, & Prior, 2007; Kline, Stein, & Susser 1989; Wilcox et al., 1988), our age-adjusted miscarriage rates still evidence that miscarriage is higher in the US LEO population, in addition to the miscarriage rates collected on over one million Danish general population pregnancies (Andersen et al., 2000). Despite the fact that the mechanisms contributing to miscarriage are statistically unclear, our findings are consistent with recent research published on female firefighters by Jahnke and colleagues (2018), a similar tactical profession. Since 2017, this emerging research is now the third study attempting to quantify birth outcomes among tactical athletes (see Jahnke et al., 2018 and Ippolito et al., 2017). All miscarriage rates in these groups appear higher than the stated US average according to ACOG (2015). While preterm birth was not measured among servicewomen (Ippolito et al., 2017), it was also statistically higher amongst both firefighters (Jahnke et al., 2018) and female LEOs compared to US averages. The fact that our findings are consistent with previous literature on two similar tactical occupational groups helps validate our study, and are a loud cry for further research.

Miscarriage

Miscarriage is challenging to study for several reasons. First, the very definition of miscarriage and other terms for miscarriage are varied and inconsistent across the literature (e.g., pregnancy loss before 20 weeks (see Maconochie et al., 2007; Michels & Tiu, 2007) or pregnancy loss before 24 weeks gestation (see Neilson et al., 2010; Lashen, Fear, & Sturdee, 2004). Other terms used in place of miscarriage have been pregnancy loss, early pregnancy loss, and spontaneous abortion, making literature searches somewhat difficult. Although spontaneous abortion is commonly used in the literature, we used the term miscarriage, since it was the recommended terminology for pregnancy loss prior to viability before the mid-second trimester (Kolte et al., 2015) and because of families' preference of the word miscarriage compared to abortion, which has negative emotional connotations (Silver, Branch, Goldenberg, Iams, & Klebanoff, 2011).

There have been few biological, socioeconomic, or behavioral factors that have been definitively associated with increased risk of miscarriage, however, increased maternal age is the strongest independent predictor (Andersen et al., 2000; Maconochie, Doyle, & Prior, 2007; Kline, Stein, & Susser 1989; Wilcox et al., 1988). The age-adjusted miscarriage rate for female LEOs under 35 years was 17.9%, and increased to 24.7% in female LEOs aged 35 and older. According to a recent bulletin published by the ACOG, miscarriage risk is between 9 and 17% for ages 20 to 30 years, and 20% for ages 35 to 40 (ACOG, 2015). Thus, our findings still appear to be on the higher end for both age groupings.

The crude miscarriage rate across all pregnancies and ages in our sample was almost 6% higher than that reported in the Andersen et al. sample (2000), a large prospective study reporting over one million pregnancies and outcomes (19.6% vs 13.2%). It should be noted that miscarriage rates differ somewhat in the literature, and this variation is due to classification and how pregnancy loss is measured. For example, the ACOG (2015) estimates that 10% of all early pregnancies end in miscarriage. One systematic review reported that miscarriage occurs in between 11% and 22% of all pregnancies (Ammon Avalos, Galindo, & Li, 2012). Thus, while it may not be definitive, our results indicate that miscarriage in LEOs is higher than the general US population. Future research should continue to examine miscarriage rates among female LEOs and other tactical occupations, and the potential mechanisms that drive these rates up. Until the causes are more clearly outlined, it is advisable that any female LEO of child-bearing age be advised on the potential miscarriage risks with evidenced occupational exposures such as shiftwork, high occupational stress, and exposure to various chemicals, vapors, or lead (Amani & Gill, 2013; Brandt & Nielsen, 1992; Figà-Talamanca, 2006; Gardella, 2001; Knutsson, 2003; Mentzer, 1997; Mozurkewich, 2000; NIOSH, 2015; Nurminen, 1998; Puttonen, Harma, & Hublin, 2010). Additionally, female LEOs should be counseled on modifiable behavioral factors that have been linked to miscarriage such as caffeine intake, drug use, alcohol use, smoking, and BMI (Anokute, 1986; Bech, Obel, Henriksen, & Olsen, 2007; Chasnoff, Burns, Schnoll & Burns, 1985; Dominguez-Rojas et al., 1994; Harlap & Shiono, 1980; Satpathy 2008)

Preterm birth

One live birth outcome that was significantly higher in our sample of female LEOs compared to both our control group and the US average was preterm birth, occurring in 16.4% of our sample. The national rate of preterm birth is between 9.8% (March of Dimes, 2017), and 12% (Blencowe et al., 2012). Occupational exposures such as working nights (Bodin, Axelsson, & Ahlborg, 1999) and prenatal lead exposure (Andrews, Savitz, & Herz-Picciotto, 1994) can increase risk of preterm birth. Working shiftwork, which includes night-time shifts, was reported in almost 20% of all pregnancies that occurred on the job. Lead exposure, such as handling lead based ammunition, was reported in 9.31% of on the job pregnancies.

Gestational diabetes and gestational hypertension are also risk factors for preterm birth (Madan et al., 2010). Pre-pregnancy body mass index (BMI) is a strong risk factor for gestational hypertension, gestational diabetes, and preterm birth (Shin & Song, 2014). Women with BMIs of 30 or greater have increased likelihood of gestational hypertension (Shin & Song, 2014). Just over 11% of our female LEOs were diagnosed with some form of gestational hypertension during their pregnancy, which was higher than the reported U.S. average of 6-8% (National Heart Lung and Blood Institute, 2000). Just over 7% of our sample was diagnosed with gestational diabetes, which fell under the nationally reported rate of 9.0% (DeSisto, Kim, & Sharma, 2014).

Future research should continue to investigate preterm birth among female LEOs and the potential mechanisms behind this. Until then, it is advisable that all LEOs with a pregnancy be closely monitored for gestational hypertension, maintain a healthy body

weight pre-pregnancy, and be advised on the potentially adverse risks for preterm birth with regards to lead handling and working nights.

Occupational exposures

More than 71% of our female LEO sample reported they were actively responding to emergency calls when they learned of their pregnancy. The three highest exposures during pregnancy onset reported by our sample were shift work, high job stress, and shift lengths lasting ten or more hours. Logistic regression revealed no significant association between any specific job exposures and pregnancy loss among female LEOs. Since there were no previous female LEO studies to suggest specific exposures to focus on, we looked at all possible exposures. This may have resulted in a saturated model where one or more variables may have been significant, yet due to all of the variables, statistical power was lost. A noted limitation is that our sample size may not have supported this type of analysis, as having at least ten participants per variable of interest is recommended for running a more saturated regression model (Sperandei, 2014). Future research should attempt to obtain a larger sample size in order to increase the frequency of the various exposures of interest (particularly shift work, high job stress, and working long hours).

Stress

Occupational-related psychosocial stress is the personal response when work demands and pressures do not align with an individual's knowledge and abilities, which affects a person's ability to cope (Leka, Griffiths, & Cox 2003). It is well documented that stress interferes with females' endocrine system, which is often manifested via menstrual disorders (Figà-Talamanca, 2006). Occupational studies featuring female

nurses (Lawson et al. 2012) and lawyers (Schenker et al., 1997) have linked stressful work conditions to disordered menstrual function, miscarriage, and fertility issues. High occupational stress is a major cause of job turnover among organizations (NIOSH, 1999). Stress management in female LEOs may be a possible avenue to minimize reproductive harm, and potentially increase female representation in law enforcement.

Shift work

Several studies have established that shift workers not only experience increased miscarriage risk, but also low birth weight in infants, and preterm delivery (see Amani & Gill, 2013; Knutsson, 2003; Mozurkewich, 2000; Nurminen, 1998; Puttonen, Harma, & Hublin, 2010). In a review of the literature, Figà-Talamanca (2006) reported that irregular work hours were linked with an even higher risk of miscarriage and reduced fertility, while regular work shifts, including night shifts, did not appear to have the same effect. Therefore, this suggested that consistent shift work schedules might be an important factor for reproductive health in female LEOs.

Long hours

Working long hours may impact reproductive health. Schenker and colleagues (1997) found that female lawyers working 10+ hour days had increased risk of miscarriage. Another study linked increased risk miscarriage rates among female nurses working more than 40 hours a week during the first trimester compared to those working between 21 and 40 hours (Whelan et al., 2007). To expand upon these possible adverse outcomes, future research with female LEOs should also examine total weekly hours worked.

Similar tactical occupations

Law enforcement officers and firefighters share a unique set of job characteristics such as shiftwork, unpredictable and highly stressful nature of first response work, and potential exposure to loud noise and toxins. Both occupations are often classified together, along with emergency medical service (EMS) as first responders (Reichard & Jackson, 2010). Recent research reported some alarming preliminary data on birth outcomes of female firefighters, when Jahnke and colleagues (2018) reported an overall miscarriage rate of 27%, which ranged from 22.6% for first pregnancies, to 31.7% for fourth pregnancies. Preterm birth also appeared to be elevated compared to National level data, and was reported at rates between 11.6% (first pregnancy) up to 16.7% (fourth pregnancy) (Jahnke et al., 2018).

Ippolito et al. (2017) reported that 31% of military servicewomen reported a miscarriage. After adjusting for demographic, behavioral, and military characteristics, miscarriage was not correlated with combat exposure or cumulative days deployed. Age was the strongest predictor of miscarriage in this study, followed by smoking, and alcohol consumption as opposed to the two military-specific exposures. It is worth noting that servicewomen are not able to deploy if pregnant, therefore, appropriate exposure selection is called into question. Authors acknowledge this and that not all occupational exposures were examined.

Interestingly, a large proportion of the sample (45.1%) reported having a spouse that also worked in law enforcement. While we did not ask any reproductive health questions about their partners, it might be useful if future research asked about reproductive health and occupational exposures about the female LEOs spouse. Recent

research has suggested that paternal age is associated with increased odds (OR 1.012, 95% CI 1.003-1.022) of infant low birth weight while controlling for maternal factors, and that paternal race/ethnicity was also significantly associated ($P < 0.05$) with preterm birth, low birthweight, high birthweight, and light for gestational age infants (Meng & Groth, 2018). One review concluded that paternal lifestyle factors such as smoking and being overweight (BMI [kg/m^2] of $\geq$ 25) affects reproductive performance (Horman, Davies, & Norman, 2007).

Other occupations

In addition to tactical athletes, including military and firefighting, adverse birth outcomes have been documented in other occupational groups that share some of the same occupational characteristics common in law enforcement.

Nurses often operate on shift-work schedules, long hours, and experience high job-related stress (Yang et al., 2014). Additionally, nurses encounter chemical, biological/infectious exposures which can have adverse effects on reproductive health (Whelan et al., 2007; Lawson et al., 2012). A Taiwanese study comparing nurses and non-nurses found that both miscarriage and preterm birth rates were significantly higher in the nurse population (6.0% vs 5.3%, and 8.1 vs 4.4%, respectively) (Yang et al., 2014). After adjusting for socioeconomic status and age, the miscarriage difference became insignificant, however, preterm birth remained significantly higher among nurses. Researchers hypothesized that high workload, job-related stress, shift work, and exposure to infectious/dangerous substances were possible explanations (Yang et al., 2014).

Flight attendants also share some unique job similarities with LEOs, including circadian disruption via night shifts, and physically demanding work (Grajewski et al., 2015). Miscarriage among flight attendants was found to be significantly higher compared to teachers when they experienced circadian disruption (flying 15 hours or more during home-base sleep hours) combined with physical job demands (defined as prolonged standing/walking or bending) in addition to cosmic radiation exposure.

Study Strengths

This study has several strengths. To our knowledge, this study is the first to quantify birth outcomes among female law enforcement officers, and is validated by similar findings among two occupational groups; firefighters and military personnel. We had a geographically representative sample of US female LEOs with detailed information collected on maternal characteristics and pregnancy outcomes. Additionally, this study directly responds to the call for more research that addresses reproductive health concerns among tactical athletes (Jahnke et al, 2018; Kehler et al., 2018).

Study Limitations

Our study was not without limitations. Self-reported pregnancy outcomes, especially loss or terminations, may be sensitive information for some participants, and may not represent a fully accurate representation of birth outcomes within this sample of female LEOs. However, the survey was anonymous, and was advertised as so. While the majority of female LEOs reported an average of 2-3 pregnancies each, some women having five or more pregnancies, and researchers acknowledge that recollection of details pertaining to maternal health, fetal health and job tasks at the time of pregnancy would be difficult and may not be entirely accurate. While we did look at age,

the strongest predictor of miscarriage, we did not control for other potentially confounding variables, such as previous miscarriage, or behavioral factors such as smoking and alcohol use at time of pregnancy. Further, we are not able to determine how representative this sample is of US female LEOs as a whole. While the large majority (90.9%) of our sample identified as Caucasian, census information reveals that 79% US LEOs (male and female) are Caucasian (Census Bureau, 2016), therefore we may be missing key reproductive health information from other racial groups. However, it is worth noting that complete racial and ethnic information on the US female LEO population was not available at time of publication, therefore exact stats on racial and ethnic representation of US female LEOs is not known.

Future Recommendations

Our results justify the concern for the reproductive health of the female LEO. Policy makers and health care practitioners should advise any female LEO of child-bearing age on the occupational risk factors associated with police work and their implications for maternal and fetal health. Future epidemiological research should provide more insight into the magnitude or combinations of common LEO exposures and behavioral risk factors responsible for adverse reproductive outcomes. Since almost half of our sample reported being partnered with a spouse also working in law enforcement, it would be interesting to know if adverse birth outcomes are even greater among these couples. It would also be useful to know the specific reproductive health concerns amongst female LEOs, and if these concerns might be impacting recruitment and retention in the profession.

Chapter 5 - Conclusion

Summary of Findings

The overarching goal of this research was to highlight the importance of the potential reproductive health issues for female tactical athletes. This was done through several smaller objectives: 1) Introduce the female tactical athlete and discuss the physical and occupational demands along with the reasons for reproductive health concern; 2) present the prenatal exercise literature with focus on the scientific rigor behind previous guidelines and explore the limitations of exercise during pregnancy; 3) determine the reproductive health concerns among female firefighters; 4) determine if adverse reproductive outcomes are greater than average among female LEOs; and 5) provide a brief summary of the dissertation findings in addition to future recommendations on further directions for research on female tactical athletes and reproductive health.

Continued participation in high intensity workouts should still be considered by pregnant women, especially tactical athletes, if it is important for job preparation. Exercise at high-intensity among athletes is not a proven risk factor during healthy pregnancies if the athlete is accustomed to that type of training. In fact, high-intensity exercise may have protective effects for both mother and baby (Bell, 2002; Figà-Talamanca, 2006; Kardel, 2005; Kardel, 2009). Overall, reproductive health is a major concern among female firefighters. This concern stems from unknown exposure risks, lack of research and sufficient education for firefighters, as opposed to physically challenging work demands. LEOs share many similar job characteristics with

firefighters. Based on a similar study design on firefighters carried out by Jahnke and colleagues (2018), our findings suggest that LEOs also experience higher rates of miscarriage (19.1%) and preterm birth (16.4%) compared to general population comparison groups (13.2 and 12.0%, respectively), and the stated US national averages (10% and 9.8%, respectively)(ACOG, 2015; March of Dimes, 2017). Both strenuous physical work demands and high intensity exercise were not associated with pregnancy loss or preterm birth among female LEOs.

Explanation of Results and Future Research Directions

Exercise and exercise intensity among women and athletes are not proven risk factors for females with healthy pregnancies, and in fact may have protective effects (Bell, 2002; Figà-Talamanca, 2006). Labor duration has been found to be inversely associated with a woman's aerobic capacity after adjusting for birthweight (Kardel et al., 2009), and strength training may also positively address labor and birth discomforts (Pennick & Young, 2007). However, some physically strenuous work demands such as heavy lifting or frequent bending may increase risk of adverse birth outcomes such as miscarriage (Figà-Talamanca, 2006). One prospective study found that strenuous physical strain right around time of implantation resulted in increased miscarriage risk (Hjollund et al., 2000). Therefore, based on the findings of this dissertation and previous literature (Bø et al., 2016; Juhl et al., 2013), it is advisable that female tactical athletes wanting to become pregnant should consider limiting physically strenuous exercise or work in the week after ovulation, during time of planned conception. For further precautionary measures, especially in the case of the female tactical athlete with other risk factors such as advanced maternal age ($\geq$35 years) or previous pregnancy losses,

refraining from repetitive heavy lifting efforts during the first trimester of pregnancy could be considered. However, this recommendation is based on very low evidence and may not be necessary (Bø et al., 2016).

Reproductive health is a large concern among female firefighters. The four themes that emerged from the data were: 1) department variation regarding pregnancy policy; 2) decision-making by firefighters for disclosure of a pregnancy; 3) lack of education, research, and information for firefighters on reproductive health; and finally, 4) reproductive health concerns impact female recruitment and retention. It is recommended that departments implement an appropriate pregnancy policy such as that outlined in the NFPA Standard 1582, Comprehensive Occupational Medical Programs for Fire Departments, section 9.18 (see Appendix B) (NFPA, 2013). It is also recommended that decision-making for female fighters be guided via increased awareness and education on the possibly deleterious effects of certain job duties common to firefighting and adverse reproductive health outcomes (Amani & Gill, 2013; American Pregnancy Association, 2018; Bhatt, 2000; Brandt & Nielsen, 1992; El-Metwalli et al., 2001; Fabian et al., 2010; Figà-Talamanca, 2006; iWomen, 2012; McDiarmid, & Agnew, 1995; McDiarmid et al., 1991; McDonald et al. 1988; Moretti, Bar-Oz, Fried, & Koren, 2005; NIOSH, 2015; NIOSH, 1999; Strand, Barnett & Tong 2011; Taskinen et al., 1990; Treitman, Burgess, & Gold, 1980; Wong et al., 2010). These practices may subsequently help in female firefighter retention, since evidence suggests that valuing employees' health and safety and the health of their families improves employee morale and retention (NIOSH, 2015).

Miscarriage occurred at a crude rate of 19.1% in all LEO pregnancies, and preterm birth accounted for 16.4% of all live births. These rates were both significantly higher than the comparison groups (13.2%, Andersen et al. 2000, and 12%, Blencowe et al., 2012, respectively). Gestational hypertension was also higher (11.1%) among female LEOs compared to the 6-8% U.S. average reported by the National Heart Lung and Blood Institute (2000).

Our results justify concern for the reproductive health of the female LEO. Further research should continue to investigate miscarriage and preterm birth among female LEOs and the potential mechanisms behind them. Until then, it is advisable that all LEOs with a pregnancy be closely monitored for gestational hypertension, and be advised on the potentially adverse risks for preterm birth and miscarriage with job exposures such as shiftwork, high job stress, and exposure to various chemicals, vapors, or lead (Amani & Gill, 2013; Brandt & Nielsen, 1992; Figà-Talamanca, 2006; Gardella, 2001; Knutsson, 2003; Mentzer, 1997; Mozurkewich, 2000; NIOSH, 2015; Nurminen, 1998; Puttonen, Harma, & Hublin, 2010).

Significance

This dissertation addresses the gap on what is known and understood on the potential adverse reproductive health consequences of female tactical athletes. The research presented has practical implications for not only for the health and well-being of the female tactical athlete, but also from an organizational standpoint. Along with providing more data on female tactical athletes, this research provides information that could guide policy change, and positively impact recruitment and retention of females in tactical professions.

Strengths and Limitations

This research has several strengths. First, the comprehensive review in Chapter 2 brings awareness to the idea that much of the information regarding exercise safety during pregnancy is hypersensitive and dated, and highlights how earlier guidelines had no scientific rigor. Second, Chapters 3 and 4 are two of the few studies that have focused on females serving in tactical professions. At the time of publication, it is also the first time birth outcomes have been quantified in US female LEOs. It is well-recognized that research in tactical professions is predominantly conducted on males (Kales et al., 2009). Third, this dissertation was unique in its research methodology. Both qualitative data and quantitative data were collected at different points in the research process. The qualitative data provided a rich, descriptive picture of the issues concerning reproductive health. The quantitative data in the female LEO study used a mix of statistical methodologies and the survey distributed was comprehensive with the questions asked. Both studies with firefighters and LEOs included diverse representation, with the sample representing the majority of U.S. states.

There are also several limitations of this research. First, chapter 2 was a comprehensive review; therefore it did not summarize all empirical evidence that fits the prenatal exercise criteria, as would be done in a systematic review. Further, in Chapters 3 and 4, both tactical athlete studies relied on recall, therefore recall bias may be a limitation. There are also inherent issues with self-report physical activity data (Sallis & Saelens, 2000), which was part of the comprehensive survey in female LEOs. In addition, both firefighter and LEO studies may have sample bias and the opinions of

firefighters and pregnancies among LEOs may not be representative of the entire population.

Conclusions

Females are often left out of tactical occupational research due to small sample sizes (Kales et al., 2009). Despite this low representation, females still account for 12,850 career firefighters (Haynes & Stein, 2017), and 96,900 law enforcement officers (Langton, 2010). Results from this dissertation, combined with further research in tactical athlete reproductive health, could help dramatically reduce adverse birth outcomes in these populations, and benefit tactical organizations as a whole. This dissertation highlights that the reproductive health of the female tactical athlete is a viable concern and highlights the need to protect the brave and essential females who protect us.

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Appendix A - NFPA 1582 (2018) Standard on Comprehensive Occupational Medical Program for Fire Departments.

Chapter 5: Essential Job Tasks

(1) While wearing personal protective ensembles and self-contained breathing apparatus (SCBA), performing firefighting tasks (e.g., hoseline operations, extensive crawling, lifting and carrying heavy objects, ventilating roofs or walls using power or hand tools, forcible entry), rescue operations, and other emergency response actions under stressful conditions including working in extremely hot or cold environments for prolonged time periods
(2) Wearing an SCBA, which includes a demand valve–type positive-pressure facepiece or HEPA filter mask, which requires the ability to tolerate increased respiratory workloads
(3) “Exposure to toxic fumes, irritants, particulates, biological (infectious) and nonbiological hazards, and heated gases, despite the use of personal protective ensembles and SCBA
(4) Depending on the local jurisdiction, climbing six or more flights of stairs while wearing a fire protective ensemble, including SCBA, weighing at least 50 lb. (22.6 kg) or more and carrying equipment/tools weighing an additional 20 to 40 lb. (9 to 18 kg)”
(5) Wearing a fire protective ensemble, including SCBA, that is encapsulating and insulated, which will result in significant fluid loss that frequently progresses to clinical dehydration and can elevate core temperature to levels exceeding 102.2°F (39°C)
(6) While wearing personal protective ensembles and SCBA, searching, finding, and rescue-dragging or carrying victims ranging from newborns to adults weighing over 200 lb. (90kg) to safety despite hazardous conditions and low visibility
(7) While wearing personal protective ensembles and SCBA, advancing water-filled hoselines up to $2\ ^{1/2}$ in. (65 mm) in diameter from fire apparatus to occupancy [approximately 150 ft. (50 m)], which can involve negotiating multiple flights of stairs, ladders, and other obstacles
(8) While wearing personal protective ensembles and SCBA, climbing ladders, operating from heights, walking or crawling in the dark along narrow and uneven surfaces that might be wet or icy, and operating in proximity to electrical power lines or other hazards
(9) Unpredictable emergency requirements for prolonged periods of extreme physical exertion without benefit of warmup, scheduled rest periods, meals, access to medication(s), or hydration
(10) Operating fire apparatus or other vehicles in an emergency mode with emergency lights and sirens

(11) Critical, time-sensitive, complex problem solving during physical exertion in stressful, hazardous environments, including hot, dark, tightly enclosed spaces, that is further aggravated by fatigue, flashing lights, sirens, and other distractions
(12) Ability to communicate (give and comprehend verbal order) while wearing personal protective ensembles and SCBA under conditions of high background noise, poor visibility, and drenching from hoselines and/or fixed protection systems (sprinklers)
(13) Functioning as an integral component of a team, where sudden incapacitation of a member can result in mission failure or in risk of injury or death to civilians or other team members
(14) Working in shifts, including during nighttime, that can extend beyond 12 hours

Appendix B - NFPA 1582 (2013) Standard on Comprehensive Occupational Medical Program for Fire Departments.

Chapter 4: Roles and Responsibilities

9.18 Pregnancy and Reproductive Health.
9.18.1 Fire Departments shall make available to all male and female fire fighters educational materials outlining the risks from firefighting on reproductive health.
9.18.2 It is recommended that members who become pregnant report the pregnancy immediately to the fire department physician. Once informed of the pregnancy the fire department physician shall inform the pregnant member of the numerous hazards to the pregnancy and the fetus encountered during routine firefighting tasks.
9.18.2.1 If the member requests an alternative duty assignment in an environment deemed safe for the pregnancy and the fetus, the physician shall provide appropriate restrictions for essential job tasks 1, 3, 5, 6, 7, and 8 that are unsafe for her or her fetus.
9.18.3 During later stages of pregnancy the member will eventually be unable to safely perform essential job tasks 1, 2, 3, 4, 5, 6, 7, 8, and 9 due to issues with diminished aerobic capacity, balance, speed, and agility. As with any other member, when performance due to medical issues is of concern, the AHJ (**authority having jurisdiction**) shall inform the fire department physician and a medical evaluation will be performed to determine the need for restricting the member from those activities that they are not able to safely perform. The NFPA has no power, nor does it undertake, to police or enforce compliance with the contents of NFPA Documents. Nor does the NFPA list, certify, test, or inspect products, designs, or installations for compliance with this document. Any certification or other statement of compliance with the requirements of this document shall not be attributable to the NFPA and is solely the responsibility of the certifier or maker of the statement.