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A literary review on musculoskeletal pregnancy disorders experienced during the gestation period with evidence based reasons for exercise during this time and an introduction to the Pilates exercise method.

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Introduction

Sex-specific care of musculoskeletal impairments is an increasingly important topic in women’s health (Borg-Stein 2005). It is estimated that almost all women experience a certain degree of musculoskeletal discomfort during pregnancy and 25% have at least some momentarily disabling symptoms (Borg-Stein 2005).

The purpose of this review is to provide a guide focusing on the musculoskeletal disorders which affect women during pregnancy.

Pregnancy is associated with profound anatomical and physiological changes (Artal 2010). The changes in a woman’s body throughout pregnancy include hormonal surges, biochemical changes and altered biomechanics that result in an array of symptoms affecting the whole body (Ponnapula 2010). Weight gain, change in the centre of gravity, increased joint laxity, alterations in the skeletal alignment, and altered postural balance can also occur (Butler 2006). This review will place special attention on the differentiation of the musculoskeletal complaints during the three trimesters of the gestation period.

Evidence will be provided for the benefits of exercising during pregnancy. It is currently recognized that habits adopted during pregnancy could affect a woman's health for the rest of her life. Regular exercise is promoted for its overall health benefits and there are very few instances that should prevent healthy, pregnant women from following the same recommendations (Artal 2002).

Patients frequently seek information about complimentary therapies for wellness. This is often based on popular interest, as well as recognition of the incomplete efficacy of current therapies for treatment of chronic pain and other illnesses. One exercise approach that has become a popular trend in rehabilitation and fitness is Pilates (Segal 2004). This review will mention Pilates as an option for exercising during pregnancy. Pilates focuses on strength, flexibility, balance and inner awareness as a form of strength and flexibility training that can be done by someone at any level of fitness. It promotes a feeling of physical and mental well-being and also develops inner physical awareness (Sekendiz 2007). Pregnant women who practice Pilates exercise can develop body alignment, improve concentration and develop body shape and tone during pregnancy (Pilates 2000).
This review aims to help physiotherapists gain a general overview of the physical changes that can be expected in a pregnant body in order to reassure and anticipate problems for a future mother/patient during treatment.

In relevance to physiotherapy Pilates may not be seen as a mainstream treatment option but it is showing more evidence based relevance (Sakash 2005).

As physiotherapists it may be likely to come across pregnant women suffering from the complaints mentioned in the above introduction. It is therefore of interest to be able to offer the best treatment methods available this includes: Pilates which is proving to be evidence based and increasingly popular in this field. Pilates exercises can be introduced into a physiotherapy program as a procedure incorporating both the traditional application of physiotherapy principles and goals, affecting strength, flexibility and pain, while enhancing it with a re-education approach using somatic principles and theory (Bryan 2003).

Methods and Materials

An electronic literature search was conducted; research began on October 18th and ended on November 17th 2010. Databases searched were PeDro, Cochrane, Pubmed, Science Direct and Google scholar. Literature had to be in English; it was agreed that all relevant scientific articles of good quality are translated to English. English also allowed both reviewers to take part in the grading and discussion of all articles, which had to be full text to be considered. Randomized controlled trials, Systematic Reviews, Cohort Studies, Case Series, follow-up studies, literary reviews, books, analysis’ and guidelines were researched.

All material was searched and graded by both reviewers separately and a mean score of the two assessors was taken as the final grade as Higgins et al. (2009) suggest. Randomized Clinical Trials (RCTs) were scored using the PEDro Scale (Physiotherapy evidence database 2010). All other articles were scored using the Oxford Centre for Evidence-based Medicine – Levels of evidence (Philips 2009; see Appendix 1). More weight was given to high scoring RCTs, graded by the PEDro, than articles scored by the Levels of Evidence Scale.

Since literature was scarce, almost all of the located references in literature were studied in
detail and judged as to quality and relevance to answer the research question. Findings relevant to this investigation were combined to yield qualitative results.

Results

Once research was completed 44 articles were read and graded by both reviewers. All grades and article types can be read in the Results table below.

Six of these articles were considered irrelevant due to lack of validity and physiotherapeutic relevance towards this study (Bamigboye 2006, Pernoll 1975, Yeo 2006, Robinson 2010), or due to their focus being solely on postnatal issues (Wagg 2007, Pereira 2007).

All RCTs relevant to this study received a sufficient grade and were therefore considered in this literary review.

Articles have been divided according to the topic they deal with.

Musculoskeletal problems during pregnancy:

The basic musculoskeletal and orthopaedic considerations during pregnancy were illustrated in four articles (Monaco 1996, Heckman 1994, Borg-Stein 2005, Paul 1994). They all illustrate the most relevant and common musculoskeletal disorders experienced by pregnant women including lower back pain (LBP), Carpal Tunnel Syndrome, DeQuervain’s Tenosynovitis, leg cramps, hip and pubic symphysis problems.

Noren et al. (2002), Wang et al. (2004) and Ostgaard et al. (1991) focus specifically on back pain and the prevalence of back pain throughout the pregnancy. These were measured using a pain questionnaire, an anonymous survey and pain drawings. Moore et al. (1990), Panjabi (1992), Butler et al. (2006) and McCrory et al. (2010) are concerned with postural changes and stability problems. Moore et al. (1990) measured the degree of spine curvature, Panjabi (1992) discussed the stabilizing system of the spine, Butler et al. (2006) collected static postural balance measures and lastly, McCrory et al. (1990) discussed alterations to dynamic spinal stability in response to translation.
Ponnapola et al. (2010) is the sole article regarding lower extremity changes. Participants were interviewed regarding dermatologic, vascular, neurologic, and musculoskeletal changes. Wesnes et al (2009) focuses on urinary incontinence experienced postpartum. Questionnaires showed that urinary incontinence is most likely to be present postpartum if previously experienced during pregnancy.

Steer (2005) and Morgen (1991) gave academic and expert background into the physiology and general minor problems of pregnancy.

**Benefits and opinions on exercise during pregnancy:**

Mudd et al. (2009), Cioffi et al. (2010) and Clarke et al. (2004) deal with women´s levels of exercise during pregnancy and the need to inform pregnant women about the benefits of moderate exercise. All three articles provide evidence showing that pregnant women feel that only moderate physical activity is safe during pregnancy.

Artal et al. (2003), Brown (2002), Wadswarth (2007) and Pivarnick et al. (2006) have researched and support the benefits of exercising during a normal pregnancy period. These include decreasing the risk of preeclampsia, weight gain, foetal distress and increasing fitness levels facilitating labor. Artal et al. (2003) can be considered of high evidence as it is the Guideline of the American College of Obstetricians and Gynaecologists for exercise during pregnancy and the postpartum period.

Dumas et al. (1995) evaluated the effect of fitness classes for pregnant women on posture and back pain and does not see exercise as an aid to improve posture during the pregnancy.

**Specific Interventions:**

Nilsson-Wikmar et al. (2005) focuses on three different physical therapy treatments for pelvic girdle pain: an information group, home exercise group and clinic exercise group. Pain intensity was measured on a visual analogue scale and pain drawings concerning localisation. All three groups reported improved pelvic girdle pain.
Pennick et al. (2008) studies pregnancy specific exercises to relieve back or pelvic pain compared to prenatal care alone using only RCTs. They concluded that adding pregnancy specific exercises, physiotherapy or acupuncture to usual prenatal care appears to relieve back or pelvic pain.

Ostgaard et al. (1994) analyzed an education and training program concerning back and pelvic problems among pregnant women and supports that good physical fitness reduces back pain, specifically an individually designed program compared to a group program.

Richardson et al. (1995) studied that the retraining of the deep trunk muscles, the lumbar multifidus and the transversus abdominis provides stability for the spine and back pain relief.

One article showed evidence for pelvic floor muscle training (PFMT) in women having their first babies preventing urinary incontinence in late pregnancy and postpartum (Hay-Smith 2009). The article compared PFMT to usual antenatal and postnatal care on incontinence. The more intensive the program the greater the treatment effect.

**Pilates:**

Muscolino et al. (2004) discusses the Pilates method of body conditioning and discusses the effects the powerhouse has in three major ways, on pelvic posture, lengthening of the spine and structural integrity or tone of the abdominopelvic cavity.

Bryan et al. (2003) gives an expert opinion on the Pilates method being incorporated into a patient´s treatment plan to improve strength, range of motion, coordination, balance, muscular symmetry, flexibility and proprioception.

Bernardo et al. (2007), Sekendiz et al. (2007), Emery et al. (2010) study the effectiveness of Pilates in healthy adults to improve flexibility, transversus abdominis activation, endurance, lumbar pelvic stability and muscular strength. Sekendz et al. (2007) and Emery et al. (2010) find evidence for this by assessing the outcomes with specific tests, for example the crunch test.

Emery et al. (2010) interprets the Pilates training program as effective for upper spine posture and the use of Pilates in the prevention of neck and shoulder disorders.
Segal et al. (2004) and Kloubec (2010) believe that Pilates improves abdominal endurance, pelvic control and all flexibility variables. Yet the effects on posture and balance are still difficult to establish.

In Culligan et al. (2010) results indicate that Pilates exercise programs can be used to treat and prevent pelvic floor dysfunction emphasizing its use during the peripartum period. The study compares the Pilates exercise program and the PFMT program. Strength was measured via perineometry concluding that there were no group differences.

<table>
<thead>
<tr>
<th>First Author and date of the article</th>
<th>Type of Article</th>
<th>Final Grade</th>
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<tbody>
<tr>
<td>Artal R, et al. 2003</td>
<td>Analysis based on systematic reviews and multi way sensitivity analysis</td>
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<td>Qualitative study</td>
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<td>Richardson CA, et al. 1995</td>
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<td>Wesnes SL, et al. 2009</td>
<td>Cohort study</td>
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<tr>
<td>Yeo S. 2006</td>
<td>Randomized comparative trial</td>
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Outcomes of the articles

There are several normal musculoskeletal changes that occur during pregnancy as a result of mechanical influences of the gravid uterus and hormonal factors (Monaco 1996).

One obvious postural change throughout pregnancy is lordosis. Progressive lordosis occurs during pregnancy to compensate for the growing anterior position of the uterus, thereby maintaining the women’s centre of gravity over the lower extremities (Monaco 1996). Moore et al. (1990) studied the behaviour of the lumbar spine in the nine pregnancy months concluding that after an initial decrease in the lumbar curvature during the first trimester women experience an increase in lumbar curvature in the second trimester and postpartum. They also concluded that the greater the lumbar lordosis the greater the lower back pain, the flatter the back the less pain was experienced. Moore et al. (1990) and Borg-Stein et al. (2005) both agree that the increase in the lumbar curvature increases the mechanical strain on the lower back, sacroiliac joint and pelvis.

Ostgaard et al. (1991) and Wang et al. (2004) both agree that significant predictors for the presence of LBP throughout the pregnancy are LBP during menstruation, previous history of back pain and previous LBP during previous pregnancies. They contrast however concerning the onset of LBP. It is believed that the onset of LBP in pregnant women is very subjective and that it can start at any point during pregnancy. Ostgaard et al. (1991)’s results conclude that it is between the fifth and seventh month that LBP is most commonly experienced while Wang et al. (2004) believes the prevalence of LBP during pregnancy is towards women in their third trimester. Wang et al. (2004) further stipulates that the duration of LBP ranges from one day to the entire pregnancy.

Ostgaard et al. (1991) contrasts Borg-Stein et al. (2005) in believing that younger patients have a greater risk of back pain while the latter believes that back pain has been found to increase with advancing maternal age. The latter is also supported by Paul et al. (1994). According to Borg-Stein et al. (2005), Paul et al. (1994) and Pennick et al. (2008) LBP causes include: mechanical strain, pelvic and spine ligamentous laxity due to relaxin, sacroiliac pain, vascular compression, spondylolisthesis, discogenic pain, hip pathology, muscular fatigues, referred pain and pull or pressure on structures of the musculoskeletal system. Panjabi (1992) adds that spinal instability is considered to be one of the most important causes of LBP. He
states that the stabilizing system of the spine has three subsystems: passive musculoskeletal subsystem, active and neural feedback. These three subsystems are highly coordinated and optimized. Compensation for dysfunction of the system, within certain limits, may be provided by the system. If dysfunction is beyond limits then acute or chronic problems may rise one of which is LBP.

Paul et al. (1994) supports Noren et al. (2002) on types of back pain experienced by pregnant women: back pain is not a single type but varies during pregnancy and it should be separated into at least lumbar back pain and posterior pelvic pain. Pain is described as either a pulling sensation, a shooting sensation, or an aching sensation (Wang 2004). The aggravating factors are also very subjective as Paul et al. (1994) describes that some positions such as: sitting, lying or standing aggravate back pain in some women while they relieve pain in others.

Despite the high prevalence of back pain, evaluated and documented treatment programs are scarce (Nilsoon-Wikmar 2005). Most symptoms of LBP can be reduced by limiting physical activity. Pain can be partially relieved if pelvis is kept in flexed position thereby improving spinal alignment. As soon as pain decreases it is advisable to begin an exercise program to increase the tone of the back and abdominal muscles (Heckman 1994). Richardson et al. (1995) proved that the transversus abdominis and the lumbar multifidus are the major stabilizers of the spine and that training these particular muscles will provide lumbar segmental stabilization. The patients should hold a low level tonic contraction. The best position for the training is the four point kneeling position or prone lying as these positions seem to be inhibitory for the rectus abdomins. It is best to repeat the contractions as many times as possible throughout the day. The isolated action of these local muscles is taught by asking the patient to gently draw in the abdominal wall especially in the lower abdominal area. Useful cues are the instructions “draw your lower abdomen up and in” or “pull your navel up towards your spine”. The contraction of the transversus abdominis can be palpated just medial to the anterior superior iliac spines. Rib cage, shoulders and pelvis should remain in a constant position. Patient must breath normally. An arbitrary target is the ability to perform 10 by 10 second holds in succession without fatiguing. Pain relief is usually concomitant with the patient mastering this task. Dumas et al (1995) emphasises posture training as the way to reduce or prevent back pain during pregnancy.

According to Monaco (1996) posterior pelvic pain is located on the posterior part of the pelvis, distal and lateral to the lumbosacral junction. This pain may radiate to the posterior
part of the thigh or to the knee (Heckman 1994). Noren et al. (2002), Paul et al. (1994) and Steer (2005) all agree that pain may derive from strained ligaments and joint capsules because of muscular dysfunction reducing the dynamic stability of the pelvic joints.

Heckman et al. (1994) states that the pelvic joints are relaxed because of the hormone relaxin, which is elevated in first trimester, reduced in the second trimester and stable for the rest of pregnancy. Relaxin lowers strength of the connective tissue permitting its expansion and lessening its rigidity (Paul 1994). This relaxation of pelvic joints also shows symptoms of spontaneous pain and tenderness of the sacro-iliac joints. Pain is elicited by direct or indirect pressure. Paul et al. (1994)’s results state that for the majority of women with sacroiliac dysfunction pain started in the second trimester. On extremely rare occasions hernations of the sacro-iliac joints, ruptures of the symphysis or severe pelvic dislocations occur (Heckman 1994).

Borg-Stein et al. (2005) and Heckman et al. (1994) warn that intraarticular hip pathology can refer to the pelvis and back, and can be misdiagnosed as pelvic instability. In any pregnant woman presenting with an antalgic gait either transient osteoporosis of the hip, or osteonecrosis of the femoral head must be considered even though they are relatively rare conditions. Transient osteoporosis of the hip is a rare condition which may occur in the third trimester of pregnancy and is to be treated with protective weight bearing.

Pennick et al. (2008) found that specifically tailored strengthening exercise, sitting pelvic tilt exercise programs and water gymnastics all reported beneficial effects for back or pelvic pain during pregnancy. It was found that the intensity of back pain in pregnant women decreased significantly with strengthening exercises and sitting pelvic tilt exercises. Stabilizing exercises for pelvic girdle pain reported less intense morning pain and less intense evening pain. Ostgaard et al (1994) partially agrees with Pennick concluding that back pain problems can be reduced by individual education and training programs that start early in the pregnancy, while women with posterior pelvic pain do not benefit from being physically fit. Nilsson-Wikmar et al. (2005) followed Panjabi’s theory hypothesizing that it is important to activate and stabilize the muscles around the pelvis in order to achieve pain reduction, concluding that performing exercises does have an effect on pain reduction.
Other articles such as Wesnes et al. (2009) and Steer (2005) focus or mention another common problem during pregnancy: urinary incontinence (Wesnes 2009). Urinary incontinence starting before or during pregnancy is likely to be associated with incontinence after pregnancy. Steer (2005) states that both stress and urge incontinence increase sharply in incidence during pregnancy, attributable partly to the fetus “bouncing” on the bladder and partly due to the increased laxity of pelvic supports induced by the hormonal changes.

Pelvic floor muscle training (PFMT) is commonly recommended during pregnancy and postnatally for prevention and treatment of incontinence (Hay-Smith 2009, Borg-Stein 2005). A recent study demonstrated that participants in a 12-week intensive PFMT program during pregnancy had significantly less urinary incontinence during pregnancy and 3 months after delivery. Sessions included exercise, postural training, and ergonomics once weekly over a 5-week period (Borg-stein 2005). The use of PFMT in the treatment of urinary incontinence is based on two functions of the pelvic floor muscles: support of the pelvic organs and a contribution to the sphincteric closure mechanisms of the urethra. During pregnancy, training the pelvic floor muscles might help to counteract the increased intra-abdominal pressure caused by the growing fetus, the hormonally mediated reduction in the urethral pressure and the increased laxity of fascia and ligaments in the pelvic area. A PFTM program may be prescribed for women to: increase strength, endurance, coordinate muscle activity or a combination of these. PFMT was defined as a program of repeated voluntary pelvic floor muscle contractions taught and supervised by a healthcare professional (Hay-Smith 2009).

Separation or diastasis of the rectus abdominus muscle from the linea alba, the midline anchor point of the stomach muscles, can occur in pregnancy. Rectus abdomins muscles originate from the rib cage and diaphragm, and attach on each pubic bone. Spontaneous reduction usually occurs but in rare cases separation may continue chronically in some women. Long-term sequel may include abdominal pain, LBP and pelvic dysfunction (Pivarnik 2006).

The most obvious change in a pregnant body is the weight gain. Butler et al. (2006) studied that there is approximately a 12-16kg (16-23%) increase in body weight. Weight gain is minor during the first trimester and increases linearly during the second and third trimesters. Weight gain peaks in the second trimester.
Gradual weight gain in the first trimester may explain the maintenance of postural stability while increased weight gain in the second and third trimester may account for decrease in postural stability. McCrory et al. (2010) conclude that most falls occur during the second trimester and this is also related to the substantial weight gain. His team discovered that there is a decreased rotational motion of the torso in studies of pregnant women during gait and that this change in mechanics may be related to the higher incidence of falls in pregnant women.

These findings by both studies suggest a need for postural training during pregnancy. Dynamic and static balance training exercise, which might include strength training, have been shown to improve postural stability (Butler 2009).

Linked to balance problems Ponnapula et al. (2010) studied the lower extremity changes experienced during pregnancy. More than 50% of pregnant women report swelling of the foot, ankle and leg, unsteady gait, increased foot width and hip pain. The onset of lower limb pain usually occurs in the second or third trimester of pregnancy (Borg-stein 2005).

Biomechanical changes compensate for the increase in weight and the ventrally driven center of gravity. 64% of women reported hip pain, as lower extremity joints have to adapt to absorb extra force while 22% of women experienced knee pain. Joint instability and patellofemoral dysfunction exacerbate strain on the hip and knee (Ponnapula 2010).

In Ponnapula et al. (2010) 43% of postpartum women reported tingling, burning, or numbness sensations in their feet and legs during pregnancy. 88% of the patients with lower extremity neurological symptoms also reported ankle swelling. Increased fluid retention can predispose to tenosynovial or nerve entrapment: compression and traction are the most common mechanisms of peripheral nerve entrapment in pregnancy (Borg-Stein 2005). These neurological symptoms may ensue from fluid retention exerting pressure on the posterior tibial nerve, indicating a possible tarsal tunnel syndrome. Steers (2005) recommends the use of compression stockings and leg elevation to treat swollen ankles.

In the upper extremities the median nerve can be entrapped at the wrist in the enclosed space formed by the carpal bones and the overlying transverse carpal ligament causing Carpal Tunnel Syndrome (CTS). CTS typically presents with pain and paresthesias in the first three digits of the hand, often bilaterally, and is most frequently diagnosed during the third
trimester. Splinting of the wrist in a neutral position is recommended (Borg-Stein 2005). This is the most common compression neuropathy, affecting up to 35% of pregnant women, most commonly in the third trimester (Ponnapula 2010). It virtually always resolves completely and quite dramatically soon after delivery (Heckman 1994). Activities that reduce peripheral edema via hydrostatic pressure may reduce CTS risk: exercise in normal temperature pool water is advised (Pivarnik 2006).

Heckman et al. (1994) and Borg-Stein et al. (2005) both describe another common ‘hand pain’ experienced during pregnancy: De Quervains tenosynovitis. This is an inflammatory condition of the abductor pollicis longus and extensor pollicis brevis tendons of the first dorsal compartment of the wrist near the styloid process of radius. Symptoms are usually self-limited and respond to conservative management, including thumb spica splints, icing, and activity modification.

Leg cramps are most common in the second half of the pregnancy. Leg cramps consist of painful, titanic contractions that occur primarily in the calf muscles that last for a few seconds or several minutes. They usually occur while sleeping (Heckman 1994). The increased functional demand on the ankle plantar flexors during pregnancy exacerbates these symptoms (Ponnapula 2010). The etiology is unknown, but it is possibly due to calcium or magnesium deficiency (Heckman 1994). Treatment recommendations include: stretching the affected muscle, taking a brief stroll or exercising the legs while lying down and adding calcium gluconate supplements to the diet (Steer 2005, Ponnapula 2010).

**Benefits of exercise:**

Many pregnant women do not exercise even though exercise in pregnancy is correlated with a decrease in many common problems of pregnancy (Wadsworth 2007). Clarke et al. (2004) confirm that levels of maternal exercise may decline during pregnancy both as a result of the physical changes of pregnancy and from a combination of social and physiological factors. Present health education may be failing to correct inaccurate perceptions of the risks associated with the physical exercise in pregnancy. Mudd et al. (2009) and Pivarnick et al. (2006) report that barriers to physical activity during pregnancy include fatigue, lack of time,
nausea, physical discomfort, such as sore knees, breast tenderness and back ache. Studies also indicate that some women fear that exercise may hurt their baby.

Physical activity is defined as bodily movement that is produced by the contraction of skeletal muscle and that substantially increases energy expenditure (Cioffi 2006).

According to Artal et al. (2003) regular physical activity is promoted for overall health benefits. Habits adopted during pregnancy could affect a woman’s health for the rest of her life. Clarke et al. (2004) and Cioffi et al. (2010) agree and link participation in physical activity with the promotion of good maternal posture, the prevention of excess maternal weight gain, stress, and a reduction in lower back pain.

Both Clarke et al. (2004) and Cioffi et al. (2010) further suggest that higher amounts of exercise have been associated with a reduced incidence of caesarean section and shorter hospitalization. Amongst vaginal births fitness may also be associated with a shorter duration of active labor. Wadsworth (2007) includes the benefits of moderate exercise on caesarean delivery, stating that it may help reduce the risks that result from a cesarean delivery such as uterine infection, surgical wound complications, cardiopulmonary and thromboembolic conditions. Overall, physical activity was considered to contribute to a healthy pregnancy; it also prepared women for the hard work of labor, recovery from childbirth and ongoing work that a baby would bring (Cioffi 2010).

Pivarnick et al. (2006) looks at exercises effects on chronic disease risks and finds that physical activity may reduce the risk of preeclampsia through several relevant physiological and metabolic pathways. Everson et al. (2010) supports that the risk of preeclampsia may be reduced, and includes reduced risk in gestational diabetes, although evidence was not conclusive.

Exercise during pregnancy is beneficial to fetuses as well. In most cases, there appears to be no harm to the fetus with moderate exercise (Wadsworth 2007). Mudd (2009) elaborates that research indicates that participation in vigorous activity during pregnancy does not adversely affect birth weight and may reduce the risk of preterm delivery. According to Pivarnick et al. (2006) researchers have begun to consider the role of physical activity in a more traditional chronic disease prevention light, for both mother and offspring.
Pilates:

Pilates is a comprehensive body conditioning method that is directed towards the development of both the body and the mind of the individual (Muscolino 2004, Culligan 2010).

Remarkably, very little research studies have been published in which Pilates has been rigorously and empirically tested and evaluated, in any population. This lack of published research is disappointing considering the popularity of Pilates (Bernardo 2007). In spite of this, the articles researched for this review are recent articles dating to the past few years demonstrating that research is being done to provide evidence of the benefits of this new exercise technique.

The popular exercise program known as the “Pilates method” (named after the founder, Joseph Pilates, who developed this method in the 1920s) focuses on exercises believed to produce flexibility and strength for the entire body. Pilates incorporates six key principles; centering: referring to the concept that all movements of the human body emanate from the centre or core of the body (or what Joseph Pilates called the powerhouse), concentration: so that the mind guides the body, control: over the movements, precision: over the exercise quality, breathing: to maintain rhythm and obtain optimal blood circulation and lastly flow: regarding grace of exercises (Muscolino 2004).

Pilates consists of a series of exercises with minimum movement, low repetitions, and a dynamic pace, exercise repetitions rarely exceed ten, with resistance usually coming in the form of body weight and specially designed springs (Bryan 2003, Culligan 2010). It is a physical training approach that also focuses on posture, flexibility, range of motion, strength, coordination and proprioception (Bryan 2003, Emery 2010). For these reasons Bryan et al. (2003) believes Pilates exercises can be introduced into a physiotherapy program. Physiotherapy procedures for which Pilates exercise is used include therapeutic exercise, neuromuscular reeducation and functional activities.

Pilates exercises are designed to put participants in positions that minimize unnecessary muscle recruitment, which could potentially lead to early fatigue, decreased stability, and impaired recovery. Pilates instructors use verbal cues to teach these techniques which focus specifically on “core” abdominal, lower back and medial thigh muscles (Bryan 2003, Culligan 2010). Core strengthening is, in essence, a description of the muscular control
required around the lumbar spine to maintain functional stability (Kloubec 2010). With attention to core or spinal stabilization, an introduction to Pilates work starts with visualizing a corset wrapped around your midsection. This corset is made up of core muscles: the transversus abdominus, the internal and external obliques, the pelvic floor and the multifidi. A strong core allows for more efficient movement of the extremities (Bryan 2003). Muscolino et al. (2004) refers to the core as the ‘powerhouse’, seeing it more broadly and defining it as ranging from the pelvic floor muscles inferiorly to the ribcage superiorly, which is where the power and strength of the body is derived and from where all peripheral muscle actions are carried out. They also include that Pilates has three major effects on the powerhouse, firstly it affects the posture of the pelvis, which results in postural changes to the lumbar spine. Secondly, it works directly upon the musculoskeletal structure of the spine (lumbar in particular) by strengthening, stretching and lengthening the spine. Thirdly, Pilates affects the structural integrity or tone of the abdominopelvic cavity as a whole.

It is often said that the pelvis is the keystone of the skeletal structure (Muscolino 2004). The posture of the pelvis largely determines the posture of the spine. One of the major benefits of Pilates is addressing the posture of the pelvis. With age the pelvis tends to anteriorly tilt forward, as it would in pregnancy. This is not just due to lax ligaments of the pelvic region but also to an imbalance of the musculature of the pelvis (Muscolino 2004). Culligan et al. (2010) recognizes this and emphasizes that most Pilates exercises are performed in conjunction with a powerhouse contraction, improving among others pelvic floor strength. Culligan et al. (2010) further studied whether a Pilates exercise program could result in specific pelvic floor muscle strength improvement at the same degree as a traditional PFMT program; there was an encouraging outcome which may eventually lead to widespread use of Pilates-based exercise programs to treat and prevent pelvic floor dysfunction (incontinence). Because of this encouraging outcome Pilates exercises are an obvious recommendation during the peripartum and postpartum periods as a form of pelvic floor rehabilitation following vaginal deliveries.

Segal et al. (2004) further studied the effects of Pilates training associated with increased flexibility, increased truncal lean body mass, improved posture and improved health self-assessment. Unfortunately they did not use pregnant women in their study. Flexibility of subjects using the Pilates method improved significantly. Back pain subjects also showed improvements of flexibility and mobility. Flexibility may contribute to improved physical
performance, reduced energy requirements for movements of joints and reduced likelihood of soreness or injury with physical exercise. Subjects also reported a sense of improved posture: this may be due to the retraction of shoulders or straighter sitting. Kloubec (2010) agrees with Segal et al. (2004) about the effects that Pilates has on promoting flexibility and adds that Pilates exercises promote increase in abdominal endurance, pelvic control and upper body muscular endurance. Contrarily he believes Pilates does not have an effect on either posture or balance: however subjects in his study demonstrated a statistically significant increase in height, which indicates that there may have been some structural changes in spinal alignment. In a review by Bernardo et al. (2007) and an RCT by Sekendiz et al. (2007) they confirm the effectiveness of Pilates in healthy adults to improve flexibility, transversus abdominis activation, abdominal muscular endurance, lumbar-pelvic stability, lower back muscular strength and muscular activity. Sekendiz et al. (2007) found that in recent studies it was presented that Pilates mat exercises, utilized as a therapy technique for the rehabilitation of severe low back pain, can be beneficial and effective with improved results documented in patients. A trial on arm-trunk posture and movement by Emery et al. (2010) adds and supports the use of Pilates in the prevention of neck/shoulder disorders.

**Pilates exercises recommended during pregnancy**

The type of Pilates exercises important during pregnancy focus on all the major complaints already mentioned; these include: decreasing LBP (Pennick 2008, Ostgaard 1994, Nilsson-Wikmar 2005), maintaining postural strength, flexibility and balance (Butler 2009, McCrory 2010), increasing pelvic floor muscle strength (Hay-Smith 2009, Borg-Stein 2005) and treating neck and shoulder disorders (Emery 2010). During the first trimester many pregnant women experience nausea and exhaustion so find it hard to continue or begin a Pilates program, but the body will slowly adjust to the new changes (Robinson 2009). Pilates exercises focus on, and simultaneously work on different body functions. One exercise does not solely help one complaint, but may also effect others. Throughout the pregnancy exercises will strengthen and maintain the powerhouse. Examples of these are: Roll Ups, an exercise which activates the powerhouse and allows a nice hamstring and spine.
stretch, Crisscross which is great for the abdominals, working on them diagonally and the Astronaut which helps to strengthen various muscles used during delivery.

In regards to relieving back pain problems, exercises such as Rolling Like a Ball act as a massage for the back, Spine Stretch Forward and Rolling Down the Wall are nice full back stretches, Little Piece of Heaven also releases the lower back and the Can Can is for slimming and creating definition in the waist line while stretching the lower back muscles. Improvements for posture exercises include: Spine Twists, which improve posture by loosening the spine and increasing flexibility in the hips and waist, Rowing 5 improves posture while creating more room between the shoulder blades, Rowing 3, done alongside Rowing 5, promotes proper breathing and enhances coordination while simultaneously improving posture, also to be included is the Neck Pull which strengthens the powerhouse and improves posture!

There are many exercises which help with stretching, but some are previously mentioned above and include the Spine Stretch and Roll Ups.

Balance problems are controlled by exercises such as: Single Leg Stretching, which is designed to work on coordination, relax the hip flexors, and link breath to one movement, Leg Pull Up and Down is good for the abdominals, triceps and will help with balance and coordination, Rowing 4 promotes better sense of balance and enhances flexibility.

Neck problems are not forgotten in Pilates, the Neck Roll and Neck Stretch exercises stretch the neck muscles, the Neck Stretch focusing especially on the Trapezius and the Levator Scapulae.

### Pilates exercises to avoid during pregnancy

In general it is recommended to avoid: restrictive and tight clothing, getting up from the floor too quickly, holding your breath, dizziness, nausea, shortness of breath or pain and overheating while doing the exercises.

Pilates exercises which should be avoided during pregnancy include exercises in the side lying position focusing on leg work, for example Side Leg Raises and Pulling Leg Springs. These put a lot of force on the sacroiliac joints which may lead to an irritation or a displacement of the joint.
Exercises that include double leg lifts contract the rectus abdominis too strongly against gravity; this may cause a loss of integrity in this muscle, and the two halves of the muscle will shorten and contract as separate units. Furthermore, flexion of the spine after the first trimester is better to be avoided so Crunch exercises are not recommended. Overstretching should also be avoided because ligaments are lax during pregnancy and the stretching should remain within a comfortable range of motion. Especially avoid overstretching of the adductors, for example, the Butterfly Stretch to avoid increasing the instability of the pelvis. Prolonged periods in the supine position, especially in the second and third trimester, could cut off the oxygen provided to the fetus; as soon as this position becomes uncomfortable it is suggested to change position. It is always better to change positions and perform exercises slowly and safely in order not to lose balance.

**Personal Pilates Opinion**

Keeping up with an exercise program can be difficult during pregnancy, especially during the first trimester due to nausea and tiredness. We consider Pilates to be a safe way of exercising, but we recommend that women consult their doctor before starting any exercise program to ensure that the body is equipped to handle it. Although Pilates is the latest craze to hit gyms everywhere we conclude that this exercise regime is genuinely beneficial. The dynamic moves challenge women by helping build muscular endurance (for labor and delivery!), flexibility and, most importantly, good balance, something needed as pregnancy progresses.

We think that because the moves are so controlled Pilates can be a great choice during pregnancy since you have time to adjust your posture, and alignment for maximum support and challenge. We also find Pilates very versatile since you don't need special equipment, other than a mat, to get a great workout, and though it is always better to take classes information is freely available allowing it to be done independently.

As future physiotherapists we feel educated by this review. We now have an insight into Pilates regarding its effects and evidence basis. We consider it a valid and useful treatment tool to relieve complaints suffered by pregnant women. The number of articles and books we
found supporting the benefits of Pilates in general and during a pregnancy was encouraging. The literature researched and used was mostly recent, showing that evidence is currently being looked for and found as Pilates practitioners and pupils increase constantly.

We do however suggest the need for further Randomised Controlled Trials comparing Pilates effects to other exercise programs, which would give increased evidence based validity to the Pilates exercises. We found concerning this review that the current literature is lacking in Pilates evidence, controlled effects and benefits specific for pregnancy, more research focusing on pregnancy and Pilates would be beneficial for practitioners and future mothers.
References


### Appendix 1

**Oxford Centre for Evidence-based Medicine Levels of Evidence (March 2009)** *(for definitions of terms used see glossary at [http://www.cebm.net/?o=1116](http://www.cebm.net/?o=1116))*

<table>
<thead>
<tr>
<th>Level</th>
<th>Therapy/Prevention, Aetiology/Harm</th>
<th>Prognosis</th>
<th>Diagnosis</th>
<th>Differential diagnosis/symptom prevalence study</th>
<th>Economic and decision analyses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>SR (with homogeneity*) of RCTs</td>
<td>SR</td>
<td>SR</td>
<td>SR (with homogeneity*) of prospective cohort studies; CDR† with 1b studies from different clinical centres validated in different populations</td>
<td>SR (with homogeneity*) of Level 1 economic studies</td>
</tr>
<tr>
<td></td>
<td>Individual RCT (with narrow Confidence Interval‡)</td>
<td>Individual inception cohort study with &gt;80% follow-up; CDR† validated in a single population</td>
<td>Validating*** cohort study with good††† reference standards; or CDR† tested within one clinical centre</td>
<td>Prospective cohort study with good follow-up****</td>
<td>Analysis based on clinically sensible costs or alternatives; systematic review(s) of the evidence; and including multi-way sensitivity analyses</td>
</tr>
<tr>
<td>1b</td>
<td>All or none§</td>
<td>All or none case-series</td>
<td>Absolute SpPins and SnNouts††</td>
<td>All or none case-series</td>
<td>Absolute better-value or worse-value analyses ††††</td>
</tr>
<tr>
<td>2a</td>
<td>SR (with homogeneity*) of cohort studies</td>
<td>SR</td>
<td>SR</td>
<td>SR (with homogeneity*) of Level &gt;2 diagnostic studies</td>
<td>SR (with homogeneity*) of Level &gt;2 economic studies</td>
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<tr>
<td></td>
<td>Individual cohort study (including low quality RCT; e.g., &lt;80% follow-up)</td>
<td>Retrospective cohort study or follow-up of untreated control patients in an RCT; CDR† after derivation, or validated only on split-sample§§§ only</td>
<td>Exploratory** cohort study with good††† reference standards</td>
<td>Retrospective cohort study, or poor follow-up</td>
<td>Analysis based on clinically sensible costs or alternatives; limited review(s) of the evidence, or single studies; and including multi-way sensitivity analyses</td>
</tr>
<tr>
<td>2c</td>
<td>&quot;Outcomes&quot; Research; Ecological studies</td>
<td>&quot;Outcomes&quot; Research</td>
<td>Ecological studies</td>
<td>Audit or outcomes research</td>
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<tr>
<td>3a</td>
<td>SR (with homogeneity*) of case-control studies</td>
<td>SR</td>
<td>SR</td>
<td>SR (with homogeneity*) of 3b and better studies</td>
<td>SR (with homogeneity*) of 3b and better studies</td>
</tr>
<tr>
<td>3b</td>
<td>Individual Case-Control Study</td>
<td>Non-consecutive study; or without consistently applied reference standards</td>
<td>Non-consecutive cohort study, or very limited population</td>
<td>Analysis based on limited alternatives or costs, poor quality estimates of data, but including sensitivity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Case-series (and poor quality cohort and case-control studies §§)</td>
<td>Case-series (and poor quality prognostic cohort studies ***</td>
<td>Case-control study, poor or non-independent reference standard</td>
<td>Case-series or superseded reference standards</td>
<td>Analysis with no sensitivity analysis</td>
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<tr>
<td>4</td>
<td>Expert opinion without explicit critical appraisal, or based on physiology, bench research or &quot;first principles&quot;</td>
<td>Expert opinion without explicit critical appraisal, or based on physiology, bench research or &quot;first principles&quot;</td>
<td>Expert opinion without explicit critical appraisal, or based on physiology, bench research or &quot;first principles&quot;</td>
<td>Expert opinion without explicit critical appraisal, or based on physiology, bench research or &quot;first principles&quot;</td>
<td>Expert opinion without explicit critical appraisal, or based on economic theory or &quot;first principles&quot;</td>
</tr>
</tbody>
</table>

Notes

Users can add a minus-sign "-" to denote the level of that fails to provide a conclusive answer because:

Either:

A single result with a wide Confidence Interval

Or:

A Systematic Review with troublesome heterogeneity.

Such evidence is inconclusive, and therefore can only generate Grade D recommendations.

| * | By homogeneity we mean a systematic review that is free of worrisome variations (heterogeneity) in the directions and degrees of results between individual studies. Not all systematic reviews with statistically significant heterogeneity need be worrisome, and not all worrisome heterogeneity need be statistically significant. As noted above, studies displaying worrisome heterogeneity should be tagged with a "-" at the end of their designated level. |
| † | Clinical Decision Rule. (These are algorithms or scoring systems that lead to a prognostic estimation or a diagnostic category.) |
| ‡ | See note above for advice on how to understand, rate and use trials or other studies with wide confidence intervals. |
| § | Met when all patients died before the Rx became available, but some now survive on it; or when some patients died before the Rx became available, but none now die on it. |
| §§ | By poor quality cohort study we mean one that failed to clearly define comparison groups and/or failed to measure exposures and outcomes in the same (preferably blinded), objective way in both exposed and non-exposed individuals and/or failed to identify or appropriately control known confounders and/or failed to carry out a sufficiently long and complete follow-up of patients. By poor quality case-control study we mean one that failed to clearly define comparison groups and/or failed to measure exposures and outcomes in the same (preferably blinded), objective way in both cases and controls and/or failed to identify or appropriately control known confounders. |
| §§§ | Split-sample validation is achieved by collecting all the information in a single tranche, then artificially dividing this into "derivation" and "validation" samples. |
| †† | An "Absolute SpPin" is a diagnostic finding whose Specificity is so high that a Positive result rules-in the diagnosis. An "Absolute SnNout" is a diagnostic finding whose Sensitivity is so high that a Negative result rules-out the diagnosis. |
| ‡‡ | Good, better, bad and worse refer to the comparisons between treatments in terms of their clinical risks and benefits. |
| ††† | Good reference standards are independent of the test, and applied blindly or objectively to applied to all patients. Poor reference standards are haphazardly applied, but still independent of the test. Use of a non-independent reference standard (where the 'test' is included in the 'reference', or where the 'testing' affects the 'reference') implies a level 4 study. |
| †††† | Better-value treatments are clearly as good but cheaper, or better at the same or reduced cost. Worse-value treatments are as good and more expensive, or worse and the equally or more expensive. |
| ** | Validating studies test the quality of a specific diagnostic test, based on prior evidence. An exploratory study collects information and trawls the data (e.g. using a regression analysis) to find which factors are 'significant'. |
| *** | By poor quality prognostic cohort study we mean one in which sampling was biased in favour of patients who already had the target outcome, or the measurement of outcomes was accomplished in <80% of study patients, or outcomes were determined in an unblinded, non-objective way, or there was no correction for confounding factors. |
| **** | Good follow-up in a differential diagnosis study is >80%, with adequate time for alternative diagnoses to emerge (for example 1-6 months acute, 1 - 5 years chronic) |

Grades of Recommendation

| A | consistent level 1 studies |
| B | consistent level 2 or 3 studies or extrapolations from level 1 studies |
| C | level 4 studies or extrapolations from level 2 or 3 studies |
| D | level 5 evidence or troublingly inconsistent or inconclusive studies of any level |

"Extrapolations" are where data is used in a situation that has potentially clinically important differences than the original study situation.