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A selective review of prenatal exercise guidelines since the 1950s until present: written for women, health care professionals, and female athletes

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Abstract

Background—Traditional society values have long-held the notion that the pregnant woman is construed as a risk to her growing fetus and is solely responsible for controlling this risk to ensure a healthy pregnancy. It is hard to ignore the participation of pregnant women in sport and exercise today, especially in high-level sports and popular fitness programs such as CrossFit™. This challenges both traditional and modern prenatal exercise guidelines from health care professionals and governing health agencies. The guidelines and perceived limitations of prenatal exercise have drastically evolved since the 1950's.

Aim—The goal of this paper is to bring awareness to the idea that much of the information regarding exercise safety during pregnancy is hypersensitive and dated, and the earlier guidelines had no scientific rigor. Research is needed on the upper limits of exercise intensity and exercise frequency, as well as their potential risks (if any) on the woman or fetus.

Discussion—Pregnant women are physically capable of much more than what was once thought. There is still disagreement about 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.

Conclusion—Research is needed to determine the upper limits of exercise frequency and intensity for pregnant women who are already trained. Healthy women and female athletes can usually maintain their regular training regime once they become pregnant.

Keywords

pregnancy; exercise; sports; high intensity training; prenatal care

1. Introduction

The foundation of this paper is a selective 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

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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. Following this section, 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[1]. 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 scientifically 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.[2,3] 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.[4–8] 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.[8–10] 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.[10] CrossFit™ is a variation of HIFT and has recently gained great popularity.[10] 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.[11]

2. Method

2.1. Search strategy

A selective-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.

2.2. 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,[2,3] 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.

3. Review

3.1. 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.[1,12,13] 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.[1] The deeply rooted mentality of most medical professionals was anxiety-ridden surrounding the female reproductive body.[14] Medical texts, such as “Antenatal and Postnatal Care”[12] 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.[13] These exercise guidelines not only remained unquestioned for decades, but they also reinforced normative gender roles of women in the domestic field.

3.2. 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.[14] In 1968, physician Michael Bruser critiqued the way Western medicine viewed exercise during pregnancy.[1] 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.[1]

Bruser also questioned why it was so heavily stressed that fatigue and overexertion were so important to avoid during pregnancy.[1] He referred to research done by Jokl in 1964 who studied fatigue in pregnant and non-pregnant women.[15] 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.[15] Jokl concluded that there were no identified physiological limitations during exercise for pregnant women.[15]

The exception to the researcher's findings was women who were in the last few weeks of their pregnancy.[15] 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.[14]

3.3. 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.[14] The 70s also marked a time when women were recognized in the fitness industry as an important niche.[16] 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.[14]

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*".[14] 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.

3.4. 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.[17] 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.[18] 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.[19]

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.[20] 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.[21] 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.[21] 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.[21] In addition, it was thought possible that strenuous prenatal exercise could lead to premature labour and lower birth weights.[21]

Contrary to what some of the theories proposed, research conducted by Uzendoski, Latin, Berg, and Moshier hypothesized that healthy women could exercise at a moderate intensity during pregnancy without risk to themselves or the fetus.[22] 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. also noted that fitness levels had the potential to be improved or maintained during pregnancy.[22]

3.5. 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.[14] 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.[14] 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.[23] These gaps and limitations in the research methodology still exist today.

Bung, Huch, and Huch 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.[24] 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.[24] The athlete they monitored was a professional runner who trained throughout her pregnancy as many as six times per week.[24] Her workouts included sprint work, submaximal testing, strength training, and endurance training.[24] The result? She had an uncomplicated, healthy birth.[24] The subject resumed her training weeks after delivery, and was reported to have set records over various short-distance runs in the following years.[24] 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.[24] It quickly recovered to 120 bpm within 3 minutes, however, the athlete experienced dizziness and symptoms of pre-collapse.[24] 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.

3.6. 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.[25,26] This inconclusiveness has led to many different opinions and viewpoints from different types of professionals including general practitioners, sports medicine professionals, and obstetricians.[17] 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.[17]

The American College of Obstetricians and Gynecologists (ACOG) recommended that healthy pregnant women follow the guidelines put forth by the American College of Sports Medicine-Centers for Disease Control and Prevention.[11]

These included thirty minutes or more of moderate physical activity per day in the majority or preferably every day of the week.[11] Sports Medicine Australia (SMA) 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.[6] Brown found that physically active women during pregnancy had more energy, gained less subcutaneous fat, and delivered fewer large-for-gestational-age (LGA) infants.[5] 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.[5] In the postpartum period, research has shown that women experienced a lactation-induced loss of bone density.[5] 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.[5]

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, the SMA stated that this was not likely due to effective heat dissipation mechanisms in humans.[6] The SMA 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.[6] Contradictory to this literature was a meta-analyses done by Bell[25], 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.

3.7. 2010-present day

The most current recommendations obtained from the Society of Obstetricians and Gynecologists of Canada (SOGC) support exercise during pregnancy, and furthermore,

emphasize risks of not exercising.[27] 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.[27] There is legitimate fear of the uprising obesity epidemic within North America, and pregnant women are no exception to this.[17] This may be a reason why more women are expressing an interest in pushing their physical limits throughout pregnancy.[17] 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.[27] 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[28] 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[28]. 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.[29] 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.[29] In addition, strength training and muscle conditioning should be incorporated into new guidelines.[8] It is also recommended that guidelines should increase the amount of vigorous intensity exercise and weekly physical activity expenditure.[8] 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.[29]

3.8. Prenatal exercise considerations for female athletes

In 2011 the International Olympic Committee Medical Commission[30] 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, the SMA has found no reports of fetal death or injury related to contact or trauma during sports.[6] 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.[6] The SMA also stated that while studies are limited, trained athletes may exercise at a higher level than what is recommended by the ACOG.[6]

One of the few researchers in the field of high-intensity training during pregnancy is Kardel.[31] Her research has indicated that female athletes can safely train at high intensities throughout uncomplicated pregnancies.[31] 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.[31] 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.[32]

Leet noted that female endurance athletes who trained vigorously tended to have smaller infants (200–400g lighter on average) compared to control groups.[33] 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.[34]

Kardel 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.[31] 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.[31] The study provided excellent support for pregnant women who would like to continue training at high intensity or volume.[31] 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.

4. 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.[35]

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.[36] 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.[35]

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.[37] 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.[36]

5. Final prenatal exercise recommendations

Pregnancy is often a time where women become highly motivated to implement positive behavioral changes such as exercise.[29] 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.[29]

Current exercise recommendations are vague and general, but this is mostly due to individual differences in fitness level, health status, and pregnancy status.[4] 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 take into account 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.[4]

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.[4] Again, it is not necessary for healthy women to change their regular training regime once they become pregnant, unless they wish to.[4] 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.[26] 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.[11,12,26]

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.[38] Since these methods of training have been shown to significantly improve maximal aerobic capacity (V02max)[10], 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.[39] In fact, the potential benefits of strength training during pregnancy include overall body strength, improved core strengthening and improved posture.[39] Strength training during pregnancy may also positively address labour and birth discomforts.[39] 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.[40]

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.[13] 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.[13] 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 suggests that we remain open-minded on this issue until sufficient evidence becomes available for which to base exercise intensity recommendations.[25]

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.[14] 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.[14] 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.

6. Conclusion

It is generally known and accepted that exercise during pregnancy can provide positive physical and physiological effects.[32] 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.[4]

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.[14] 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.[14] 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.

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References

1. Bruser M. Sporting activities during pregnancy. Obstet Gynecol. 1968; 32(5):721. [PubMed: 5742486]
2. Court M. Pregnant athletes who stay in the game. Sports Illustrated. 2002 Jul 20.
3. Rose A. Pregnancy & CrossFit. Sweat RX. 2013 May 29.
4. Hammer RL, Perkins J, Parr R. Exercise during the childbearing year. J Perinat Educ. 2000; 9(1):1–14.
5. Brown LE. Resistance training during pregnancy. Strength Cond J. 2002; 24(2):53.
6. Sports Medicine Australia. Statement: The benefits and risks of exercise during pregnancy. J Sci Med Sports. 2002; 5(1):11–19.
7. Martens DL, Hernandez B, Strickland G, Boatwright D. Pregnancy and exercise: Physiological changes and effects on the mother and fetus. Strength Cond J. 2006; 28(1):78.
8. Zavorsky GS, Longo LD. Exercise guidelines in pregnancy. Sports Med. 2011; 41(5):345–360. [PubMed: 21510713]
9. Shiraev T, Barclay G. Evidence based exercise – clinical benefits of high intensity interval training. Aust Fam Physician. 2012; 2012; 41(12):960–962. [PubMed: 23210120]
10. Heinrich KM, Becker C, Carlisle T, Gilmore K, Hauser J, Frye J, Harms CA. High-intensity functional training improves functional movement and body composition among cancer survivors: a pilot study. Eur J Cancer Care. in press.
11. The American College of Obstetricians and Gynecologists. Committee on Obstetric Practice. Exercise during pregnancy and the postpartum period. Am Coll Obstet Gynecol. 2002; 99:171–173.
12. Browne FJ. Antenatal and postnatal care. Lancet North Am Ed. 1939; 234(6066):1192.
13. Vertinsky P. Exercise, physical capability, and the eternally wounded woman in late nineteenth century North America. J Sport Hist. 1987; 14(1):7. [PubMed: 11617514]
14. Jette S. Exercising caution: the production of medical knowledge about physical exertion during pregnancy. Can Bull Med Hist. 2011; 28(2):293. [PubMed: 22164598]
15. Jokl, E. Medical sociology and cultural anthropology of sport and physical education. Springfield, Ill: Thomas; 1964. p. 1907-97.
16. Bordo, S. Unbearable weight: Feminism, western culture & the body: A review. Berkeley, CA: University of California Press; 1993. p. 1947
17. Jette, S. Governing risk, exercising caution: Western medical knowledge, physical activity and pregnancy. Vancouver, Canada: University of British Columbia; 2009.
18. Mittelmark, AR., Wiswell, RA., Drinkwater, B. Exercise in pregnancy. 2. Baltimore-London: Williams & Wilkins; 1991. p. 313-19.
19. Mullinax KM, Dale E. Some considerations of exercise during pregnancy. Clin J Sport Med. 1986; 1986; 5:563.
20. Snyder DK, Carruth BR. Current controversies: Exercising during pregnancy. J Adolesc Health. 1984; 5(1):34–36.
21. Clapp J. A clinical approach to exercise during pregnancy. Clin Sports Med. 1994; 13:443–458. [PubMed: 8013043]
22. Uzendoski AM, Latin RW, Berg KE, Moshier S. Short review: Maternal and fetal responses to prenatal exercise. J Strength Cond Res. 1989; 3(4):93–100.
23. Davies G, Wolfe L, Mottola M, MacKinnon C. Joint SOGC/CSEP clinical practice guideline: Exercise in pregnancy and the postpartum period. Can J Appl Physiol. 2003; 28(3):329–341.

24. Bung P, Huch R, Huch A. Maternal and fetal heart rate patterns: A pregnant athlete during training and laboratory exercise tests; a case report. Eur J Obstet Gyn R B. 1991; 39(1):59–62.
25. Bell R. The effects of vigorous exercise during pregnancy on birth weight. J Sci Med Sport. 2002; 5(1):32–36. [PubMed: 12054384]
26. Wolfe LA, Davies GAL. Canadian guidelines for exercise in pregnancy. Clin Obstet Gynecol. 2003; 46(2):488–495. [PubMed: 12808398]
27. [Accessed April 20, 2013] The Society of Obstetricians and Gynecologists of Canada. Healthy eating, exercise and weight gain - before and during pregnancy. Available at: http://sogc.org/publications/healthy-eating-exercise-and-weight-gain-beforeand-duringpregnancy/
28. Bauman A, Finch C. Awareness of and attitudes to the new physical activity recommendations — perceptions of attenders of the 5th IOC world congress on sport science. J Sci Med Sport. 2000; 3(4):493–501. [PubMed: 11235012]
29. Nascimento S, Nascimento F, Surita J. Physical exercise during pregnancy. Curr Opin Obstet Gynecol. 2012; 24(6):7–394.
30. [Accessed April 27, 2015] International Olympic Committee Medical Commission Statement 2011. IOC Medical Commission statement on female reproductive system in sport. Available at: http://www.olympic.org/information-about-the-ioc-medical-commission?tab=statements
31. Kardel KR. Effects of intense training during and after pregnancy in top-level athletes. Scand J Med Sci Sport. 2005; 15(2):79–86.
32. Clapp J, Little KD. The interaction between regular exercise and selected aspects of women's health. Am J Obstet Gynecol. 1995; 173(1):2–9. [PubMed: 7631681]
33. Leet T. Effect of exercise on birthweight. Clin Obstet Gynecol. 2003; 46(2):423–431. [PubMed: 12808392]
34. Juhl M, Olsen J, Andersen PK, Nøhr EA, Andersen AN. Physical exercise during pregnancy and fetal growth measures: A study within the Danish national birth cohort. Am J Obstet Gynecol. 2010; 2010; 202(1):63. [PubMed: 19800601]
35. Lotgering FK, Gilbert RD, Longo LD. The interactions of exercise and pregnancy: A review. Am J Obstet Gynecol. 1984; 149(5):560. [PubMed: 6430089]
36. Wallace AM, Engstrom JL. The effects of aerobic exercise on the pregnant woman, fetus, and pregnancy outcome. A review. J Nurse Midwifery. 1987; 32(5):277–290. [PubMed: 3316535]
37. Lambert H, Gordon EJ, Bogdan-Lovis E. Introduction: Gift horse or trojan horse? Social science perspectives on evidence-based health. Soc Sci Med. 2006; 62(11):2613–2620. [PubMed: 16386345]
38. Kardel KR, Johansen B, Voldner N, Iverson PO, Henriksen T. Association between aerobic fitness in late pregnancy and duration of labor in nulliparous women. Acta Obstet Gynecol Scand. 2009; 88(8):948–952. [PubMed: 19562561]
39. Pennick VE, Young G. Interventions for preventing and treating pelvic and back pain in pregnancy. Cochrane Database Syst Rev. 2007; 2:CD001139.
40. Boyle R, Hay-Smith EJ, Cody JD, Mørkved S. Pelvic floor muscle training for prevention and treatment of urinary and faecal incontinence in antenatal and postnatal women. Cochrane Database Syst Rev. 2012; 10:CD007471. [PubMed: 23076935]