CANADIAN COLLEGE OF OSTEOPATHY

THE EFFECT OF OSTEOPATHIC TREATMENT OF CAESAREAN SCARS ON PELVIC MUSCLE STRENGTH

GEORGIO TRIMARCHI

RESEARCH THESIS PRESENTED TO AN INTERNATIONAL JURY

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THESIS ADVISOR

Daryl Hochman, D.O. (MP)

ACKNOWLEDGEMENTS

I would like to thank all those who gave me words of wisdom as I began my journey in the Osteopathic profession. Special thanks are due to Daryl Hochman, my thesis advisor; Emilie Perras, chiropractic student and Assistant Research Librarian; Lorie Haws, Fitness Consultant, who helped test my research; Teri Gold for her data collection and entry; Laurel Duquette, a statistician from the University of Toronto; Bruno Ducoux who helped with French translation; and Stephanie Chambers for editorial assistance.

I would also like to thank my wife Ivana and my two children, Jordana and Jacob, for their incredible support and patience. With great love, I thank you all for your help and encouragement. Your support has been a blessing.

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ABSTRACT

The objective of this research was to determine how myofascial release on transverse Caesarean (caesarean) scars, in conjunction with the use of boney anchors for integration (lumbar and sacrum), alters the muscle strength of specific pelvic muscles.

In this study, which utilized a time-controlled within-subject design, the strength of five specific pelvic muscles were measured for each subject using the Lafayette instrument—a hand held muscle-strength gauge dynamometer. The control and treatment groups were made up of 27 women who were between twenty and forty-five years old and have had transverse caesarean scars for more than twelve months. The participants were volunteers recruited from the local community.

The assessments of muscle strength and treatment of scars were administered in a professional therapy centre in Thornhill, Ontario by a fitness consultant and an osteopath graduate student, respectively, over a sixteen-week period.

For all muscles measured (bilaterally except for the rectus abdominus), the adductor magnus, the gluteus medius, the iliopsoas, the obturator internus and the rectus abdominus, the mean strength measured in kilograms increased over the study period with significance of $p < 0.00$ for each muscle. Muscle strength was measured at weeks zero, four, and eight—subjects received testing only. At weeks eight and twelve subjects received the treatment procedure. The muscle testing was measured four weeks after each treatment. Muscle strength significantly increased when the average tone of the pre-treatment period was compared to both weeks twelve and sixteen of the post treatment period.

The desired results of this study were to show a deeper understanding of the effects of caesarean scars on pelvic muscles specifically and the female body in general, and how women that have caesarean sections might benefit from osteopathy and more specifically, myofascial release techniques.

RESUME EN FRANCAIS

L'objectif de cette recherché est. de determiner de quelle façon le relâchement myofascial appliqué sur les cicatrices de césariennes, en lien avec l'utilisation d'ancrage osseux (lombaire et sacré), modifie la force musculaire des muscles pelviens spécifiques.

Dans cette étude, avec l'aide d'un appareil de « time controlled » interne à la personne, la force de cinq muscles pelviens spécifiques a été mesurée chez chaque sujet, utilisant l'instrument de « Lafayette » : un dynamomètre manuel mesurant la force musculaire. Les groupes traité et de contrôle étaient constitué de 27 femmes agé de 20 à 45 ans ayant une césarienne de plus de 12 mois. Les participantes étaient volontaires, recrutées par proximité.

L'évaluation de la force musculaire et le traitement des cicatrices étaient réalisés dans un centre professionnel de thérapie à Thomhill, Ontario par un professeur de fitness et un étudiant ostéopathe en fin d'étude sur une période de 16 semaines.

Les muscles étaient mesurés bilatéralement (grand adducteur, grand fessier, psoas iliaque, obturateur interne) sauf pour le grand droit de l'abdomen. La force mesurée en kilogrammes a augmentée au cours de l'étude avec un coefficient p\0.00 pour chaque muscle. La force musculaire était mesurée à la semaine zéro, quatre, et huit, le sujet étant seulement testé. Au cours des semaines huit et douze les sujets recevaient un traitement. L'évaluation musculaire était mesurée quatre semaines après chaque traitement. La force musculaire a augmenté de façon significative si on compare la force avant le traitement à celle des semaines douze et seize.

Les résultats recherchés de cette étude étaient d’approfondir la compréhension de l’effet des cicatrices de césariennes sur les muscles pelviens en particulier et sur le corps féminin en général; d’établir comment les femmes avec une césarienne peuvent profiter des traitements ostéopathiques et plus spécifiquement de techniques myofasciales.

HYPOTHESIS

The treatment with myofascial release techniques of transverse Caesarean scars will significantly alter pelvic muscle strength as measured by the Lafayette dynamometer at $p < 0.05$.

1. CHAPTER ONE: INTRODUCTION

Throughout the years, the use of Caesarean surgeries has helped decrease mortality rates associated with childbirth and has improved survival rates of new-born infants. We have benefited greatly from the skillful hands of surgeons.

Since Caesarean Sections affect so many women today, as per the current trends (Taylor, 2007) it is both prudent and necessary to focus on improving the recovery process that follows the surgery. Caesarean scars may affect a woman's flow of movement and general vitality at the physical level and potentially at the emotional/mental level (Frymann, 1980). A thorough understanding of the relationship between the Caesarean surgical site and the rest of the female body may help to provide insight into health issues that can arise following Caesarean surgeries.

The body is vastly made up of fascia. The fascia is like an orange: it provides the framework and support that organize and hold the pulp together into sections and in totality, just like the body's muscles and organs. Without the fascia, the body would not be supported and be like "pulp" in the orange simile. Surgical scar tissue is quite different from natural scar tissue (Williams, 2006). A natural scar, such as a scrape on the leg from a fall off a bike, over time heals completely (and sometimes) without leaving a trace from the vast influence of the healing products of the body. A knife or a scalpel is used to cut the skin at its depths to the uterus (in the case of a caesarean surgery) in order to expel the infant (William, 2006). The multitude of layers required to reach the uterus is considerable and the closure of the scar with sutures creates a strong inelastic scar that creates adhesions preventing the body to apply its reconstructive mechanism such as that in a natural scar. A surgical scar creates a kinking effect and an impenetrable barrier that prevents the neurovasculature to flow freely (Williams, 2006). The caesarean scar has influence on the fascia continuity affecting the central chain by adhering to neighbouring tissues and further tugging tissues cephalically (neck and head) and caudally (legs and feet) in the body creating potential neck pain to arch problems in the feet. The caesarean scar, or for that matter, any scar, has great impact on the optimal function of the body (Williams, 2006).

This research utilizes myofascial release techniques to release the caesarean scar tissue from these tangles and adhesions interwoven in the body with regional applications to the lumbar and sacral spine. The origin of myofascial release dates back to the 19th century's Dr. Andrew Taylor Still (Manheim, 2001), inspiring his students and later labeled "fascial twist" in the 1920's by William Neidner, DO (Manheim, 2001). The myofascial release technique requires well developed palpatory skill by the practitioner to identify the "inherent tissue motion" (Manheim, 2001, p. 8) and subtle release of three-dimensionally related motion barriers. The myofascial release techniques that were introduced in 1981 by Manheim (2001) describe direction of tissue tension in its three-dimensional parameters relating to both indirect parameters into the ease of the tissue and direct parameters into the rigidity of the tissue. Myofascial release technique requires significant palpatory experience by the therapist to interpret feedback from the patient's body to determine the duration of application, the direction of parameters and the force required to stretch and release (relax) the restricted tissues. Due to the kinesthetic link between the practitioner and the patient, the inherent motion of the tissue can be felt and the resultant release of the neurophysiology of the tissue tone and or overlying muscles.

This research focuses on analyzing the effect of the caesarean scar on muscle strength of five related muscles of the pelvis: rectus abdominus, iliopsoas, adductor magnus, gluteus medius and obturator internus. This study measures the strength of these muscles with a dynamometer and determines changes in muscle strength after treatment of the caesarean scar with myofascial release. Since 1990 the author uses manual muscle testing as a form of assessment in clinical practice. This form of testing helps the author gain an understanding of the body's neural circuitry and the connections between muscle strength and potential causes of muscle dysfunction. Through osteopathic practice the author has exponentially improved his knowledge of anatomical relationships within the human body and has applied this knowledge to enhance patient care. This model of application utilizes a dynamometer to measure the actual muscle strength in kilograms (kg) of force. The dynamometer is a scientifically verifiable tool (see Chapter 2 for details).

The examination of scar tissue is compelling because of the great patient benefits that can be unlocked through an understanding of the web of connections within the body. The author has had opportunity to treat women with Caesarean scars, which has been a common focus within this area of study, resulting in a substantially improved quality of life for many women over the years. For example, a decrease in lower back and scar site pain; improved menstrual flow; alleviation of organ ptosis; improved posture; and some expressed improved intimacy in their relationships. Compassion and an understanding of the needs of women who have undergone trauma as a result of childbearing drives this investigation in the hope of preventing or alleviating such trauma in the future with osteopathic intervention prior to delivery. By assessing pelvic muscle strength as an indicator, the author hopes to better understand the effects of osteopathic treatment on Caesarean scars with myofascial release techniques and the benefits to the patient as a whole.

2. CHAPTER TWO: LITERATURE REVIEW

2.1. CAESAREAN INVESTIGATION

Various techniques of the Caesarean surgical approach are employed throughout the years. Studies are made to investigate the most efficient techniques in order to minimize wound infection, wound dehiscence, analgesic requirements, post-operative fever, endometritis, operating time, paralytic ileus, duration of hospital stay, and cost implications (Bamigboye & Hufmeyr, 2003). Another study (Alderdice, Mckenna, & Dornan, 2003) reviews long-term effects such as adhesion formation, chronic pelvic pain, urinary symptoms, and sub-fertility. Today, many caesarean sections are performed using a transverse supra pubic skin incision at the isthmus level (a horizontal cut just above the pubic bone) due to the faster healing rate enabled by reduced tension of the skin edges (Alderdice *et al.*, 2003), although some women receive midline vertical incisions for various reasons (see Appendix A).

The general surgical procedure involves the opening of the skin, fat, muscle, peritoneum, and finally the uterus (Alderdice *et al.*, 2003). Before cutting through the uterus the bladder is moved away to prevent bladder trauma (Alderdice *et al.*, 2003). During the repair, the uterus usually has two separate sutures to ensure integrity of the uterine wound (Alderdice *et al.*, 2003). More recently, single-layer suturing has been recommended (Karumpuzha & Johanson, 2001). In animal studies, histological and hysterographic studies show that single-layer closure provides the best anatomical result and the strongest scar tissue (Jelsema, Wittingen, & Vandenkolk, 1993). Bamigboye and Hofmeyr (2003) note that "During Caesarean, the peritoneal surfaces have to be breached before the uterus can be incised" (Bamigboye and Hofmeyr, 2003, p. 4). The peritoneal closure was thought to reduce the formation of adhesions, but findings suggest that a deperitonealized surface heals without permanent adhesions (Karumpuzha & Johanson, 2001).

The rectus muscle fascia sheath is repaired next. This layer gives the whole wound its strength. Wound healing is optimized if the stitches are inserted 10 mm from the edge and 10 mm apart to promote collagenolysis (Karumpuzha & Johanson, 2001) (see Appendix B). If the wound closure is shorter the wound will become weaker. Also, if this repair is done incorrectly, a risk of developing incisional hernia can occur (Alderdice et al., 2003). The next layer repaired is the subcutaneous layer. Few obstetricians stitch this layer (Alderdice et al., 2003). Lastly, the skin is repaired. With regards to the techniques of skin closure, there is no conclusive evidence about how the skin should be closed after a caesarean (Alderdice et al., 2003). In a study (Alderdice et al., 2003) comparing staples to absorbable subcuticular suture, the subjective results show less post-operative pain and better cosmetic result at the post-operative visit with the absorbable subcuticular sutures. In keeping with these findings, a United Kingdom study shows that in 73.9% of caesarean surgeries the surgeons use subcuticular techniques (Alderdice et al., 2003).

The healing time of a caesarean scar is a factor and a consideration in the criteria of accepting a subject for this study. A study using magnetic resonance imaging (MRI) evaluation of incision healing after caesarean sections were conducted by Dicle, Kucukler, Pirnar, Erata, and Posaci (1996) involving seventeen women after having their first delivery with a transverse Caesarean . The women were examined five days postpartum, and following this, three more times in three-month intervals. Various MRI images were obtained (see figure 1-5) to measure signal alteration of the scar area to determine recovery. Although signals are lost within the first three months, maturation time of the scar in uncomplicated caesarean sections is approximately three months and recovery of pelvic zonal anatomy require at least six months. Unlike the obstetrical literature which suggests the uterus reverts to normal size in three months (Van Rees, Bernstine, & Crawford, 1981), the uterus did not revert back to normal size before six months (in the study of Dicle *et al.*,1996) but was independent of the healing period for the caesarean scar. Other complications are observed (Figure 3), for example hematoma formation from hemorrhage materials accumulating in the bladder flap area, which is next to the low transverse caesarean section, as a result of the peritoneal dissection (covers the uterus) (Dicle *et al*, 1996.*)* Another complication noted is endometrial edema (figure 4) from a physiological phenomenon occurring in the final stage of pregnancy (Willms, Brown, Kettritz, Kuller, & Semelka. 1995). This edema did not affect the healing time of the scar (Dicle et al, 1996) and concludes that women with uncomplicated transverse caesarean sections have maturation of the scar tissue occurring in three months and require at least six months recovering anatomically.

Figure 1-5: MRI of incision healing after Caesarean Section (Dicle et al, 1996)

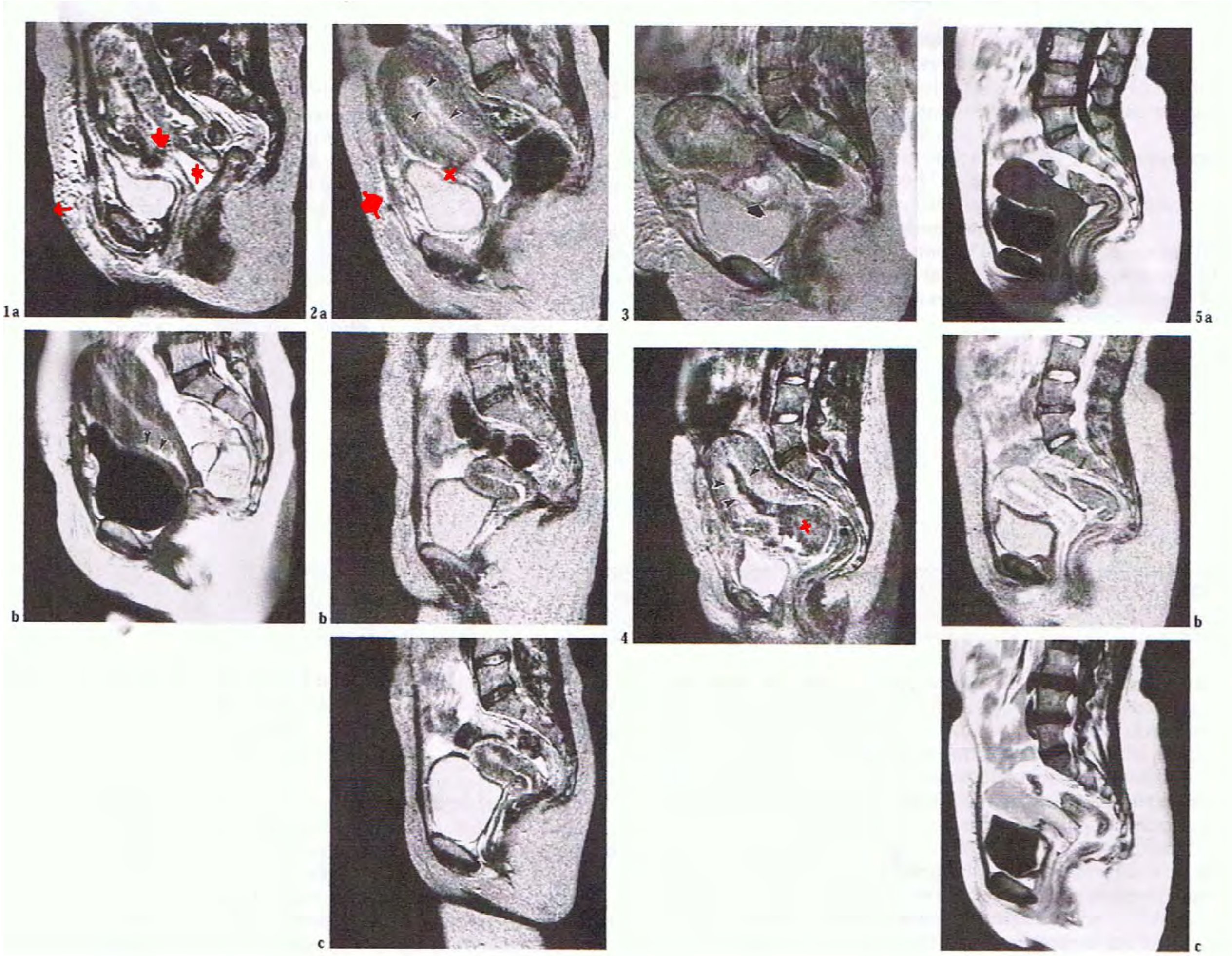


Fig.1 a *Sagittal T2-weighted (TR/TE 2000/80) scan of the pelvis taken 2days after delivery shows characteristic MRI signals of congestive and hyperplastic appearances related to the hemorrhagic processes within or around the* ***uterine incisia (arrow)****. Mucoid secretion in the* ***cervical canal (asterisk)*** *gives high signal intensity in the sequence.* ***b*** *Sagittal T1-weighted (TR/TE 550/15) scan in the early postpartum period shown the* ***myometrial incision (arrowheads)*** *with its high signal intensity in a patient.* ***Fig.2 a-c****.* ***Appearance of healing pelvis after Caesarean at 3 month intervals. a*** *The T2-weighted (TR/TE 2000/80) Sagittal MRI scans of a woman that were obtained in the early postpartum period. The early postpartum scan that was performed before she left the hospital show a huge, enlarged, and dilated uterus which measures 16 cm in crainocaudal dimension. Hypointense signal of the endometrial cavity comes from the hematoma in the subacute phase. Endometrial epithelium has typical high signal intensity related to* ***congestive edema*** *in this early stage* ***(arrowheads)****. The endometrial line is ill defined, and there is no evidence of low signal ring representing the junctional zone. The heterogeneous signa in the myometrial incision line is the result of subacute hematoma and the early reaction to tissue healing.* ***Note the small hematoma in the bladder flap (asterisk) and the hyperintense signals in the abdominal was (arrow)****.* ***b*** *In the third-month examination the uterus is approximately normal in size, but the zonal anatomy is still indistinct. The incision line is poorly detected in this period and there is the indication of matured scar tissue with low-signal characteristics in that area. The endometrial cavity is uniform and there is no evidence of synechia. Similar signal intensities can be seen in the abdominal wall.* ***c*** *MR! examination of the patient 6 months after the delivery shows a normal-sized, anteverted uterus and the related pelvic structures. Note that the zonal anatomy can be clearly identified. Thinner endometrial bright signal represents the early proliferative phase.*

Fig. 3 *Appearance of the* ***bladder flap (arrow)*** *on a T2-weighted (TR/TE 2000/80) Sagittal scan of a patient taken the day after delivery. Hemorrhage material that was accumulated in the flap area has high signal intensity centrally. Some bladder and cervical indentation of the flap were observed.*
Fig. 4 *The Sagittal T2-weighte (TR/TE 2000/80) scan of the uterus performed 2 days after delivery shows a* ***dilated and fluid-filled endometrial cavity*** *giving typically signals of hemorrhagic material and edema around the endometrial mucosa* ***(arrowheads)****. The endocervical canal was dilated due to the massive* ***hemorrhage material accumulated in the endometrial cavity (asterisk)****. Endometrial edema has typically high signal intensity on T2-weighted images.*
Fig. 5 a,b. *The Sagittal* ***a*** *T-weighted (TR/TE 550/170) and* ***b*** *T2-weighted (TR/TE 2000/80) and the* ***c*** *postcontrast T1-wighted (TR/TE 550/170) MRI scans of a patient obtained 3 months after delivery. There is little information about the incision line in T1-weighted image. An ill-defined hypointense signal can be detected. The T2-weighted MRI scan shows additional detail about the healing myometrial incision. It gives low-intensity signals representing the poor proton content of the scar tissue. The endometrial cavity and the cervical region can also be examined in detail. The postcontrast scan shows a diffuse mural enhancement in the uterus, whereas the incision line remains unenhanced. This is due to the poor vascular structure of the scar tissue (Dicle et al, 1996, p.33).*

A transverse incision, suturing the uterus in one layer, and not closing the visceral and parietal layers of the peritoneum improved post-operative recovery time. These methods also appear to lower febrile morbidity, reduce antibiotic requirements, encourage early return of bowel movements, and result in fewer adhesions (Karumpuzha & Johanson, 2001). Some research findings for injuries to the urinary and gastrointestinal tract during caesarean operations result in a low-percentage risk (Karumpuzha & Johanson, 2001), although it would be a major complication should such problems arise (Hofmeyr & Mathai, 2007). A consideration of bowel (or any other organ) adherence to the caesarean scar or injury during incision may impact the proposed research study because the treatment protocol does not focus directly on organ adherence. Caesarean scar healing and return to normal pelvic anatomy occurs within three to six months postpartum, which supports the criteria inclusion of one year and provides extra safe guards for participants in this study.

2.2. INSTRUMENTATION TOOL

The 01163 Lafayette model is sometimes still referred to as the Nicholas model. The Lafayette model was introduced in 2001 – any studies prior to this used the earlier Nicholas model. The reliability and validity of the current 01163 Lafayette hand-held muscle dynamometer (HHD) is the same as the Nicholas model since it uses the same load cell with some improved functions (Hanrahan, Van Lunen, Tamburello, and Walker, 2005).

A number of studies conclude that the hand-held Lafayette model is a reliable instrument. A study concluded that the Hand-held dynamometry (HHD) is a valid and reliable tool for assessment of knee extensor strength after hip fracture (Gilles Roy & Doherty, 2004). Another study uses the Nicholas manual muscle tester (kg) to measure subjects' hip abductor torque and concludes that runners with iliotibial band syndrome have weaker hip abduction strength (Fredericson et al., 2000). Hanrahan *et al.*, (2005) use the Lafayette instrument to determine the effects of lumbar joint mobilization on force generation in the lumbar paraspinal muscles and conclude that force increases over time. This study finds a significant increase in force production within the experimental group, as measured by the HHD, with pretest, immediate post test and twenty-four-hour post test. This study also finds a significant increase in force between immediate post test and twenty-four-hour post test. For the control group there are no significant findings in force production, although the researchers did find a difference in force between the pretest and post test measures of both groups.

Keller and Colloca (2000) observe muscle activity in the lumbar spine using electromyography (EMG) recordings after lumbar spine manipulation is consistent with the later study (Hanrahan *et al.*, 2005). The muscle activity is recorded, using the EMG, after a maximal voluntary isometric contraction pre- and post-lumbar spine manipulations and result in a significant increase in muscle activity. Dishman and Bulbulian (2000) also observe, with an EMG, the effects of lumbar spinal manipulation with and without a thrust. They find that stimulation of joint mechanoreceptors, muscle spindles and cutaneous receptors create an inhibition effect decreasing hypertonicity of surrounding paraspinal musculature. This stimulation might play a role in muscle re-education and recruitment due to a decrease in muscle spasm that results in an increase force in muscle contraction. A limitation of the Hanrahan et al (2005) study is that subjects receive grade one to four lumbar spinal manipulations, depending on individual need and specific injury, and thus receive dissimilar treatment. Fosang and Baker (2006) also employ the Lafayette instrument. Their study questions the validity of using a measure of isometric muscle strength as an indicator of muscle function during activity of able-bodied children. Their study also demonstrates the reliability of isometric muscle testing, but finds that it requires care and is time consuming. Compliance of the child population and disposition of the examiner may be factor in achieving maximum voluntary contractions on request.

Martin et al. (2006) compare the "Gold Standard Biodex Dynamometry" with the HHD and conclude that:

> HHD using a supine positioning offers a feasible, inexpensive, and portable test of quadriceps muscle strength for use in healthy older people. It underestimates the absolute quadriceps strength compared to the Biodex, particularly in stronger people, but is a useful tool for ranking muscle strength of older people in epidemiological studies. It may also be of value for quick and objective assessment of physical function in the clinical setting. (Martin et al., 2006, p. 158)

Wang, Belza, Thompson, Whitney, and Bennet (2007) also use the Lafayette instrument further supporting the instrument's reliability. Dunn and Iversen (2003), conclude the “instrument reliably measured force when a standardized protocol and proper examiner training were implemented” (Dunn and Iversen, 2003, p. 28)

It can be concluded from the above studies that the 01163 Lafayette (Nicholas) manual muscle dynamometer would be acceptable for the use in this study.

2.3. MUSCLE TESTING

Pollard, Lakay, Tucker, Watson, and Balbis (2005), conclude that the manual test procedure for the deltoid and psoas muscles show good interexaminer reliability between experienced and novice examiners. Bohannon (2005) examines the manual muscle testing procedure and assesses whether it meet the standards for an adequate screening test. The results suggest that in practice, a manual muscle test is adequate as a screening tool, but that hand-held dynamometry would provide more accuracy.

Perry, Weiss, Brunfield, and Gronley (2004) concluded that a supine manual muscle test using a hand held dynamometer is a reliable and valid method for assessing hip extensor strength. In this study, the muscle testing is performed in a supine position.

Kendal and Kendal (1983) report that muscle testing for assessing response to injury is widespread and generally accepted. Muscle-testing used in this thesis involves the subject maximally contracting against a dynamometer, or make test. A make test requires a subject to maximally voluntarily contract against a resistance such as the examiner’s static hand or a dynamometer, allowing a measurement of the actual strength of the contracted muscle. Pollard et al. (2005) add that muscle testing is used to detect musculoskeletal and neurological functioning throughout the peripheral and central nervous system beyond the actual muscle(s) being tested. Hass, Cooperstein, and Peterson (2007) indicate that muscle testing results beyond the actual muscle(s) being tested is found in applied kinesiology (AK) studies with mixed results, and further investigation in this arena is required.

An examination of this concept (AK) is warranted to provide an understanding of functional neurologic assessment and treatment methods that are common to the practice of applied kinesiology and to further support why a muscle may be weak.

AK, founded in the 1960's by chiropractor George J. Goodheart (Green & Gin, 1997), provides a popular diagnostic and therapeutic system that many health care practitioners use in practice. Goodheart developed origin and insertion treatment and Chapman, D.O., Bennett, D.C. and Sutherland, D.O., later developed and added methods to AK such as, neurolymphatic reflexes, neurovascular reflexes and cerebrospinal fluid flow (Green & Gin, 1997). Goodheart later introduced acupuncture meridian therapy to the AK system through the writings and inspiration of Felix Mann, M.D. (Green & Gin, 1997). Additionally, L.L. Truscott, D.C., proposed the vertebral challenge method (Green & Gin, 1997). The methods postulated by Goodheart in the AK system do support evidence for altered muscle strength in a subject despite negative or inconclusive results from many peer-reviewed papers that are primarily published by non-AK practitioners (Green & Gin, 1997).

Although the scientific community does not clearly substantiate the AK system, clinical evidence by many practitioners (Green & Gin, 1997) supports alternative theorized models on the effects of muscle strength and therefore a closer examination should be considered. The system of AK is used in addition to other standard diagnostic measures to augment rather than to replace existing diagnostic methods (Schmitt & Yanuck, 1999).

Altering muscle strength by treating a scar and its surrounding boney structures will further an understanding of the neurophysiologic basis of muscle testing procedures and would further support the science of muscle activation in the AK system.

This thesis utilizes a make test technique when the muscle testing procedure is applied. The AK system utilizes a break test. In a break test the subject is instructed to maximally contract (shortening the muscle with an isometric contraction) against the examiner's hand, then the examiner applies a slight increasing pressure in an attempt to elongate the tested muscle (creating an eccentric contraction) (Garten, 1996). Both the make and break tests examine muscle strength. Exploring the latter would help to understand changes in muscle strength.

The elongation or dynamic eccentric contraction (maximum three degrees of joint motion (Garten, 1996)) caused by the examiner's increased gradual pressure brings the feedback mechanism of the muscle spindle into action (elongates) causing the 1a-fiber to conduct an impulse towards the dorsal horn creating monosynaptic and polysynaptic excitation, which in turn activates additional fibers in the contracting muscle (Garten, 1996). Since the dynamic eccentric contraction created by the examiner is greater than the isometric contraction by the subject, a muscle that is strong withstands the increased force by the examiner and maintains the test position (hyperreactive or normoreactive). A weak muscle is not able to adapt to this increase force and will not hold the test position (hyporeactive) (Garten, 1996). The central integrative state (CIS), which is the summation of all excitatory and inhibitory inputs at the anterior horn motor neuron cells, is assumed to be associated with functional strength of skeletal muscles (Schmitt & Yanuck, 1999). As a consequence, it is possible to have a wide variation of central excitatory and inhibitory inputs of neurons summating from many sources that will contribute to altering muscle strength (Schmitt & Yanuck, 1999).

The health of the neuron also affects the CIS (Schmitt & Yanuck, 1999). The demand placed on the neuron by the excitatory and inhibitory inputs is a critical factor. The neuron must be able to maintain membrane receptors, metabolic pathways and membrane pumps in order to respond effectively (Schmitt & Yanuck, 1999). This thesis deals with healthy individuals without degenerative neuron states or disease conditions, which may alter muscle strength.

A weak muscle is measured, according to Kendall and Kendall (1983), with a commonly used graded weakness measurement system. This thesis utilizes a dynamometer to measure muscle strength. Weakness in a muscle can be caused by lesions of the central nervous system, brain and spinal cord motor neuron lesions, and intramuscular lesions (metabolic disturbances, torn fibers etc.) (Garten, 1996).

AK is performed by introducing a sensory-based stimuli and monitoring the CIS through the muscle strength test, taking into consideration the totality of the person (Schmitt & Yanuck, 1999). A truly inhibited pattern of a weak muscle stays the same independent of any sensory stimulus given to the subject to gain strength in the muscle (Garten, 1996). Thus, muscle strength can be altered from a variety of stimuli and life experiences.

2.4. TECHNIQUES

The following gives a closer examination of the various AK techniques employed in the diagnostic and treatment application of weak muscles and gives rise to greater understanding of the dynamics of the body.

2.4.1. ORIGIN AND INSERTION TECHNIQUE

Goodheart discovered that digitally stimulating nodules palpated near the origin or insertion of muscles corrects the structural imbalances caused by weak or hypotonic muscles, which led him to believe that he was treating micro avulsions at the musculotendinous junctions (Green & Gin, 1997). Figure 6 and Figure 7 depicts this idea.

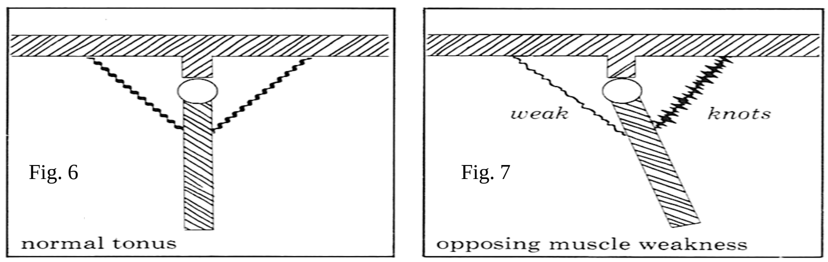


Figure 6 & 7: Description of the cause of muscle spasms (Thie, 1987)

Popular belief is that tight, spasmed or painful muscle is hypertonic. Goodheart, on the contrary, postulates that the weak muscle (figure 7) on one side of the body can cause normal opposing muscles to become tight or hypertonic (Green & Gin, 1997). The application of muscle testing would improve treatment considerations and thus positive results.

2.4.2. NEUROLYMPHATIC REFLEX TECHNIQUE:

In the late 1930's, Chapman, D.O. and Owens, D.O. wrote about lymphatic reflex points (Goodheart, 1989). Chapman believes that the lymphatic system greatly influences bodily function and that when the lymphatic system is blocked to some degree, it is responsible for various phases of disease. Chapman advocates that the removal of such blockage will expedite a return to normal function (Owenes, 1937). Chapman and Owens came up with the term neurolymphatic reflex points (NLR points).

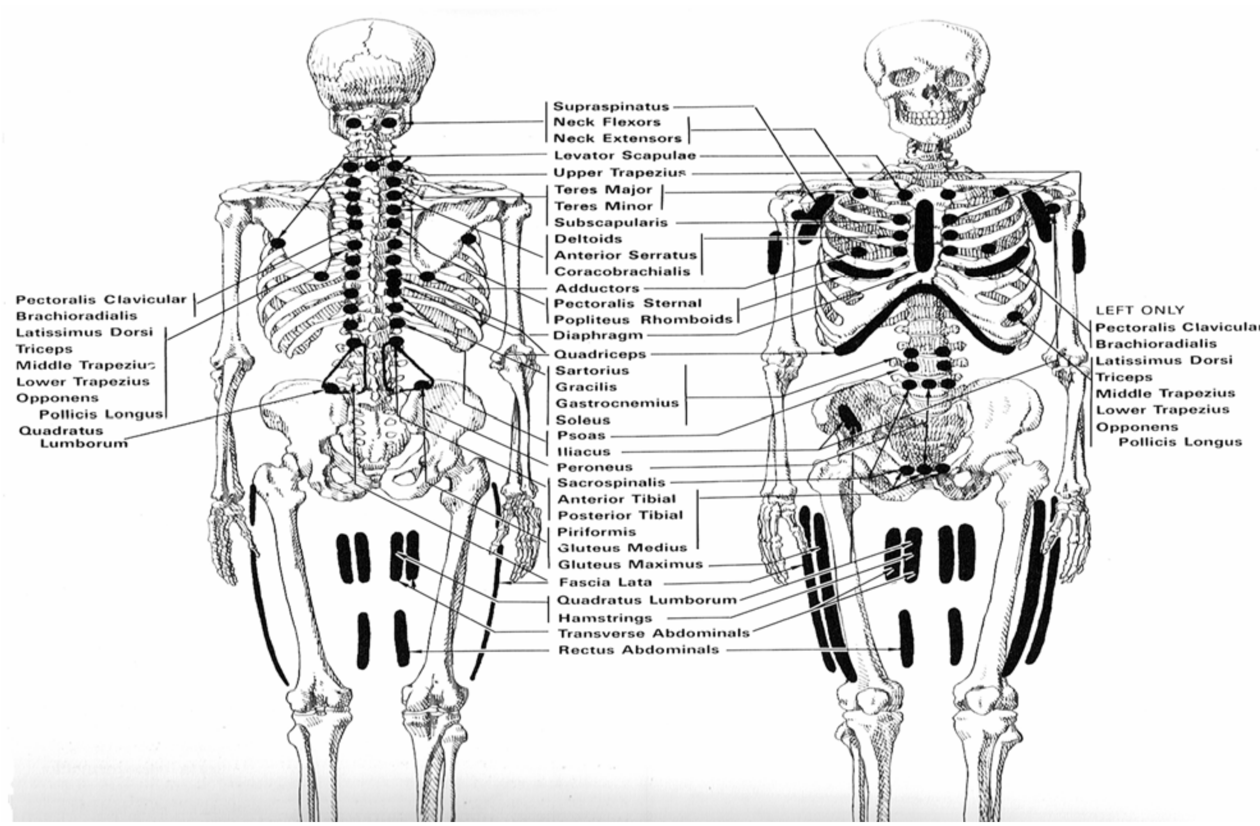


Figure 8: Neurolymphatic reflex points (Thie, 1987)

They postulate that there is a mapping of NLR points on the body wall that are manifestations of blocked lymph flow that often are recognized as palpable nodules. They believe that these reflexes had visceral organ correlation (Owens, 1937, Goodheart, 1989). These NLR points act like circuit breakers or switches that get turned on or off when the system of the body is overloaded (Thie, 1973). Goodheart (1989) began using Chapman NLR points and relating them to muscle testing results and found correlation to some specific muscles. More convincing was that every time there was a weak or dysfunctional organ, there was a corresponding weak muscle (Goodheart, 1989).

Figure 8 depicts the map of NLR points with some points overlapping the caesarean scar area and the lumbar and sacrum anchor points that this thesis investigates. These points, if active, are sensitive and can be treated by moving around the point with the fingers using a deep massage for twenty to thirty seconds (Thie, 1973).

2.4.3. NEUROVASCULAR REFLEX POINTS (NEUROVASCULAR DYNAMICS) (NVR):

Goodheart utilized neurovascular points in the AK system that were created by Bennett, D.C. in the 1930’s (Martin, 1977). Bennett (1960) hypothesizes that, “…remnants of the embryological pulse existed in humans and could be palpated at a fine rhythm of approximately 70 beats per minute” (Bennett, 1960, p. 4). He postulates that after the pulse has been felt and then activated, blood supply to specific areas of the body will increased to support proper organ function and a return to normal muscle strength (Bennett, 1960).

More specifically in regards to the technique, once a pulse has been felt on both sides of the head and becomes synchronized, then the NVR points are held for twenty seconds and up to ten minutes depending on the extent of the problem (Thie, 1973).

Figure 9 describes the connection of muscles to the NVR points on the head and NVR points’ number one and ten as they relate to the muscles investigated in this thesis.

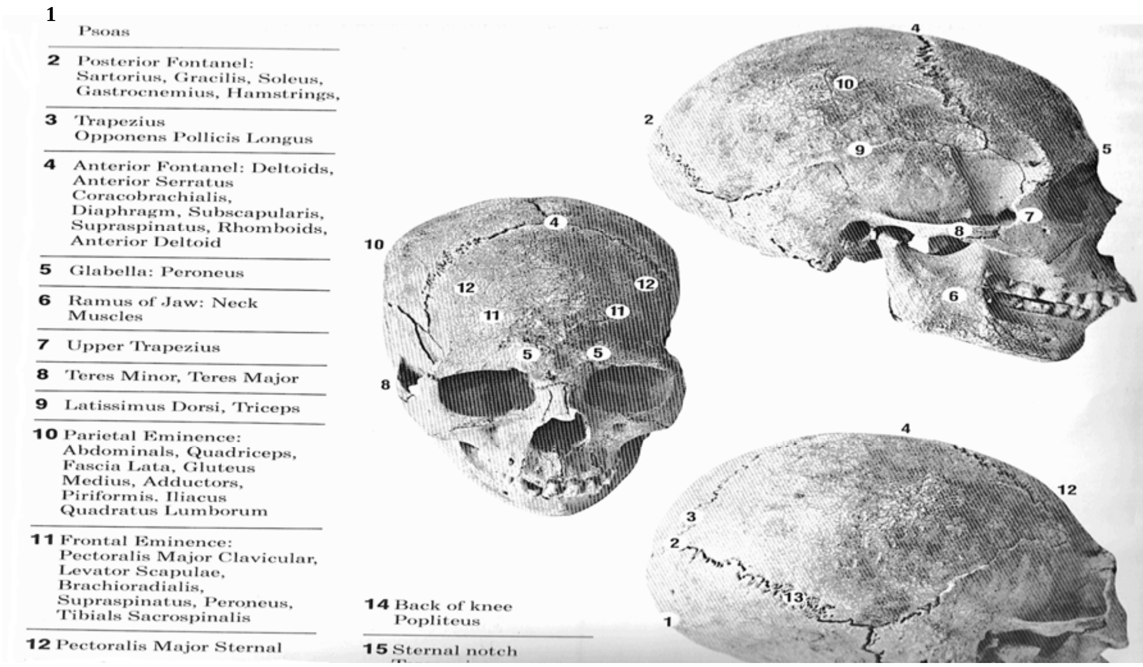


Figure 9: Neurovascular points (Thie, 1987)

2.4.4. CEREBROSPINAL FLUID

Sutherland, D.O. is most noted for postulating the concept of skull bones moving like the gills of a fish as one breathes (Sutherland, 1994). This highlights the relationship between cranial bone movements and the flow of the cerebral spinal fluid (CSF) through the nervous system. The importance of cranial bone movements and respiration harmony creates an essential pumping mechanism to produce and sustain adequate CSF flow (Green & Gin, 1997). Goodheart further hypothesizes that the spinal vertebrae and sacrum produces predictable movements during respiration (Green & Gin, 1997). This leads to the treatment of cranial lesions that manifest with specific signs when assessed through the muscle testing procedure.

2.4.5. Acupuncture Meridian Stimulation (without needles):

Meridians are located throughout the body. They contain a free-flowing, colorless, non-cellular liquid, which may be partly actuated by the heart. These meridians have been measured and mapped by modern technological methods, electronically, thermally, and radioactively.

> …There are specific acupuncture points along the meridians. These points are electro-magnetic in character and consist of small, oval cells called Bonham corpuscles which surround the capillaries in the skin, the blood vessels, and the organs throughout the body…We cannot say that a weak muscle means a weak organ—we can only note that a portion of the meridian energy flow indicates blockage or constriction (Thie, 1973, p.17).

Mann, M.D. introduces the relationship between visceral organs and acupressure points (Mann, 1962). Goodheart is influenced by this writing and later publishes an article in 1966 about acupuncture (McCord, 1991). Goodheart proposes acupuncture without needles (digital stimulation) for diagnosis and treatment and further compares the relationship between acupuncture point stimulation to muscle testing (Goodheart, 1989).

Thie, (1973) describes two basic treatments to strengthen muscles using acupuncture meridians. First, he demonstrates that the flow of energy through a meridian may be stimulated by using the hands to trace the meridian lines in the proper direction within two inches of the meridian. Second, he uses acupressure holding points to strengthen weak muscles, placing finger pads on the leg and hand of the client at the first strengthening point and holding for approximately thirty seconds or until the pulse on the leg reaches seventy beats per minute (Thie, 1973). Next the finger pads are placed on the second strengthening points on the leg and hand and held again for thirty seconds (see

Figure 10). Sedation or weakening points are also used for this particular technique as found through assessment.

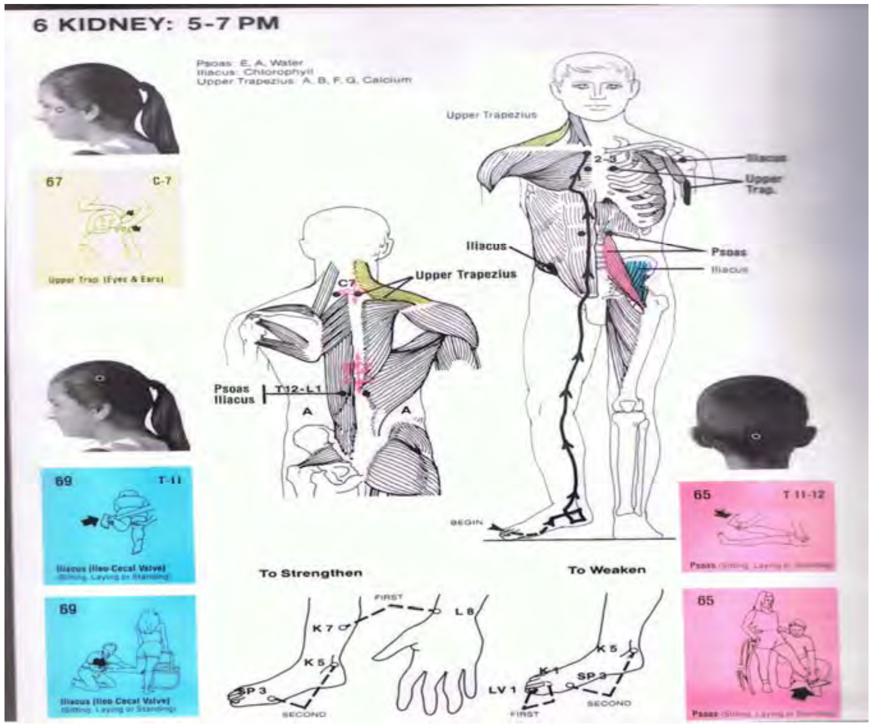


Figure 10: Kidney meridian chart depicting various techniques of diagnosing and the treatment of weak muscles (Thie, 1987)

2.4.6. VERTEBRAL CHALLENGE

Various influences from Truscott, D.C., Ph.C. (Goodheart, 1972) and DeJarnette, D.O., D.C. (Heese, 1991) brought Goodheart to propose that if a subluxed vertebrae or segment was challenged (a light pressure on the vertebrae is held by one hand of the practitioner and the muscle tested is used as an indicator for the vertebrae in question), a weakness in the muscle resulted as a response (McCord, 1991). This allowed the practitioner to adjust the specific segment of the body with precision.

To reiterate, these AK applications have been described to provide an understanding of various reasons why muscles may present with weakness. AK provides tools (Appendix C) to diagnose and treat various conditions throughout the body that is presented through muscle testing. An extensive critique and reinterpretation of a literature review by Haas, Cooperstein, and Peterson (2007) regarding AK and the standard orthopedic manual muscle testing, conclude that studies they reviewed did not support AK procedures as diagnostic tests. Also, further evidence to date does not support the use of manual muscle testing for the diagnosis of organic disease or pre/subclinical conditions (Haas et al. 2007).

The focus of this research is to discover if treating scar tissue causes any change in patient muscle strength. An understanding of the connections of the neurovascular and myofascial networks with the muscles of interest may be obvious, but less understood is the connection of active fascial contractility. In general, fascia is believed to have a passive role in transmitting mechanical tension that is generated by muscle activity or external forces (Schleip, Klinger, and Lehamann-Horn (2005). This study (Schleip *et al,* 2005*)* examines fascia contraction acting in a smooth muscle-like manner influencing musculoskeletal dynamics due to the presence of contractile intrafascial cells. Histological investigations reveal that myofibroblasts are present in normal fascia (Schleip et al. 2005). These cells have the ability to express the gene for alpha smooth muscle action (ASMA), which means that they can display contractile behavior. This effect of ASMA can be triggered by environmental situations such as increased mechanical strain and specific cytokines (chemicals produced in stressful situations) causing secondary myofascial tonus regulation system (Schleip et al. 2005) and influencing biomechanical behavior which occurs naturally in wound healing and other pathological situations.

The Schleip, Klinger, and Lehamann-Horn (2005) study suggests that a temporary increase in fascial stiffness stimulates fascial proprioception and increases muscular activation in the short term, but chronically increased fascial stiffness leads to metabolic and physiological drawbacks such as chronic fascial contractures and diminished neuromuscular coordination (Schleip et al., 2005). The presence of myofibroblasts suggests that fascia is a contractile organ, supporting the idea that myofascial release on a scar may influence muscle strength.

2.5. CURRENT TRENDS

According to data from the Canadian Institute for Health Information, the national caesarean rate reached 26.3% in 2005-2006, up from 17.6% in 1993 (Kirkey, 2008). The World Health Organization recommends caesarean sections be limited from 5 to 15% of births to avoid inappropriate usage of the procedure. British Columbia, Prince Edward Island, Newfoundland and Labrador reached about 30%, that is, one-third of babies were delivered surgically in 2006 - 2007. The caesarean rate for Alberta is 27%, Ontario 27.8%, Quebec 22.7%, with Saskatchewan, 20.8%, and Manitoba, 19.8% ranking lowest in Canada (Kirkey, 2008). Although only 2% of caesarean surgery is elective due to reasons such as fear of pain during childbirth, or convenience (Kirkey, 2008). Elective Caesarean deliveries can include medically and obstetrically indicated procedures or procedures for which there is no medical and obstetrically indicated procedure (Hitti, 2008).

> In the United States, 27 per cent of all births are caesarean sections, and 2.5 per cent of the overall birth rate is elective caesarean, then that means 1.9 per cent of the total caesarean sections performed are elective. If we apply this principle to Canada, with about 330,000 women giving birth

every year, that could mean that up to 173, 000 elective caesarean sections could be performed in Canada each year (Isings and Taylor, 2007 p.6).

On the other side of the scale, the best current estimate of the rate of caesareans in developing countries (Africa, East Asia, Latin America and Caribbean) is 12% according to the nationally representative data from eighty-two nations (Stanton & Holtz, 2006). When comparing urban to rural women in developing countries, urban women on average had three times as many caesarean births as rural women. Low Caesarean rates suggest that those who are at greatest risk of obstetric complications have limited or inadequate access to this procedure (Stanton, Holtz, 2006).

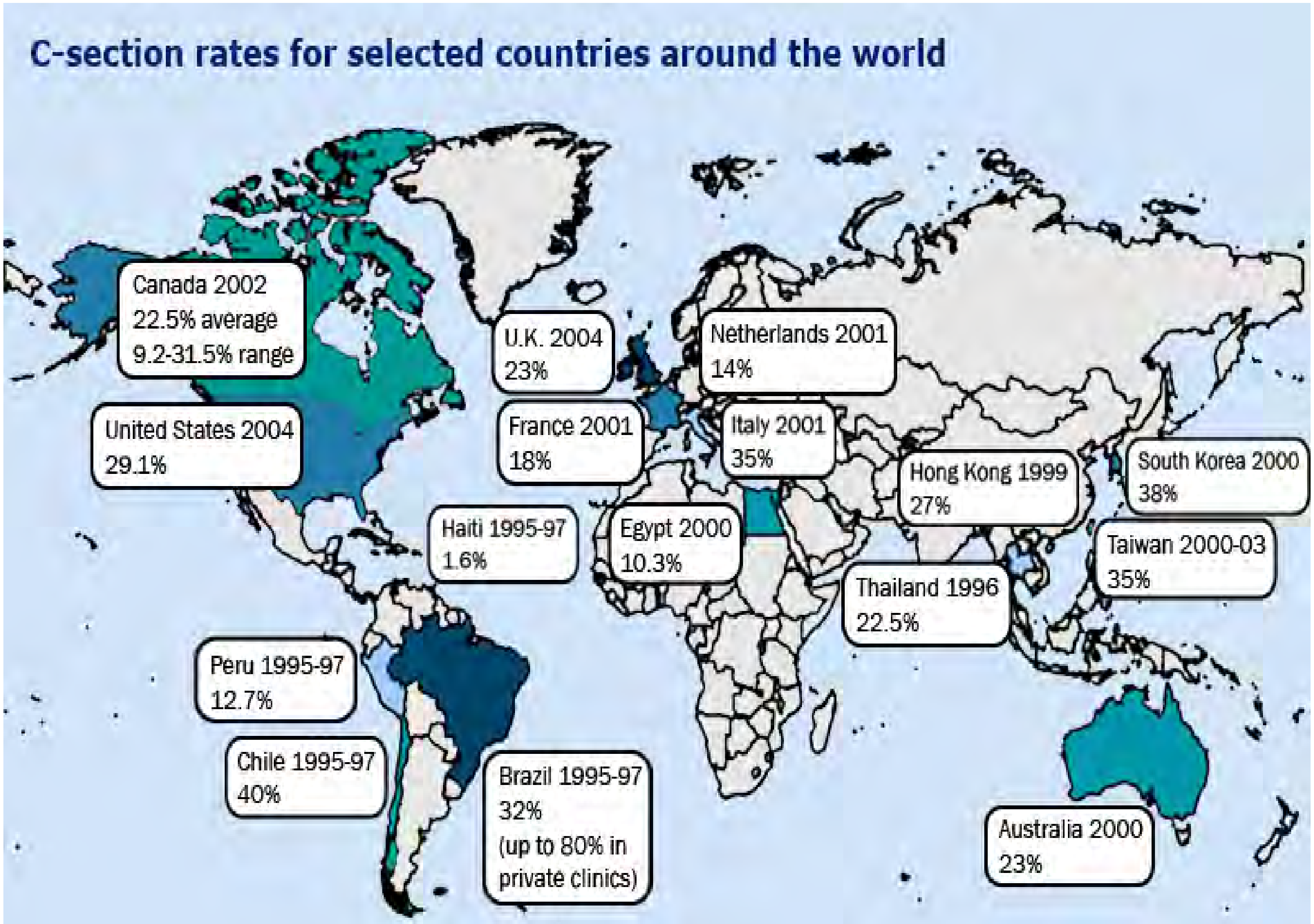
Some indications for caesarean surgery are malpresentation, antepartum bleeding, high blood pressure, macrosomia maternal soft tissue disorder and fetal heart rate abnormality (Hiiti, 2005). The most common indication for caesarean sections is fetal distress, dystocia, and previous caesarean. To this list, medical professionals are now adding the patient's mental state, a consideration of which is the expecting mother's fear, which can cause great anxiety (Isings & Taylor, 2007). Table 1 summarizes information related to elective caesarean section surgery.

Table: 1. The Pros and Cons of Caesarean (Isings and Taylor, 2007).

The Pros and Cons of Caesarean	
Pros	Cons
Medical Reasons	Medical Reasons
• reduced risk of urinary and fecal incontinence • reduced risk of pelvic organ prolapse • reduced risk of unexplained stillbirth	• increased risk of fetal death • increased risk of maternal death • increased risk of fetal injury • increased risk of fetal respiratory difficulties • increased risk of post-operative hemorrhage or infection • complications from anesthesia • increased risk of stillbirth during second pregnancy • longer recovery time
Non-medical Reasons	Non-medical Reasons
• alleviated fear and anxiety over pain and stress of vaginal delivery • no labour pain • reduced sexual discomfort	• difficulty breastfeeding • longer hospital stay • possibly less satisfying birth experience

A global view of caesarean surgeries on the rise is provided on the world map diagram below (Figure 11).

Figure 11: Caesarean section rates for selected countries around the world (Taylor, 2007).



A financial review on one of the potential reasons for an increase in caesarean births may not hold true in Canada because of the publicly funded health care system. In 2002 – 2003, the payout to a doctor providing vaginal or caesarean births are approximately the same (Figure 12), but the cost to the health care system of performing a caesarean surgery is approximately $4,600 per patient as compared to $2,700 per patient for a vaginal birth (Canadian Institute for Health Information, 2007). A study released by the Canadian Institute for Health Information found that low weight babies tend to be delivered by caesarean and spend more time in the natal intensive care unit (Varano, 2007). The cost of having an underweight new born (750 grams) is approximately $117,806 as opposed to a normal birth weight costing $795 per procedure (CIHI, 2007).

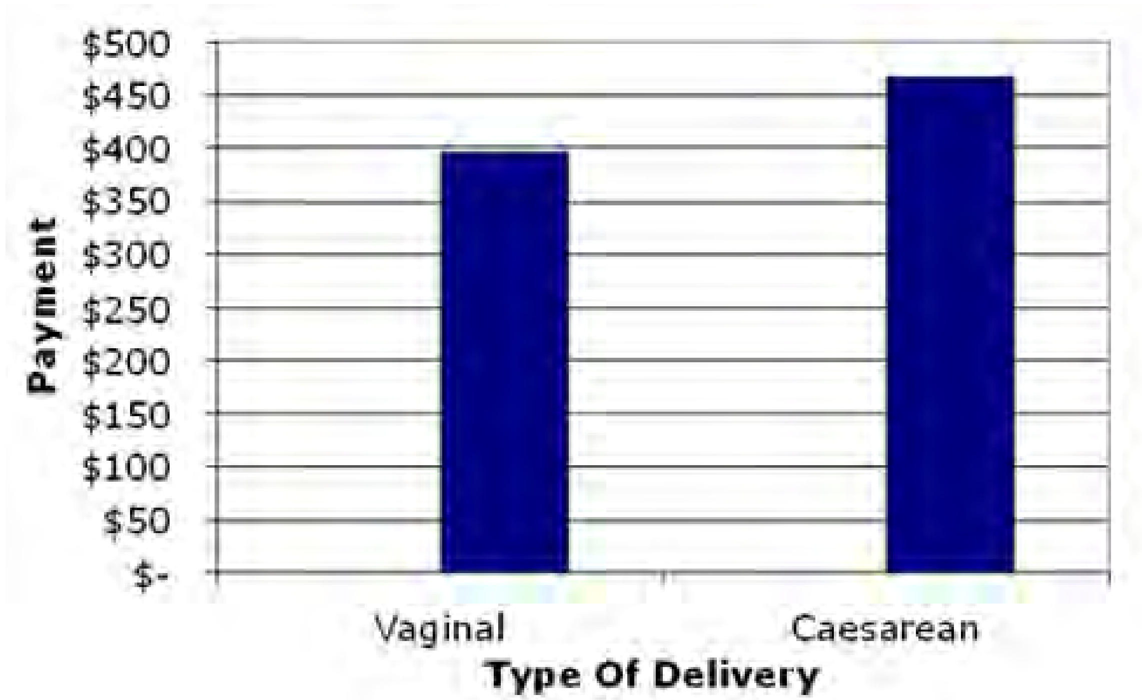


Figure 12: Payments to Doctors for Vaginal Delivery and Caesarean by the Ontarian Health Insurance Plan (OHIP, Schedule of Benefits and Fess, Physician Services) (Jovanovski, 2007).

The average time of a caesarean delivery is approximately twenty to thirty minutes as compared to a vaginal birth, which can take up to twenty-four hours or more. Less time means that more procedures can be performed during a doctor's shift, which results in more money for doctors (Jovanovski, 2007).

> The Society of Obstetricians and Gynecologists of Canada does not promote Caesareans on demand. The Society has always promoted natural childbirth and believes that the decision to perform a Caesarean during

labour and delivery should be based on medical indications (Taylor, 2007, p. 1).

2.6. PSYCHOLOGICAL IMPLICATION

A study examining the psychological impact of emergency Caesarean in comparison with elective Caesarean, instrumental vaginal delivery (IVD) and normal vaginal delivery(NVD) (Ryding, Wijma, and Wijman, 1998) found that an unplanned instrumental delivery (Emergency caesarean or IVD) reports the most negative delivery experiences and should be regarded as a pointer with respect to possible post-traumatic stress. Another study by Koo, Lynch and Cooper (2003) aims to identify whether women having emergency delivery are at increased risk of developing postnatal depression. Results show that having an emergency delivery carries approximately twice the risk of developing postnatal depression and suggests that special attention to this group is warranted.

From an osteopathic point of view, a trauma to the body, (emotional, mental or physical) if not rectified may remain within the body for many years creating compensations and/or adaptations on the totality of the body. This trauma should be a consideration in treating any patient, but considered preventative in treatment of women during pregnancy and prior to delivery.

The literature and studies discussed in this support the author's research by providing insight into common caesarean procedures that allow understanding of the depth of tissues and possible complications involved. The studies show that the measuring tool is reliable and can provide optimal assessment data. Also, the literature examines the subjects of patient position and inter-examiner reliability with regard to manual muscle testing and manual-versus-dynamometer testing. Further, an investigation in muscle testing from an AK point of view expands the potential causes of muscle weakness.

Studies on the influence of fascia contractility on the body's biomechanics present this as an influential factor in recovery from caesarean, and examination of social current trends and psychological implications of undergoing a caesarean surgery provide insight into the direction that society is moving.

Extensive librarian-assisted investigation was conducted to determine if there were any English language peer-reviewed scientific research studies related to caesarean scar and its effect on pelvic muscle strength. Limited information that directly related to this topic was on hand.

3. CHAPTER THREE: OSTEOPATHIC JUSTIFICATION

An understanding of normal human physiology is imperative to fully appreciate the osteopathic principles that the study and practice of osteopathy are based upon. The four principles are provided by the Canadian College of Osteopathy (2004) from 1st year GOT course handouts and found in Kuchera and Kuchera (1994):

1. The structure governs the function
2. The role of the artery is absolute
3. The body is a functional unit
4. The system of auto regulation

An examination of the uterus is provided and looks further at the connection of the muscles of interest with their neurovascular components and their myofascial network in order to link each muscle to the scar and uterus. Within this examination, further discussion of the scar matrix and its effects will aid in understanding the implications of Caesarean surgery on this thesis investigation.

Appendix C provides an anatomical overview of the pelvic muscles including rectus abdominus, iliopsoas, adductor magnus, gluteus medius and internal obturator. These muscles have been chosen by the author due to common clinical findings of manual muscle testing procedures for this group of subjects.

3.1. SCARS AND BONEY ANCHORS

A common point of the surgical incision made to expulse the infant is at the uterine isthmus (Appendices A and B). Scar formation alters the length of the recovery process for the mother, which is estimated to be from six months to one year for full strength of muscle tone surrounding the scar (Dicle et al., 1996). Scar tissue is weaker than normal tissue during the healing phase due to decreased water in the scar tissue caused by the reduction of ground substance and proteoglycan content, resulting in reduced metabolism and denser and less pliable tissues (Ward, Hruby, Jerome, Jones, and Kappler, 2003). Scars can also interfere with fascial load distribution, which will create adhesions to neighboring tissues (Ward *et al.*, 2003). Scars can affect the nervous system by creating an interference field that can cause pain at the site or as a referral (Ward *et al.,* 2003). Scars also have a higher neural skin resistance than normal tissue and may be as much as 600–1500 kilo-ohms compared to a normal tissue resistance of 120–500 kilo-ohms (Ward *et al*., 2003).

The use of functional boney anchors, namely, the lumbar vertebrae and sacrum, contribute connections to the muscular anatomy discussed in this investigation. Detailed information on the neural pathways linking the uterus to the investigated muscles is provided in Appendix D.

An important osteopathic principle is structure governs function. With this principle in mind, it is anticipated that this treatment will improve mobility of the boney anchors by decreasing the potential stiffness caused by Caesarean scars, allowing the neurovasculature to flow freely, enable the sacrum greater movement and improve the vitality of the cerebral spinal fluid, improve the centre of gravity lines (C-5, T-4 and L-3 pivot points were the resultant line of gravity path courses) that are required for balanced posture, contribute to an efficient diaphragmatic respiratory system, and improve patients' ability to obtain and maintain efficient muscular tone.

Korr presented the topic of Segmental Facilitation (SF) at the 1994 Montreal International Osteopathic Symposium, citing a study by Dr. Denslow in Kirksville (Korr, 1994) that shows a lowering of motor neuron threshold is associated with an osteopathic lesion. This study proposes an axoplasmic transport theory stating that "…the reason muscles atrophy as do the axons which are separated from their nucleus is that they are dependent on the delivery of protein which are synthesized by the neuron and delivered by the axon" (Korr, 1994, p. 5). The caesarean scar can create deformation, twisting, stretching or ischemia within parts of the body and impede axoplasmic flow creating a weakness or impairing trophic function in the muscle or organs (Korr, 1994). Also, a state of permanent nerve firing or continuously facilitated segments can disrupt protein synthesis and structurally affect the end organ or muscle (Korr, 1994).

3.2. NEUROVASCULAR SYSTEM

The structures investigated in this study are linked to the nervous system via the lumbar vertebrae and sacrum. The specific muscles have motor and sensory innervations from L1 to L5 and S1 to S2, with the abdominal muscles having thoracic innervations as high as T5. The uterus, pelvic and perineal organs are innervated both by the sympathetic nervous system (SNS) (T12 to L5) and parasympathetic nervous system (PNS) (S1 to S5) via the abdominopelvic plexus (see Appendix D). Various parts of these organs and tissues are innervated according to their embryological origins (see Appendix E). These innervations target the glandular cells and smooth muscle of the vasculature and mural smooth muscle, which are found in the tubular portions of these organs (Ward *et al*., 2003). The inferior hypogastric, or pelvic plexus, is a network of ganglia and fibers that surround the female pelvis travelling with the transverse cervical ligament connecting to infiltrate the uterus, cervix, and vagina (Ward *et al*., 2003). The sympathetic preganglionic neurons stem from the T10 to L2 spinal segments and influence the uterus and cervix as well as other ganglions such as the celiac ganglia, which is a major site of neurovasculature infiltration that has vast effects on the body's ability to maintain homeostasis. The sympathetic postganglionic neurons course into the superior and inferior hypogastric plexus to reach the uterus and affect its vascularization (Ward *et al.*, 2003). The vascularization may be negatively influenced by the above-mentioned neural connections if they are in dysfunction, thus stressing the importance of the osteopathic principle that the role of the artery is absolute.

The PNS to the uterus and cervix stems from S2 to S4 and travels through the inferior hypogastric plexus, which is an important area of syntonization (Druelle, 2004) in the nervous system (PNS, SNS, sensory and motor nerves) and part of the Central Chain (Druelle, 2004). The postganglionic fibers leave this plexus along with the uterine artery to innervate the uterus, affecting mainly the vascular supply and some muscle layers of the myometrium (Ward et al., 2003). The sacral plexus and, more specifically, the pudendal nerve, supplies most of the perineum and affects sexual arousal (Ward et al., 2003) which can impact the health of the gynecological structures over time due to poor physiology and possibly affect the intimacy of a relationship. The release of the sacrum (structure), which is used as a boney anchor if in dysfunction, may contribute to the osteopathic principle that structure governs function.

As part of the research methodology, the sacrum and lumbar vertebrae are integrated into the treatment of the incision and are expected to be important in obtaining a release of neural pathways that innervate the pelvic muscles and uterus. Osteopathically, the mutual levels of innervations of both the tested pelvic muscles and the uterus may be released**.** As part of the basic principle in osteopathy that structure governs function, treating and releasing each individual lumbar vertebrae and sacrum would be required to obtain effective motor and sensory innervations in the area, also supporting the principle that the body operates as a functional unit.

The circulatory network is in fact one trunk with many branches. The role of the artery is key as it provides nutrition through the circulatory system that is mandatory for optimal health and the prevention of disease. A local examination of the vascular network provides an understanding of the structures of interest. The vasculature of the pelvis stems from the abdominal aorta, which bifurcates at the common iliac artery to form the internal iliac and external iliac arteries at the L5 to S1 vertebral level. Since the lumbar and sacral vertebrae have neural innervations to this circulatory network, this further supports the need to release these boney anchors (Moore, 1985) (see Appendix F).

The internal iliac artery supplies most of the blood to the pelvic viscera and lower extremities, with some supply coming from the sacral artery and tributaries (Moore, 1985). Branches of the internal iliac artery travel to the uterine artery, which has tributaries that supply the uterus and anastomose with the ovarian artery within the superolateral part of the broad ligament to supply the ovary and uterine tube (Moore, 1985). The connection of the internal iliac artery, via the broad ligament, to the pelvic musculature and organs has implications that affect pelvic muscle function and the gynecological structures.

Still said “When you want more power, turn on the artery” (Conner, 2005 p. 23). The ovarian artery, which arises from the aorta at the level of the L2 vertebra, enters with the suspensory ligament and nerves. In keeping with the osteopathic principle that the role of the artery is absolute, the ovarian artery is important in developing an effective hydraulic pressure system filling the uterus for expulsion during vaginal child delivery.

Releasing L2 is important for ensuring the nutrition of the uterus and ovaries. The obturator artery branches from the internal iliac artery and supplies the muscles of the thigh and the ligament of the head of the femur. The external iliac artery becomes the femoral artery as it enters the femoral region. The medial circumflex femoral artery (a branch of the femoral artery) is clinically important because it supplies most of the blood to the head and neck of the femur (Moore, 1985). The internal iliac and the femoral arteries anastomose via the superior and inferior gluteal branches of the internal iliac artery, which supply the buttock and posterior surface of the thigh (Moore, 1985), and the medial and lateral circumflex branches of the femoral artery. This anastomoses ensures blood supply to the head of the femur (Moore, 1985) which may assist to prevent femoral head necrosis from compression on the medial circumflex femoral artery. The medial circumflex femoral artery branches supply the ilium and pubis and continue to anastomose with the inferior epigastric artery of the external iliac artery (Moore, 1985).

The pelvis and viscera are primarily drained by the internal iliac veins and their tributaries, which join the external iliac vein. The external iliac vein which provides further lower limb drainage from the saphoenous veins to the femoral vein and enters the common iliac vein. The common iliac vein contributes to the inferior vena cava (Moore, 1985). This drainage system is important in preventing disease of the lower limbs and pelvis region that can arise due to congestion and stagnation further supporting the osteopathic principle that the role of the artery is absolute.

Though not an artery, the role of the artery principle applies to the pelvic lymphatic system (see Appendix G). Generally, the pelvic organs, lower limbs, and abdominal wall drain into the external and internal iliac lymph nodes and the sacral lymph nodes. These all drain into the common iliac and lumbar lymph nodes, which then drain into the cisterna chili at the level of the L1 and L2 segments before reaching the thoracic duct to join the blood stream at the junction of the left subclavian and internal jugulars veins (Moore, 1985). The lymphatic duct, as the other division of the lymphatic system, empties the right side of the head, neck, right upper extremity and the right side of the thorax into the right subclavian and right internal jugular vein (Moore, 1985). This drainage system when activated through the lymphatic nodes increases production of lymphocytes by about thirty percent (Chikly, 1998), assisting with immune function and in relation to the osteopathic principle of autoregulation.

The lymphatic vessel contains two to three layers of muscles innervated by the sympathetic and parasympathetic system and produces specific peristaltic contractions stimulated by stretch receptors located in the distal end of the lymphatic vessels, which contrary to popular views, are not a passive system (Chikly, 1998).

Millard (Chikly, 1998) proposes that for every congested tissue there is a corresponding lymph disturbance, and Zink (1973) states that “Since the blood vascular system and the lymph vascular system course throughout the entire body, it is necessary to remove all myofascial tensions and functional articular strains because they would hinder the efficiency of the flow” (Zink, 1973, p. 4) Obstructions must be removed to allow proper flow of the lymphatic system, which, by activating all other fluid fluctuations of the body has a role in decreasing spasms, chronic inflammation, chronic pain and draining toxins (Chikly, 1998).

Lesions that are created by the caesarean scar affect the primary respiratory mechanism (PRM) via the reciprocal tension membrane (Appendix H), the entire spine and sacrum movement (Appendix I) during respiration and synchronicity of the diaphragms (Appendix J), and have an impact on the flow of the lymphatic system. For example, tension caused by the caesarean scar via many connections (pharyngo-prevertebral fascia, iliopsoas and rectus abdominus) that translates to the posterior thoracic diaphragm via the crus insertion on the first three lumbar vertebrae, can affect the posture of the body (Appendix K). This in turn affects mobility of the spine due to a change in the normal lumbar lordosis that can create restriction of thoracic respiration, eventually affecting normal mobility of the cranial-sacral movement, vitality and PRM (Appendix H).

The neurovasculature system is one of communication, drainage, supply, and protection (immune) for all structures of the body. Should these systems become altered by a lesion (scar), the normal physiology and function of the affected parts would begin to degenerate towards a diseased state. Treatment protocol of this study includes releasing the caesarean scar with the lumbar vertebrae and sacrum, to allow flow of lymph and fluids and normal mobility of the structures mentioned.

3.3. MYOFASCIAL SYSTEM

Still states: “The fascia is the place to look for the cause of disease and the place to consult and begin the action of remedies in all diseases” (Kuchera & Kuchera, 1994 p.39). The following is a description of the fascial connections of the pelvic muscles to the uterus and to the body as a whole and, a brief overview of the myofascial chains depicting direct links to all the structures involved in this study.

Fascial chains act like ropes that transmit forces via the muscular contraction and are usually anchored at joints (Paoletti, 2006) Figure 13.

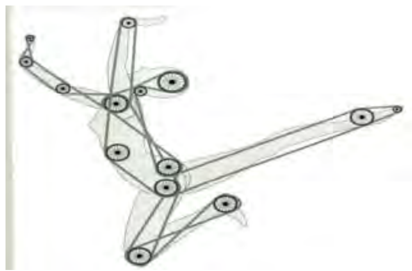


Figure 13: Fascial Pulley and Chain systems (Paoletti, 2006)

Figure 14: Points Where Shocks Can Be Absorbed (Paoletti, 2006)

The fascial chains have major points of dampening, or absorbing, forces (see figure 14) via the pelvic girdle, diaphragm, scapular girdle, hyoid bone and occipital-cervical junction that, if lesioned may disturb their function (Paoletti, 2006). The fascial system can be seen to function as a unit as all fascial chains are permanently interrelated with one another (Paoletti, 2006).

The following will show how the fascial chains can provide a link to the cranial vertebrae (CV) via the connection of the muscles of interest, the caesarean scar and the uterus.

3.3.1. POSTERIOR MEDIAN CHAIN

The first CV, pre sphenoid**,** is made up of the lesser wing of the sphenoid, the frontal bone, the ethmoid, and the bones of the face and is connected to posteromedial chain (Figure 15). The posteromedial chain starts between

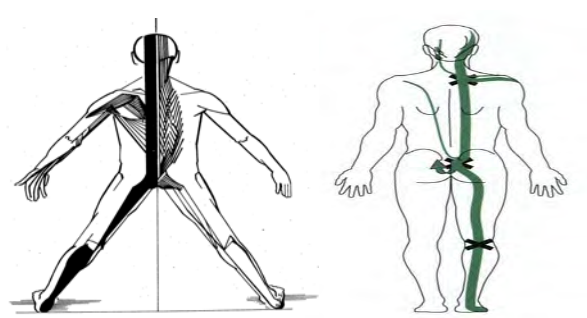


Figure 15: Posterior Median Chain (Paoletti, 2006, and CCO-LaFlamme, 2006).

the falx cerebri and the tentorium cerebelli to the anterior clinoid processes providing a possible influence on the anterior pituitary gland and the hormonal system.

The posterior median chain continues via the falx cerebri to the ethmoid through the nasion and spreads to the muscles of the face and along the occipital-frontalis aponeurosis running inferiorly along the posterior body close to the spinal vertebrae and posterior upper extremities. It continues through the sacroiliac joint ligaments and gluteal muscles to the hamstrings and soleus, and ends in the plantar aponeurosis. This fascia is related to three aponeurosis (occipital frontalis, lumbar and plantar).

The connection to the lumbar vertebrae and sacral bone are apparent with the continuum to the uterus. The fourth finger and toe are considered end points of this fascia. This chain is related to the sense of smell and the kidney (bladder meridian system). Morphologically, when out of balance, people with this personality typology worry or fear a lot. Their posture resembles a "bubble butt with a flat spine" look, with the chest protruding outward, and they commonly have heart problems (Canadian College of Osteopathy-Laflamme, 2006).

3.3.2. PHARNYGO PREVERTEBRAL CHAIN

The second CV, post sphenoid**,** is connected to the pharnygo-prevertebral chain (PP chain). This CV is made up of the body and greater wing of the sphenoid and the parietals. This chain is also considered the posterior anterior–anterior posterior chain (PAAP) (Figure 16). This chain starts on the lateral side of the pituitary and medial side of the cavernous sinus, continues inferiorly to the

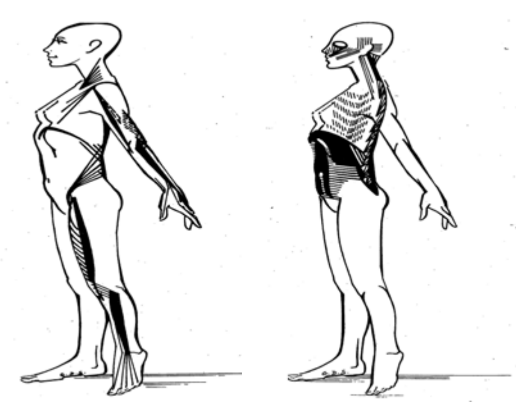


Figure 16: PA (left) and AP (right) (CCO-Laflamme, 2006).

pterygoid, and meets up with the dura mater extension. It continues on to the pharynx muscles and crosses behind the pharynx in front of the cervical vertebrae and then comes back anteriorly. The chain continues down along the prevertebral muscles with the pharyngeal constrictor, levator palatine, and tensor palatini with tongue attachments. It continues inferiorly to the intercostals and thoracic diaphragm with iliopsoas and iliacus attachments, and continues with the quadriceps to the dorsal foot. The upper extremities have portions of this fascia along the medial portion of the triceps. The third fingers and toes end its path. The PAAP chain relates to the posterior pituitary and represents more of a neurological connection than the posteromedian facial chain which is connected to the anterior pituitary, representing a hormonal connection.

A weakness of the iliopsoas muscle may have influencing affects on the entire chain. An example of this may affect the thoracic diaphragm, influencing the respiration and digestion system, as well as, lesions along the central chain and thus influencing the uterus.

From the embryological stages of development of the anterior/posterior pituitary, as they came together they formed the hormonal/nervous system balance, respectively, and are considered by many that follow eastern systems, the Ying/Yang or balance of the body in the meridian system. This type of people are morphologically described as “fun people” or “thinker/dreamer” types who they tend to have ballet-dancer body types and show concerns in the heart and small intestine meridian system which are psychologically related to choices in life (Canadian College of Osteopathy-Laflamme, 2006).

3.3.3. ANTERIOR MEDIAN CHAIN

The third CV, the occiput, is connected to the lingual chain (anterior median, or AM chain) (Figure 17). The path of the lingual chain commences at the pineal gland and runs through to the straight sinus and onto the internal occipital protuberance. It spreads throughout the occipital squama and tympanic cavity and then densifies in the medial malleus, emerging to the mandible. It continues through the buccal and hyoid muscles and runs inferiomedially to the sternocleidomastoid and anterior scalene through to sternal attachments. The AM chain further connects to the abdominal muscles and the pelvic floor (internal obturator), reaching its final destination in the adductors of the lower limb. The upper limb connections commence from the anterior deltoid to the supinator and adductor polices muscles, thus ending in the thumb and big toe.

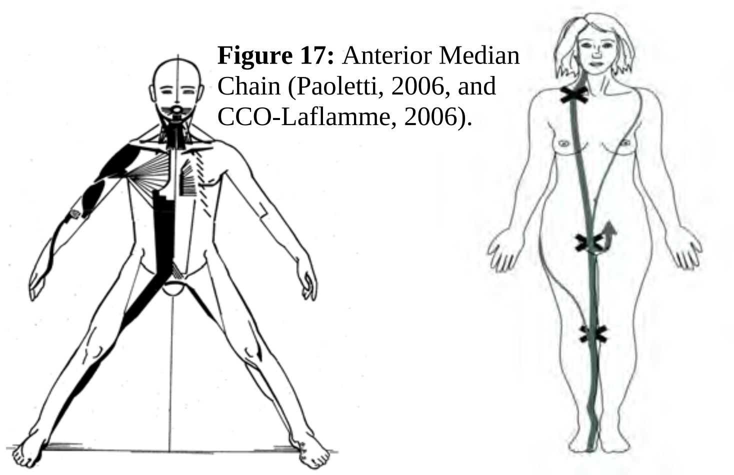


Figure 17: Anterior Median Chain (Paoletti, 2006, and CCO-Laflamme, 2006).

The affects of weakness in any of the above muscle groups has direct influences on posture, centre of gravity lines and diaphragmatic movements of the three main diaphragms (tentorium, thoracic and pelvic) resulting negatively in efficiency of the fluid systems in the body.

The AM chain is morphologically considered the love chain (looking for love) and when these types of people weaken, they have trouble in the stomach-pancreas meridian (duodenum, spleen and esophagus). This chain is linked to the sense of taste and an organ to observe would be the thyroid (Canadian College of Osteopathy-Laflamme, 2006).

3.3.4. ANTERIOR AND POSTERIOR LATERAL CHAINS

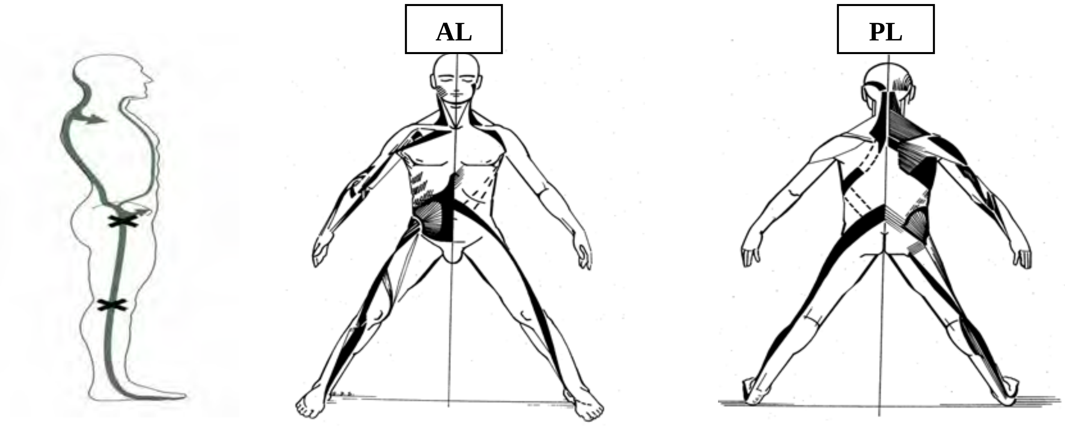


Figure 18: From left to right: Lateral chain (side view), Antero-lateral, and Postero-lateral (Paoletti, 2006, and CCO-Laflamme, 2006).

The temporal bones are considered the fourth and fifth CV. These bones connect the anterior lateral (AL) and posterior lateral (PL) chains (Figure 18) at the sphenoid squamous (SS) and condylar squamous mastoid (CSM) points, respectively (Canadian College of Osteopathy-Laflamme, 2006). These chains start at the pineal gland like the lingual chain but connect to the tentorium cerebelli, run through the tympanic cavity to densify on the petrous bones, and exit through the zygomatic process to the ascending branch of the zygoma. These chains continue along the lateral angles of the frontal bone to the superior portion of the squama of the temporal bone and exit at the mastoid. These lateral adaptive chains then cross to the other side of the body and each chain follows its anterior SS point through the masseter and clavicular sternocleidomastoid muscles and its posterior CSM point through the temporalis and levator/rhomboid muscle attachments respectively. The AL chain further continues along the anterolateral muscle fibers of the thorax down to the tensor fascia lata to the deep plantar muscles and anterior-lateral aspects of the upper extremities with attachments to the second fingers and toes. The path of the PL chain continues on the posteriolateral side of the thorax and upper extremities.

Inferiorly, this chain propagates through the gluteus medius and lateral sides of the lower leg. This chain ends and can be examined via the fifth finger and toe and the liver-gallbladder meridian system. The chains continue throughout the rest of the body.

A weakness in the gluteus medius, not only affects gait and posture, but may influence, globally, the circulatory system with lesion of the temporal bones and its connections to the carotid arteries.

The following provides a local examination of the pelvic fascia. A pelvic imbalance caused by a caesarean scar can produce eventual disruption to all areas of the body via its connections. Still states, “Disease is the result of anatomical abnormalities followed by physiological discord” (Sutherland, 1962, p. 54).

Appendix L illustrates the regional connections of the fascia of the uterus to the pelvis and abdominal cavities. Connected by the transversalis fascia of the abdomen, the perineal fascia is divided into the superficial, middle, and deep (urogenital diaphragm) fascia and serves to close the lower part of the abdominal cavity (Paoletti, 2006). The perineal fascia has extensions into the central tendon of the perineum and closes the bottom of the thoraco-abdominal cavity (Paoletti, 2006). The perineal fascia has attachments to the lower limbs through fascia from the boney landmarks of the pelvis and the aponeurosis of the gluteal muscles. The deep perineal fascia extends throughout the entire peritoneum, which joins the middle peritoneal fascia, deep abdominal fascia, and umbilical fascia. Laterally, this fascia joins with the internal obturator muscle and the aponeurosis of the coccygeal and piriformis muscles. Posteriorly, this fascia joins the presacral septum with the periphery of the transversalis fascia (Paoletti, 2006).

Caesarean scars have direct links to the perineal fascia and its connection with the transversalis fascia. Through changes in tension of the fascia and disruption of the position of the pelvis structures the rectus abdominal muscle (primarily) and the internal obturator, gluteus medius, and adductor magnus (secondarily) are affected. These structural changes could cause a potential dysfunction of the urogenital systems and the pelvic sphere.

The sacrum, part of the boney anchors used in the integration techniques, is connected to the uterus via the uterosacral ligament and the broad ligament along, with neurovascular components (pudendal artery, nerve, lymph, PNS, and SNS). If the sacrum, a structural element, is in lesion, the function of the pelvic sphere can be disrupted via its connections, and dysfunction of the contents may result**.** Treatment of fascial connections related to the lumbar anchors improves the function of the suspensory ligaments of the ovaries, as well as lumbar sensory/motor nerves and sympathetic drive to the entire gynecological star (Appendix M).

Treatment of caesarean scars may help to reduce fascial tensions and dysfunction and thus reduce or eliminate disease associated with the scars.

3.4. MUSCLES OF INTEREST

The connections of the muscles of interest in this study are continuous with each other and the surrounding anatomy, and are not studied in isolation (Appendix C).

The interconnection**s** of the caesarean scar to the entire gynecological sphere (Appendix M) and the muscles of interest, that will be described, and ensuing tissular dysfunction of these structure**s** may implicate and impact on the four osteopathic principles and may cause disharmony in the health (physiology) of the body.

The rectus abdominus muscle is relevant to this study because during caesarean surgery the muscle is cut above its origin at symphysis pubis. The insertion of the rectus abdominus muscle is on the lower ribs (Kendall & Kendall McCreary, 1983) and if the muscle is influenced by tension of the scar, respiration and posture may potentially be affected. The scar could potentially weaken the muscle, which may result in low back pain or opposite shoulder restriction, if the weakness is one-sided (Kendal *et al.*, 1983).

Though not scientifically supported, acupuncture or applied kinesiology theories associate the rectus abdominus muscle with the small intestines/duodenum, which is involved with “stomach” aches and indigestion (Thie, 1973). See Appendix C (AK chart-small intestines).

The internal and external oblique and transversalis muscles are omitted from this work. Although they have great importance in abdominal strength, the investigation of these muscles could support a thesis on its own. They are omitted here in order to maintain the focus and scope of the present investigation.

The iliopsoas muscle is composed of the psoas major and the iliacus. In 40% of patients it also includes the psoas minor (Kendall & Kendall McCreary, 1983). The psoas major originates from the anterior surfaces of the transverse processes of all the lumbar vertebrae, sides of bodies, the intervertebral discs of lumbar and last thoracic vertebrae, and membranous arches traversing the sides of the lumbar vertebral bodies. This muscle helps keep the curve in the lumbar spine (Kendal *et al*, 1983). A relationship of the psoas major muscle to the uterus can made through the anterior longitudinal ligament of the spine via the pharyngo-prevertebral fascia of the central chain (Canadian College of Osteopathy-Laflamme, 2006). This is continuous with the presacral fascia and perineal fascia. The psoas major attaches to the iliacus muscle, which has attachments on the iliac fossa, internal iliac crest, iliolumbar, and anterior sacroiliac ligaments and the ala of the sacrum. The iliopsoas muscle and the broad ligament share a common attachment onto the internal iliac fascia.

Within the broad ligament, which hold the uterus in its normal position**,** are the round ligament of the uterus and uterine vessels (Paoletti, 2006). Both muscular and ligamentous relationships may be affected by lesion caused by the caesarean scar at their mutual attachment site, and could alter uterine function. Also, a lesion of the innominate, caused by a dysfunction of the iliopsoas (from the caesarean scar connections), may have structural implications on the uterus.

There is a regional connection between the thoracic diaphragm and the kidney and the ovarian artery, particularly the left kidney via the shared renal artery/vein (Canadian College of Osteopathy-Laflamme, 2007). If lesioned or weak, the iliopsoas muscle can disrupt lumbar alignment and inhibit the mobility of the kidney on its rail, creating discomfort or pain in the patient’s lower back and affecting the kidney filtration system. Decreased kidney function may result in skin conditions like acne, pimples, eczema and can aggravate heart conditions such as blood pressure (Thie, 1973). Blood flow to the ovaries and uterus may be affected because of the shared left renal-ovarian artery and the ovarian arteries stemming from the level of L2 (Appendix F) which is treated in this study.

Weakness of the iliopsoas can result in difficulty ascending stairs since the patient may not be able to elevate the thigh enough to clear a step. Indeed, this may be the earliest clinical sign of a stenotic lumbar spine (LaBan, 2004) and can be associated with an ipsilateral degenerative hip joint due to the loss of internal joint rotation and muscular atrophy (LaBan, 2006). It can be postulated, that one sided weakness with this muscle can be further associated with internal rotation of the foot or lowering of the hip causing further changes to the body’s structure and function.

A weakness in the iliacus muscle may affect the ileocecal valve (Thie, 1973), allowing contamination to occur from the large intestine to the small intestine. Possible symptoms include nausea, sudden low back pain, shoulder pain, headache, sudden thirst, dark circles under the eyes and pallor (Thie, 1973).

The adductor magnus stems from the inferior pubic ramus, the ramus of the ischium, and the ischial tuberosity (Kendall & Kendall McCreary, 1983). From these origins, it attaches to the medial femur. This muscle is chosen as the hip adductor component of the muscle testing in this study since it is the largest of the adductors. The adductor muscle is part of the AM chain crossing over the abdominal area, with fascial connections extending cephalically to the pineal gland, straight sinus, and occiput in the fascial continuum. A weakness in the adductor muscle may contribute to hip joint instability causing hip pain and potential hip joint bursitis and degeneration, knee alignment problems such as capsular and ligamentus dysfunction causing inflammation, gait changes and knee pain. A weakness in this muscle can cause a person to have a varus or bow-legged position of the legs (Thie, 1973).

The gluteus medius muscle is part of the buttock group (gluteus maximus and minimus) and originates on the external surface of the ilium between the iliac crest and posterior gluteal line dorsally, and anterior gluteal line ventrally, as well as the gluteal aponeurosis (Kendall, 1983). This hip abductor muscle connects to the gluteal aponeurosis with fascial attachments to the iliac crest, sacrum, coccyx and sacrotuberous ligaments. The anterior portion of the fascia continues with the fascia lata muscle and the posterior portion goes as deep as the gluteus maximus (Paoletti, 2006).

The connection of the gluteal aponeurosis to the sacrum and ilium via the gluteus medius muscle creates a relationship with the uterus via these boney structures and fascial continuum. The gluteus medius muscle is part of the PL chain, which creates a fascial connection to the occipital mastoid suture, the contents of which include the vagus nerve. A local dysfunction of the gluteus medius muscle has direct effects on pelvic alignment, which influences centre-of-gravity lines and posture. Possible presentation due to weakness in the muscle show the hip and shoulder to be high and a tendency towards bowed legs or a limp (Thie, 1973). The gluteus medius muscle helps, in part, to control ankle motion and weakness can result in dysfunction of the ankle (Niemuth, Johnson, Myers, and Thieman, 2005).

Acupuncture theory relates gluteus medius to gynecological and androcological circulation, and problems can create such symptoms as menstrual cramps, prostate and impotency conditions (Thie, 1973). See Appendix C (AK chart -circulation).

The internal obturator muscle is connected to the aponeurosis of the internal obturator via the deep perineal fascia. It originates on the rami of the pubis and ischium and on the external surface of the obturator membrane (Kendall & Kendall McCreary, 1983). The internal obturator muscle is connected to the levator ani muscle (Appendix N), which makes up part of the pelvic diaphragm (Moore, 1985) that forms the fibromuscular pelvic floor and supports the pelvic contents.

The pelvic, thoracic and cranial diaphragms are linked by a fluid dynamics system and a synchronicity of all the diaphragms throughout the body (Appendix J). A weakness with the internal obturator muscle may create pelvic floor dysfunction and give rise to problems such as organ prolapse of the uterus or bladder and urinary or fecal incontinence, as well as painful urination (Thie, 1973). Pressure on the sciatic nerve resulting in pain, numbness and tingling down the legs may be associated with weakness of this muscle because of its association with the piriformis, which crosses over this large nerve network. (Thie, 1973).

Druelle (2008) said that treatment of the three main diaphragms assists in global autoregulation by decreasing neurofacilitated segments, increasing circulation, providing a balanced ANS that will help to relax the myofascial system and psycho-emotional states and maintain an optimal immune system and a regulated hormone system (tentorium—pituitary, thoracic—pancreas/adrenals and pelvic—ovaries).

Acupuncture and AK theories associate the adductor, gluteus medius and internal obturator muscles with the circulation meridian (Appendix C) (Thie, 1973).

The strength and function of the muscles of interest rely on the influence of various systems such as the neurovascular, myofascial and skeletal systems. A caesarean scar that creates lesions within the body disrupts neural, circulatory, lymphatic, myofascial muscular inputs, potentially affecting muscle strength.

3.5. SCAR MATRIX

The scar matrix of subjects admitted to the study will have had time for the fluid ground substance to become dehydrated and assume a contracted or hardened state that kinks the collagen bundles and shortens related structures (Hammer, 2001). Toxins and metabolic waste products accumulate in these potentially dense connective tissues due to a decrease in mechanical movement and a decrease in electric flow from the abundant negative charges in the scar (Hammer, 2001).

The benefits of release on the scar are numerous. The myofascial release technique, which is an application of pressure in three dimensions, hydrates the tissue and helps transform the fluid in the scar, affecting its ability to conduct energy (Manheim, 2001). Scar release also improves the mobility of the related structures such as organs (colon, bladder, and uterus) and lumbar-sacral bones. After treatment of the ground substance, the tissue becomes more porous assisting in the diffusion of nutrients and oxygen, as well as waste removal and metabolic regeneration.

It is theorized that compression of the tissue creates a piezoelectric effect and generates electric fields or intrinsic currents (O'Connell, 1998). These currents effect cell regeneration producing an "intermolecular shearing force by changing the relative position of the individual molecules" (Hammer, 2001, p. 2) generating micro-electricity that the fascia transfers into mechanical vibrations (O'Connell, 1998). In bone repair compressive and distractive forces create an electrical field gradient that stimulates osteoblast/osteoclast activity until the resting potential is rectified (O'Connell, 1998) or healing has occurred. Furthermore, "the piezoelectric nature of collagen allows a response to changes in mechanical stress and bioelectric potentials intelligently" (O'Connell, 1998, p. 24). Thus the release of the scar will assist the body in further optimizing homeostasis.

The myofascial release in this research uses a primarily direct treatment protocol that moves toward the restrictive barrier in a three-dimensional pattern (Manheim, 2001) which is discussed in detail in Chapter 4.10 of this thesis. The chronic state of the scar may require the use of indirect or strain counter strain techniques. A direct technique is a highly interactive stretching technique that uses a kinesthetic link with the subject and requires the therapist to determine by palpating the passive feedback from the subject the duration, force, and direction of the stretch in order to facilitate maximum relaxation of the restricted tissue (Manheim, 2001).

Druelle (2004) describes the process:

> Once the position and mobility are re-established, the quality and vitality of the tissue gradually returns as circulation fluids are allowed to pass in, through, and out of the area. With the return of flow of these fluids comes the life and health sustaining elements that are contained within that fluid. (Druelle, 2004, p. 1)

3.6. ENERGY FIELDS

Figure 19: Spiritual energy system (Grey, 1990).

Sensitivity of the practitioner treating the caesarean scar is required in order to have a deeper understanding of the totality of the patient presented in this study. Within this research study, the subject is only treated at the physical level but an appreciation of the energy fields that surround the body, such as the emotional body field, are important for the practitioner to obtain awareness in that compassion for the subject entering into this study is respected.

Osteopathy is defined by the Canadian College of Osteopathy (2004) from 1st year GOT course handout as:

> A natural medicine and science based on precise palpatory acts. Its objective is to liberate the different tissues of the organism, the mechanical constraints which prevent them from accomplishing their natural functions.
>
> It describes the interrelations between systems, the laws which protect the equilibrium and health of the Human being globally. The goal is to search for the causes of the dysfunctions and to put back into movement the functional unit of the human being (CCO, 2004, p. 1).

Frymann (1980) is quoted as saying:

> The experience of becoming a physician involves not only the mastery of skills, the acquisition of knowledge and the passing of examinations—it also demands the development of emotional diagnostic awareness and intuitive perception which, over the bridge of compassion, reveal the causes behind the causes' of the presenting complaint (Frymann, 1980, p. 18).

The etheric body is an energy field radiating perpendicularly from the physical skin approximately two inches, replicating the body of matter with a point of contact in every cell (Frymann, 1980), and can be palpated with a feeling of intense, vibrant and strong centrifugal motion in healthy individuals (Brennan, 1987) . This energy body activates and vitalizes every function in the physical body (Frymann, 1980) and is connected to the natural metabolism of energy, which maintains the structure and function of the etheric body or yin/yang balance (Brennan, 1987). The emotional body extends its energy approximately twelve to eighteen inches above the skin surface

(Frymann, 1980). This energy can be seen as a kaleidoscope of flowing colors around the body by some with trained eyes (Frymann, 1980). The gamut of emotions and negativities that influence the body are yet to be discovered in order to provide freedom to the patient to optimal health (Frymann, 1980). The natural unblocked flow of feelings corresponds with divine reality expressing and creating love (Brennan, 1987). The mental body, pure logical thought, without emotions utilizes clear thinking to implement love and will (Brennan, 1987). The spiritual body(s) (figure 20) utilizes these latter energy bodies to orchestrate their interaction to communicate and balance individual health (Brennan, 1987).

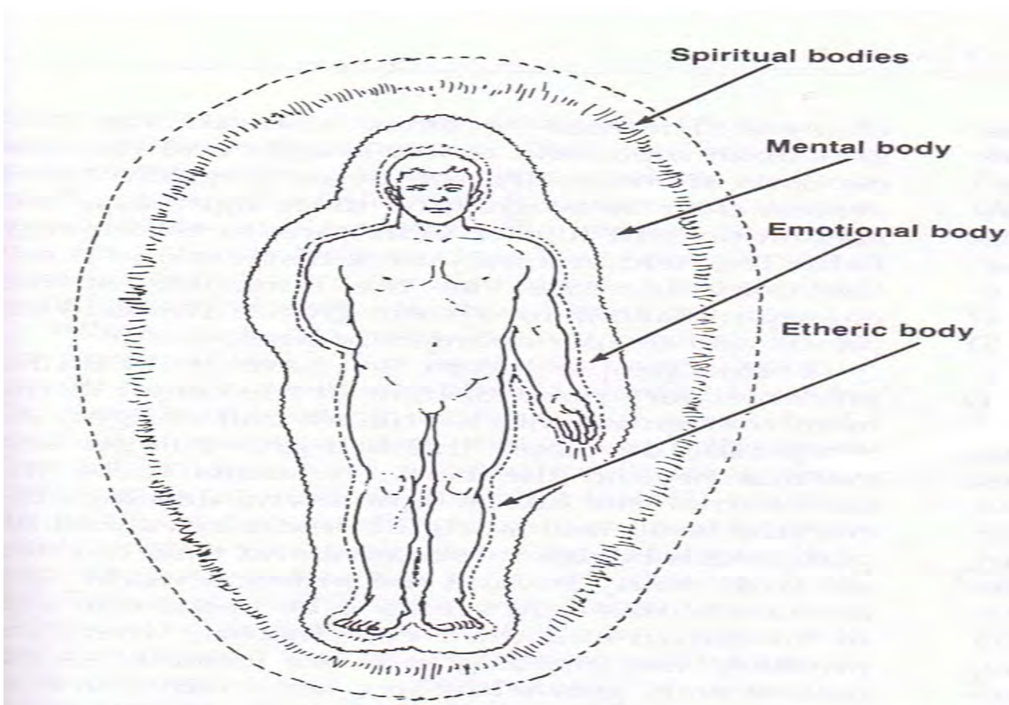


Figure 20: The Aura depicting the layers of energy body fields (Brennan, 1987).

The creative process of health in these energy fields can be affected negatively and ensue disease (Brennan, 1987). Scars from surgeries affect the physical layer and sometimes all the way to the spiritual layers (Brennan, 1987).

Scars create disfigurations and blocks within the physical body that if left untreated or distorted, will have a difficult time healing (Brennan, 1987), circumventing normal adaptation and compensation patterns and making it difficult for the osteopathic practitioner to reach the treatment goal of finding the cause(s) of disharmony in order to attain resolution.

Frymann (1980) stated:

> It is my observation that the most common, most often encountered etiologic condition of this generation may be called spiritual starvation. It requires compassionate understanding and God-given wisdom to bring awareness to our patients that they have emotional needs that must be satisfied and spiritual hunger that must be fed, before they can enjoy vital well-being (Frymann, 1980, p.18).

There are many relationships of the caesarean scar to the uterus and to the specific pelvic muscles that are included in this study. In order to have an understanding of the totality of the human framework and the impact a caesarean scar can have on this totality, this study explores the musculoskeletal system, viscera, the contiguous spinal reflex levels of the lumbar and sacrum boney anchors, myofascial chains, neurovascular systems, and energy fields of the body.

4. CHAPTER FOUR: RESEARCH METHODOLOGY

The research is a time-controlled within subject design that includes 27 female subjects ranging from twenty to forty-five years of age who have transverse Caesarean scars. Sample size is calculated from the pilot study discussed Chapter 4.10. Percentage change in muscle strength was measured for all of the subjects before and after each treatment. The subjects were obtained through flyer advertisement sent by the author to various medical and paramedical professional clinics, schools, other public places, as well as friends and family (Appendix O). The inclusion and exclusion criteria are detailed in Appendix P is sufficient and extensive enough for participation in this study, precluding the requirement for a case history form for each subject. Appendix Q is the consent form.

4.1. INCLUSION CRITERIA

To be included in this study, subjects must the following requirements:

- be female and twenty to forty-five years old
- be non-menopausal
- have had a transverse caesarean section scar
- be able to invest time for visits during the study
- be able to complete and sign all questionnaires and consent forms
- be twelve months or longer postpartum

Multiple caesarean sections are acceptable. Previous vaginal and caesarean births are acceptable. Participants may be physically active or sedentary.

4.2. EXCLUSION CRITERIA

There are a number of criteria that would exclude a subject from this study:

- any pelvic or abdominal pathologies and/or ongoing related treatments
- any abdominal surgeries other than caesarean sections
- any major whiplash injuries or head trauma with loss of consciousness
- any knee or hip traumas that prevent muscle testing
- currently pregnant
- the use of internal vaginal devices such as IUD's that may be a possible source of infection

These criteria are used to screen subjects by phone prior to inclusion in the study. The subjects are sent a research information package containing information about the study, and a consent form to be signed and returned.

4.3. RESEARCHERS

The fitness consultant (FC) performs all subject muscle testing with the Lafayette strength-gauge instrument. An assistant to the FC records the strength of the specific pelvic muscles on both sides of the body on the chart shown in Appendix R. The osteopathic thesis writer (researcher) will perform all treatments.

4.4. MEASURING INSTRUMENTS

The 01163 Lafayette dynamometer is sometimes still referred to as the Nicholas dynamometer. This tool has a load-cell recording device that displays a digital readout in kilograms of force and length of time of muscle contraction (Lafayette user's manual) as supported by literature in Chapter 2.0 of this thesis.

4.5. EQUIPMENT

The treatments for the study were provided at 390 Steeles Avenue West, suite 206, Thornhill, Ontario**.** The treatment room is set up with a hi/low massage table, pillow, towels, linen sheets, blanket, digital clock, weight scale and a surround-sound system that provides relaxation music.

4.6. SETUP PROCEDURE

A control group muscle test procedure is performed to obtain a baseline reading of the subjects. Subjects will be weighed in kilograms prior to each MMT session as this data may be useful in data analysis. The subjects were positioned on a hi/low table and the FC tested the relevant muscles of each subject using the dynamometer (Chapter 4.7).

An assistant recorded the findings. Each muscle was tested twice on each side, and the mean score will be calculated. The percentage change in strength over the period of the study is calculated to determine the effects of treatment. The same group of subjects is used for the control and the treatment groups.

4.7. TESTING PROCEDURE

The Control subjects undergo a muscle testing (MT) three times: once at week zero, once at week four, and once at week eight. At week eight, the control group becomes the treatment group. The three sets of MT's performed to this date provided baseline data. The Treatment group is treated on the eighth week for thirty minutes after their week eight MT. Each treatment is thirty minutes in length in order to minimize tissue irritation and avoid increased tension of the scar area, which would counter the goal of the session. Paoletti (2006) suggests three to five minutes is enough time for tissues to release with this procedure. The treatment is thirty minutes in length because the scar is released, as we will describe below, in relation to the boney anchors (each lumbar vertebrae and sacrum) and over the entire scar (without the boney anchors).

The treating therapist has a number of years of experience treating caesarean scars and considers that the time allotted is sufficient to complete the treatment requirements.

The subjects are tested again at week twelve and receive a second treatment following the test. The Treatment group has a final MT at week 16 (Chart 2). The treatments are provided four weeks apart in order to allow physiological and biomechanical healing time between treatments. The data from the FC's MT for the control and treatment groups is collected and analyzed for statistical purposes (Appendix R). The subjects are instructed not to speak to any of the researchers regarding this experiment and their experience.

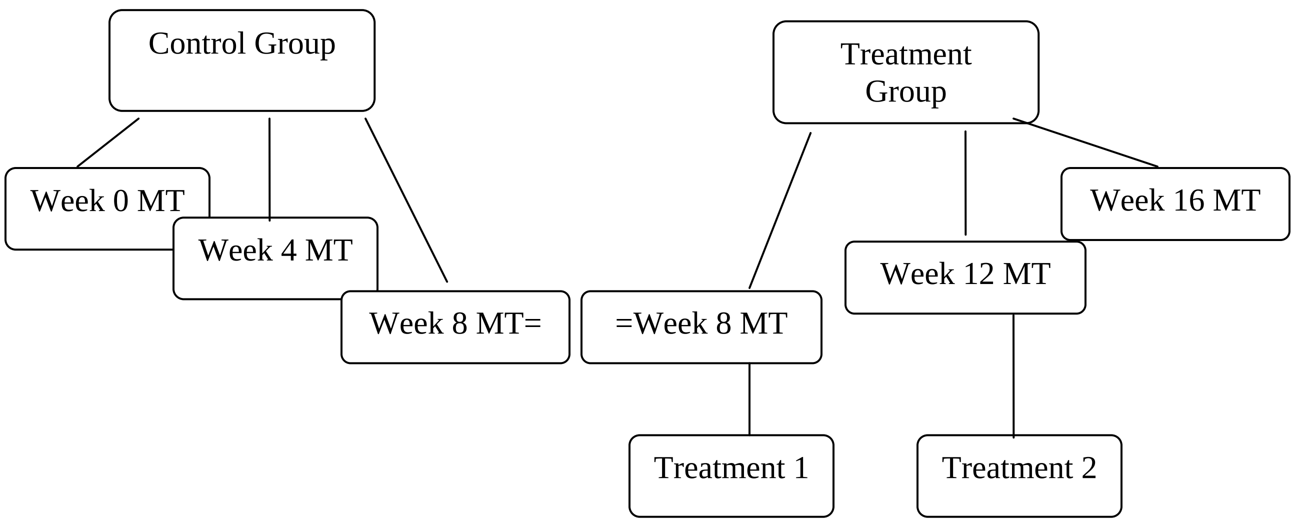


Chart 2: Summary flow chart of study (Author, 2008)

4.8. MUSCLE TESTING PROCEDURE

The FC has been a personal trainer and rehabilitation consultant for fifteen years and has experience with dynamometer testing with the specific muscles of interest. The FC follows the recommended procedures for the Lafayette dynamometer, (Appendix S), (Martin et al., 2006) after a protocol orientation to achieve rater reliability (Martin et al., 2006; Bohannon, 1990).

Figure 21: Lafayette dynamometer (Author's photo, 2008).

The hand held dynamometer (HHD) is programmed to measure the peak force in kilograms during three seconds of muscle contraction (Figure 21). The unit indicates the start and the end of the three-second duration with audible beeps (one beep for start and three successive beeps for stop) (Martin et al., 2006).

The subject is instructed to start to maximally contract with the sound of the first audible beep and the FC's command. The FC instructs the subject to stop contracting at the end of the three successive beeps. There is a thirty second rest period timed by the assistant and then the measurement process is repeated. The assistant records the force of the resistance applied by the subject in kilograms. Each muscle of interest is tested and recorded twice. The FC uses an isometric make test, whereby she/he holds the HHD in the fixed position indicated for each muscle, and the subjects are asked to maximally push against it. A make test, as opposed to a break test is considered to be easier for participants to perform and, therefore, produces more reliable results (Smidt & Rogers, 1982; Dunn & Iverson, 2003). The FC places the HHD at the indicated level (Appendix S) for each muscle as the subject performs a three-second maximal isometric contraction against resistance with motivation by the FC. These parameters are based on previous studies (Dunn & Iverson, 2003; Bohannon, 1990; and Niemuth et al., 2005). All the positions of the muscle testing procedure are standardized following the method described by Kendall and Kendall (1983).

During the muscle test, the participants are not allowed to self-stabilize by holding their hands on the table or pushing against the table. The subjects are instructed to place their hands loosely on their torso to achieve accurate readings of the muscles tested (Martin et al., 2006). If self-stabilization occurs, the results are discarded and the test is repeated after a rest period. The FC is instructed to stop testing if a test causes the subject pain. The procedure takes approximately ten to fifteen minutes per subject.

Appendix S details the contact points around the malleolus for the iliopsoas, adductor, gluteus medius, and obturator internus muscles. For the exception of the rectus abdominus muscle, the HHD contact point is placed approximately 2 cm proximal to the malleolus (Niemuth et al., 2005). The limb not being tested is stabilized by the FC while the subject is lying in a supine position. The rectus abdominus is tested in a sitting position and their arms are crossed at the wrist-joint area on their chest, creating a contact point of 2 cm proximal and dorsal to the wrist joint.

The FC will not see the muscle force produced during testing because the readout display of the HHD faces away from the FC. The FC immediately shows the results to the assistant who is in the room during the muscle-testing procedure to record the results of each muscle test and uses the stop watch to control the rest period time. The weight in kilograms of each subject is measured at the beginning of each muscle-testing visit to provide further data for statistical analysis (Figure 22).

Figure 22: Calibrated weight scale with 2- 3 pound weights (Author’s photo, 2008)

4.9. TREATMENT PROCEDURE

The author and primary researcher, an osteopathy thesis writer from the CCO, performs all treatments on the subjects. Myofascial release techniques described in Chapter 4.10 are employed to release the Caesarean scar of each subject. The primary researcher instructs the subjects to lie supine on the hi/low table with a pillow support under the knees and head to relax the muscles of the abdominals and lower back. The subject is instructed to void her bladder prior to the treatment so that discomfort and interruption of the treatment is avoided. The subject is then instructed to disrobe (in privacy) and leave on their undergarments or wear shorts and loose-fitting upper body clothing. The subject is instructed to cover their lower body with the provided linen sheet as they lay on the table. A towel is then placed over the undergarments along the base of the scar to expose the scar and for patient comfort and to protect modesty. A pillow is placed on the upper thigh of the subject for any necessary support for the researcher. The subject is asked if they are comfortable and warm.

The potential loss of function caused by a scar is common and can be a primary cause of physiological, biological, or mechanical dysfunction (Paoletti, 2006). The depth of the scar in this study takes us through all the layers from the skin to the uterus, following the surgical incision procedure.

The application of myofascial release to the caesarean scar is determined by the rhythm and sensitivity of the subject. Listening and testing allows engagement of the tissues and an introduction of the researcher to the subject.

4.10. TECHNIQUES

Appendix T provides the complete description of the treatment techniques and procedures of myofascial unwinding of the caesarean scar.

According to Paoletti (2006), an induction approach, in which the direction of tissular tension is followed using the tips of the fingers over the area of the incision, can be used to assist the release of tension in a scar. This, in turn, allows the primary researcher to move towards a particular restriction and follow the direction of tension in all its parameters (Paoletti, 2006). Assuming a release is obtained at a superficial level, the researcher was then able to penetrate deeper to promote release in the underlying scar tissue. With long-standing scars that have caused changes to the uterus and surrounding structures of the pelvis, an induction approach is not strong enough to re-equilibrate the area and a direct approach is commonly required but is not be pursued until after induction has been attempted. In Paoletti's words:

> If direct treatment must be undertaken, begin with listening and induction whenever possible. This will put you in contact with the patient's tissues and establish communication with them. It may also help lower the threshold of irritation as a first step. After this, proceed to direct treatment and then continue by listening and induction, and finally, a listening test (Paoletti, 2006, p. 294).

A direct approach uses parameters of rigidity with the scar and creates a stretching force, depending on the tissue response, accumulating all the parameters of motion, which are caudal/cephalic, left/right transverse and left/right rotation, that are rigid. The intention of the technique is to restore freedom of movement.

The use of induction and direct approaches gives the researcher the flexibility to restore elasticity to the scar in order to improve and preserve its function (Paoletti, 2006).

Other myofascial techniques used during the treatments depend on subject tissue responses, and include indirect or ease, (going into the ease of motion), strain/counter strain, and Hoover techniques (mid-point parameters of tension).

The integration of the sacrum and lumbar vertebrae with the caesarean scar is integral in attaining freedom of the restricted structures that support the neurovascular and fibrous tissues of the tested muscles, the uterus, and its neighbours. The sacrum is contacted with one hand and the scar with the finger tips of the other hand. The sacral hand provides a slight anterior motion in order to engage the sacrum. The top hand engages the scar tissue in the manner described previously. The researcher's intention is to communicate or engage with any restriction felt from the sacrum. When the accumulated parameters of motion are effectively released, further restrictions are found utilizing the sacrum as a fixed point of reference or anchor. When all the parameters of motion of the scar are released with the sacrum, no further treatment is required during the treatment session.

Treatment of the lumbar vertebrae is applied with the same intention. For example, each spinous process, starting from L1, is given anterior pressure from the bottom-hand finger tips that engage the vertebrae. Each vertebra is tested and released from the scar when required. The second treatment, four weeks later, ensures continued elasticity and mobility of the scar. The same procedures are applied, starting with the scar treatment and completing the session with the integration of the sacrum and lumbar boney anchors.

4.11. SAMPLE SIZE CALCULATION –PILOT STUDY

This study hypothesizes that muscle strength will change from pre-treatment to post-treatment and so the statistician estimates the sample size using paired t-test. To do this the statistician needs an estimate of the usual amount of variation when testing subject muscle strength and an estimate of how correlated repeated measures on these muscles might be. The statistician uses the researcher's pilot study data (Appendix U) to estimate the amount of variability in kilograms of force measured on four subjects at two muscles on both the right and left side on two different days. These results are summarized in Table 3. Table 4 (in Chapter 4.11.1) describes the calculation of obtaining the sample size for this study using the data collected in the pilot study in Table 3 provided by the statistician (Duquette, personal communication, May 10, 2008).

Table : 3. Average differences in muscle strength measurements from four subjects taken on different days

	Gluteus Medius Strength (kg)		**Obturator Internus Strength (kg)**	
Parameter	**Right**	**Left**	**Right**	**Left**
Mean	–0.2	0.46	–0.45	0.32
Standard deviation	2.2	0.51	1.16	1.0
Correlation between measures	0.87	0.99	0.72	0.32

4.11.1. POWER SCENARIOS

The statistician uses SPSS sample power software to estimate the relationship between sample size and power under a variety of scenarios. Recommended sample sizes are those associated with a power of 80%, which means that there is an 80% chance of finding a significant change in muscle strength from pretest to post-test at an alpha level of 0.05. In all scenarios, the statistician assumes that the correlation of muscle measures from pretest to post-test would be 0.72 (the mean of the four measures in Table 3.).

Table 4 provided by the statistician (Duquette, personal communication, May 10, 2008) shows the results of power scenarios. Scenarios are shown based on both a 1-tailed and a 2-tailed hypothesis. A 2-tailed hypothesis means that the researcher simply predicts a change in the outcome from pretest to post-test (increase or decrease), whereas a 1-tailed hypothesis means that the researcher predicts that the measurement at post-test will go in a particular direction (the researcher believes that muscle force will increase after treatment). A 1-tailed hypothesis is associated with a smaller recommended sample size but is only justified if the researcher has some prior evidence to suggest that the measurement at post-test will change in the predicted direction. Both the statistician and the researcher agree that such evidence is not present, so the sample size has been based on a 2-tailed hypothesis.

Also shown in Table 4 are results based on a very high standard deviation of 2.2. The statistician believes that deviations are conservative and can be considered unlikely. Results based on the average standard deviation of 1.2 are probably adequate.

The statistician constructed scenarios based on both a large (1 kg) and a small (0.5 kg) change in muscle strength, which is the amount of difference that the researcher expects to find in the measurements from pretest to post-test. An average change in muscle strength of one kilogram seems like a large amount, so a change of a half a kilogram might be more reasonable.

Table: 4. Results of power scenarios under various conditions of high and low standard deviation, change in muscle strength, and 1- and 2-tailed hypotheses.

Change in Muscle Strength	**Standard Deviation**	**1- or 2-tailed Hypothesis**	**N (for 80% power)**	**Comment**
0.5kg	2.2 (high)	2	85	Very conservative
0.5 kg	2.2 (high)	1	65	Conservative but can't justify 1-tailed hypothesis
1kg	2.2 (high)	2	23	Effect size is too large
1kg	2.2 (high)	1	18	Effect size is too large
0.5kg	1.2 (moderate)	1	21	1-tailed hypothesis is not justified
0.5 kg	1.2 (moderate)	2	26	Most reasonable
1kg	1.2 (moderate)	1	7	Effect size too large and can't justify 1-tailed hypothesis
1kg	1.2 (moderate)	2	8	Effect size too large

4.11.2. CONCLUSION

Table 4 shows the results of power scenarios based on different assumptions. Although the statistician has highlighted the scenario that seems most reasonable, the ultimate responsibility for making this decision lies with the researcher and should be based on the best information that the researcher has about the measurement in question.

The researcher has acknowledged and has accepted the recommendations of the statistician for these decisions based on a within study subject design and has followed a sample size of twenty-seven subjects enrolled in this study. Originally, thirty subjects were obtained for this research but three prematurely dropped out of the study.

5. CHAPTER FIVE: DATA ANALYSIS AND RESULTS

5.1. SUMMARY

This study measures muscle tone in twenty-seven post caesarean women over a sixteen-week period. For all muscles measured, the adductor magnus (AM), the gluteus medius (GM), the iliopsoas (IL), the obturator internus (OI) and the rectus abdominus (RA), strength measured in kilograms increases over the study period. At weeks zero, four, and eight, subjects receive testing only. At weeks eight and twelve subjects receive the treatment procedure. Muscle strength increased when the average force (Kg) of the pre-treatment period was compared to both weeks twelve and sixteen. The muscle testing is measured four weeks after each treatment. However, there is also evidence that except for obturator internus, muscle strength began to increase within the pre-treatment period and before the treatment protocol was applied for the remaining 4 muscles (RA, AM, GM, IL). This casts some doubt on the conclusion that the observed increase in muscle strength in these muscles was due to the treatment. See Appendix V for raw data collection.

5.2. INTRODUCTION

The objective of this study is to compare muscle strength during the pre-treatment period and muscle strength in the treatment period to test the hypothesis that treatment protocol will increase muscle strength. Five muscles, as mentioned above, are measured for strength (kg force) on twenty-seven subjects over sixteen weeks. Subjects receive the treatment protocol on those muscles at week eight and twelve and the post testing was done four weeks after each treatment protocol.

5.3. DATA SET

Muscle strength is measured on subjects at week zero, four, eight, twelve and sixteen. Five muscles are measured on both the right and left side of the body except for rectus abdominus, which is a single abdominal muscle. Subject age, weight and caesarean status (one or more than one) are also measured in case they have an influence on the outcome variable kilogram.

5.4. STATISTICAL ANALYSIS

This study compares the force of the tested muscles from the pre-treatment period to week twelve and from the pre-treatment period to week sixteen. The statistician uses the average strength in kilograms from week zero, four and eight for the pre-treatment measurement. The data are repeated measurements made on the same subjects and so the data are analyzed using a statistical application named repeated measure models. The statistician uses a multiple linear regression model (SAS: Proc mixed) for each of the five muscles and for measurements on each of the left and the right side of the body (ten models in total) to compare the change in muscle strength from the pre-treatment period through weeks twelve and sixteen. Using mixed models allows the statistician to include other predictors in the models. Predictors used are week, subject age, subject weight and whether they had one or more previous caesarean sections.

The statistician wants to know whether or not it is reasonable to average the measurements in the pre-treatment period and constructs another set of models using all the measurements from all the weeks without averaging measurements in the pre-treatment period. This is to observe whether the changes in muscle strength that are seen in the treatment period possibly begin before treatment is applied.

5.5. RESULTS

5.5.1. COMPARING PRE-TREATMENT TO TREATMENT PERIOD

The results comparing kilograms in the pre-treatment period to kilograms in the treatment period for the right and left side of the body for five muscles are shown in Table 5. These results show that subjects experience a statistically significant increase in muscle strength over the three periods. This is indicated by the fact that the p-value associated with the week predictor was always less than 0.05. A p-value is an estimate of the probability that the observed pattern is just due to random chance. A very small p-value (<0.05) means that there is a very small probability that the observed pattern is due to random chance and the pattern is more likely to reflect a real association. The other predictors in the model (age, weight and caesarean) are not significant, which means that none of these factors have a consistent effect on the outcome and they are not likely associated with the observed pattern.

The main model results only tell us that muscle strength varies between at least two of the three time periods. In order to determine which time periods differ, the statistician conducted additional tests, which are called post-hoc comparisons.

These results are reported in Table 5. and show that kilograms differ between the pre-treatment period and both of weeks twelve and sixteen in all cases, except for pre-treatment to week twelve for right iliopsoas. The p-value for this comparison was greater than 0.05. The increase of subjects' muscle strength is seen in Figure 23 and Figure 24 provided by the statistician (Duquette, personal communication, February 24, 2009). A slightly different way to show these results is to use box plots (Duquette, personal communication, February 24, 2009), which are included below.

Table: 5. Results of 10 within-subject mixed models for the effect of predictors on muscle strength on the right and left sides of the body.

Mixed model results							
Outcome (kg)		Predictors (P value)				Post-hoc comparisons of means (P values)	
	Muscle	Week	Age	Weight	CS	Pre-treatment versus week 12	Pre-treatment versus week 16
Right	AM	<0.000	0.9	0.2	0.8	0.003	<0.000
	GM	<0.000	0.8	0.9	0.7	0.0004	<0.000
	IL	<0.000	0.8	0.2	0.5	0.13	<0.000
	RA [1]	<0.000	0.5	0.6	0.7	0.0001	<0.000
	OI	<0.000	0.5	0.7	0.9	0.0006	<0.000
Left	AM	<0.000	0.5	0.4	0.5	<0.000	<0.000
	GM	<0.000	0.5	0.6	0.8	0.02	<0.000
	IL	<0.000	0.9	0.1	0.6	0.008	<0.000
	OI	<0.000	0.8	0.7	0.5	0.001	<0.000

[1] RA results are based on 2 measurements on the right and left side of the medial line
Adductor magnus (AM), gluteus medius (GM), iliopsoas (IL), rectus abdominus (RA), and obturator internus (OI).

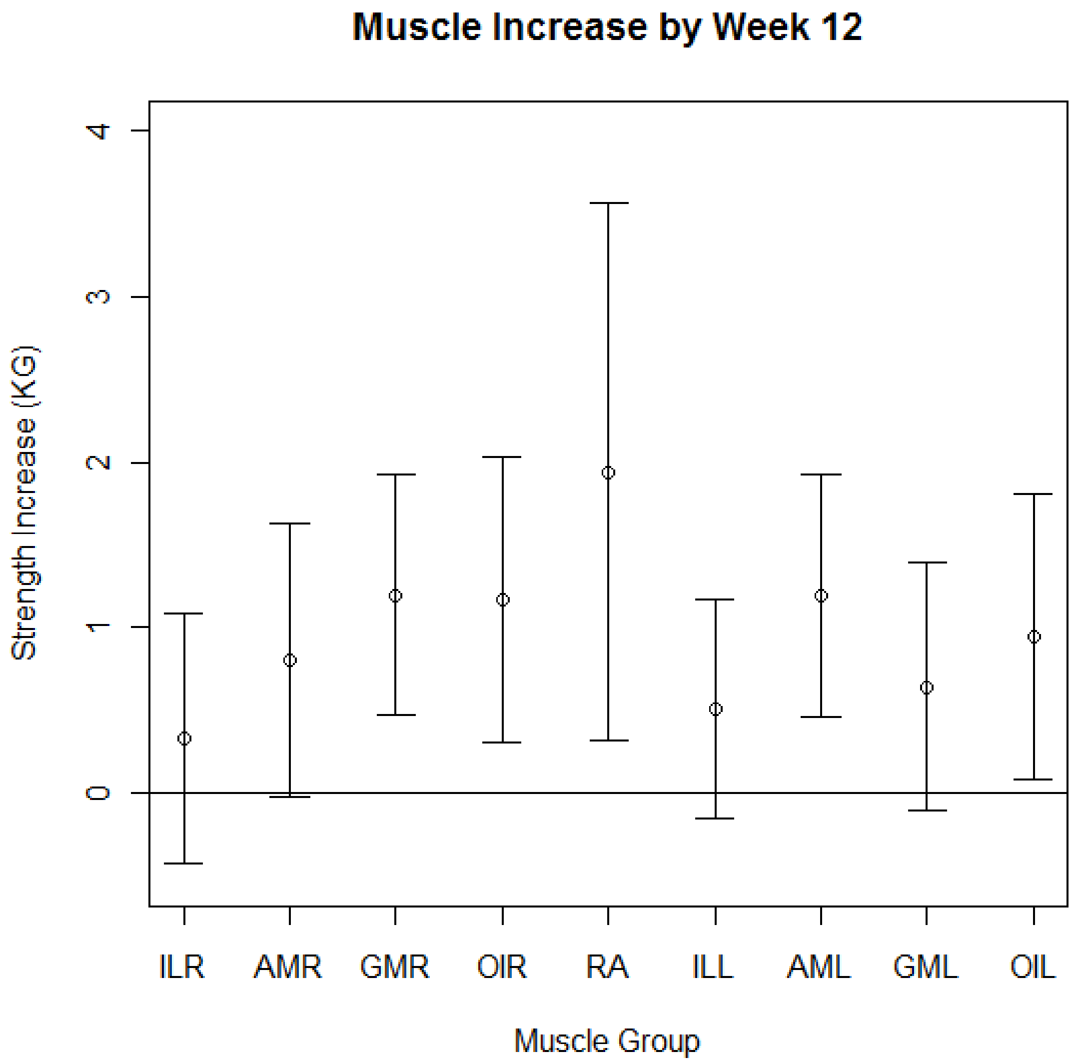


Figure 23: Improvement in muscle tone (kg) from the pre-treatment period to week twelve (week twelve - pre-treatment mean) for four muscles measured on the right side (designated by an R after the muscle acronym) and the left side (designated by an L after the muscle acronym). RA is a medial muscle so all measures were combined for this figure. The circles indicate the mean value and the vertical bars show the standard deviation. The horizontal line at zero is a reference line which indicates no change in muscle tone from the pre-treatment to week twelve.

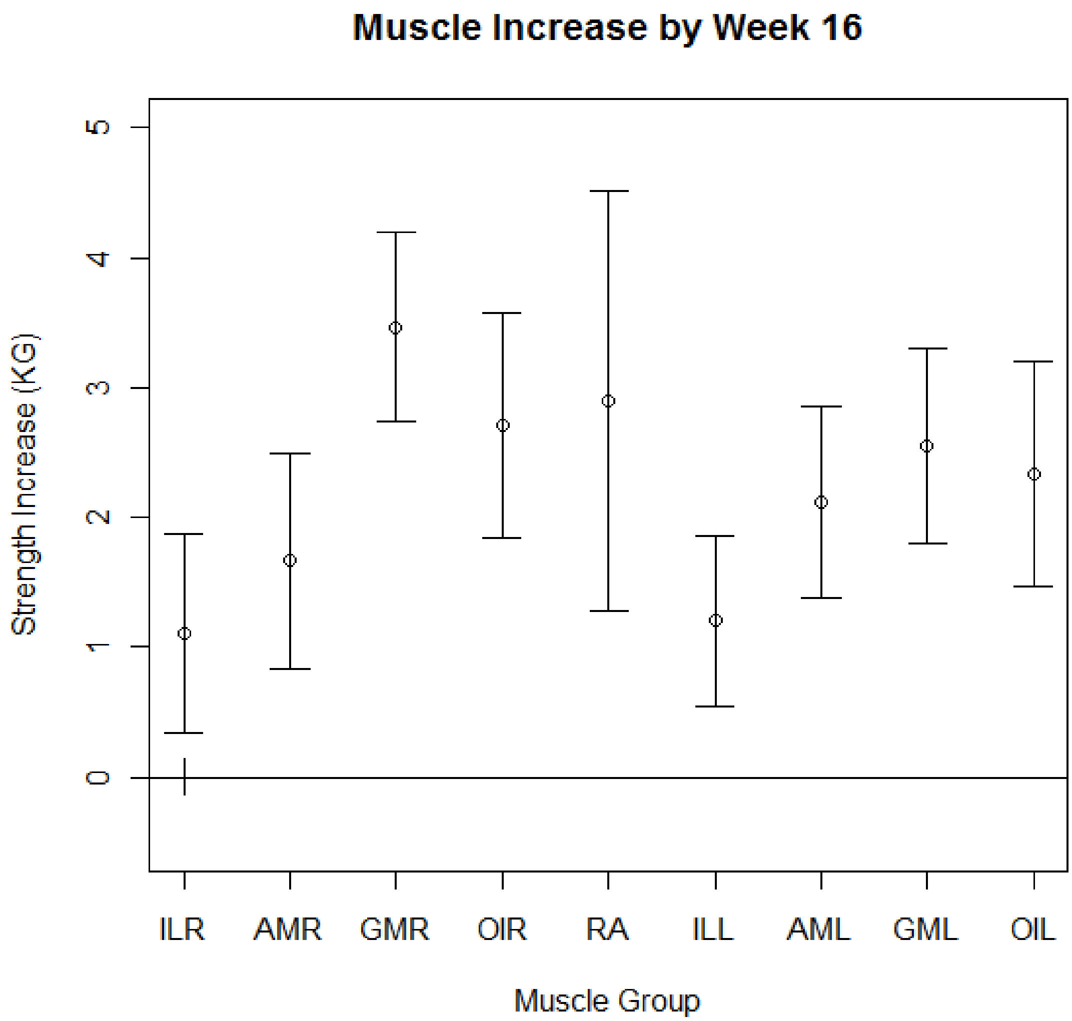


Figure 24. Improvement in muscle tone (kg) from the pre-treatment period to week sixteen (week sixteen - pre-treatment mean) for four muscles measured on the right side (designated by an R after the muscle acronym) and the left side (designated by an L after the muscle acronym). RA is a medial muscle so all measures were combined for this figure. The circles indicate the mean value and the vertical bars show the standard deviation. The horizontal line at zero is a reference line which indicates no change in muscle tone from the pre-treatment to week sixteen.

Box plots (figures 25 – 33) for each muscle showing measurements in the averaged (AVE) pre-treatment period, week 12 and week 16 for the right side and the left side. Boxes enclose 50% of the measurements. Vertical lines extend to approximately 90% of the observations. Open circles and asterisks indicate outliers and extreme values in the data set.

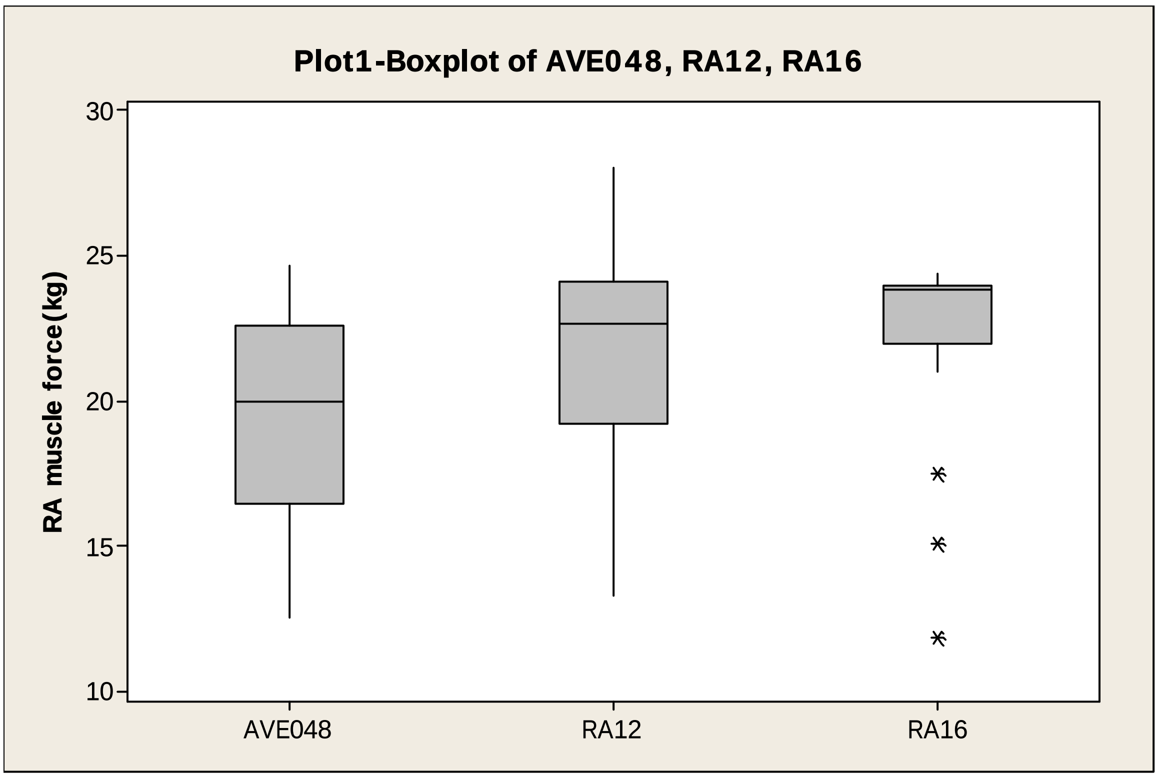


Figure 25: RA-Rectus Abdominus

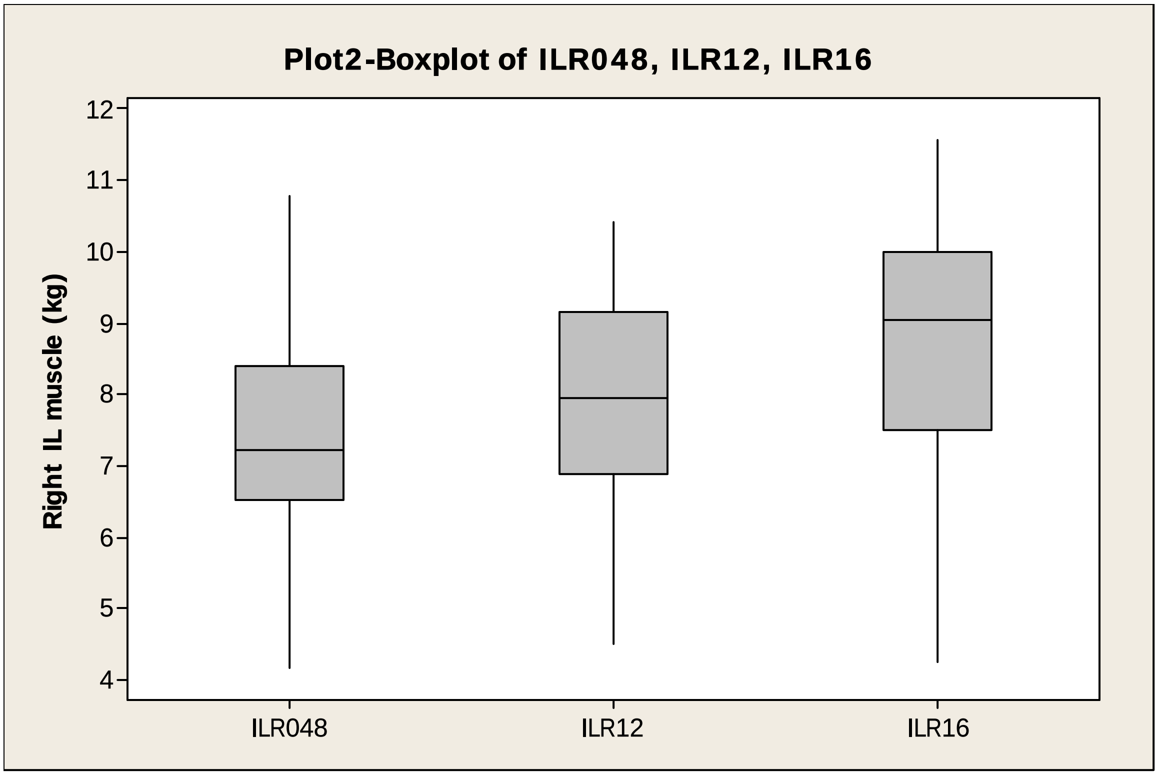


Figure 26: Right Iliopsoas-RIL

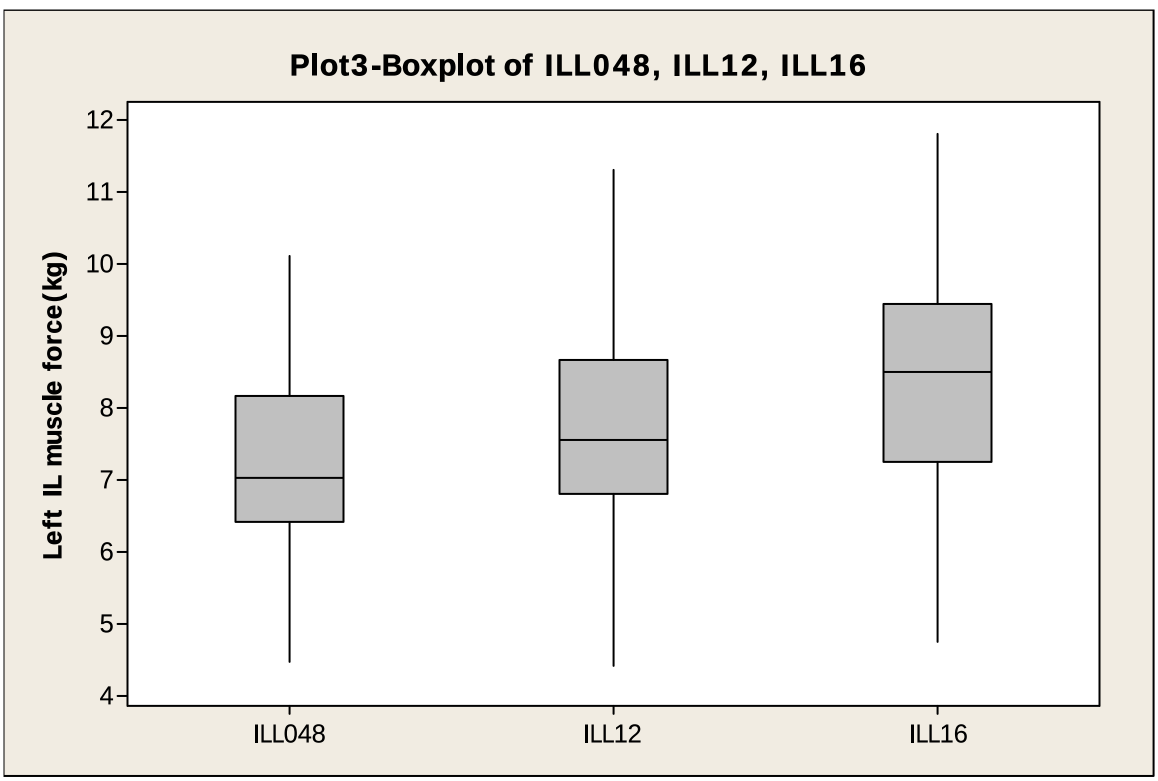


Figure 27: Left Iliopsoas-LIL

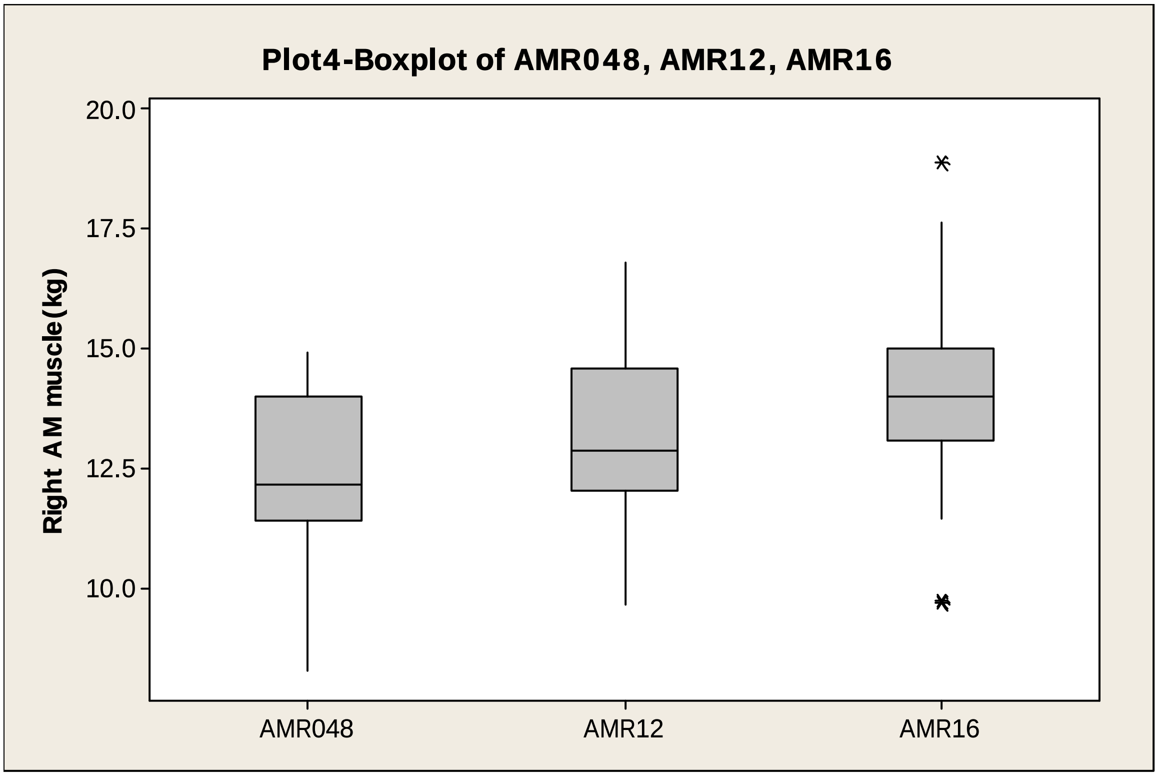


Figure 28: Right Adductor Magnus-RAM

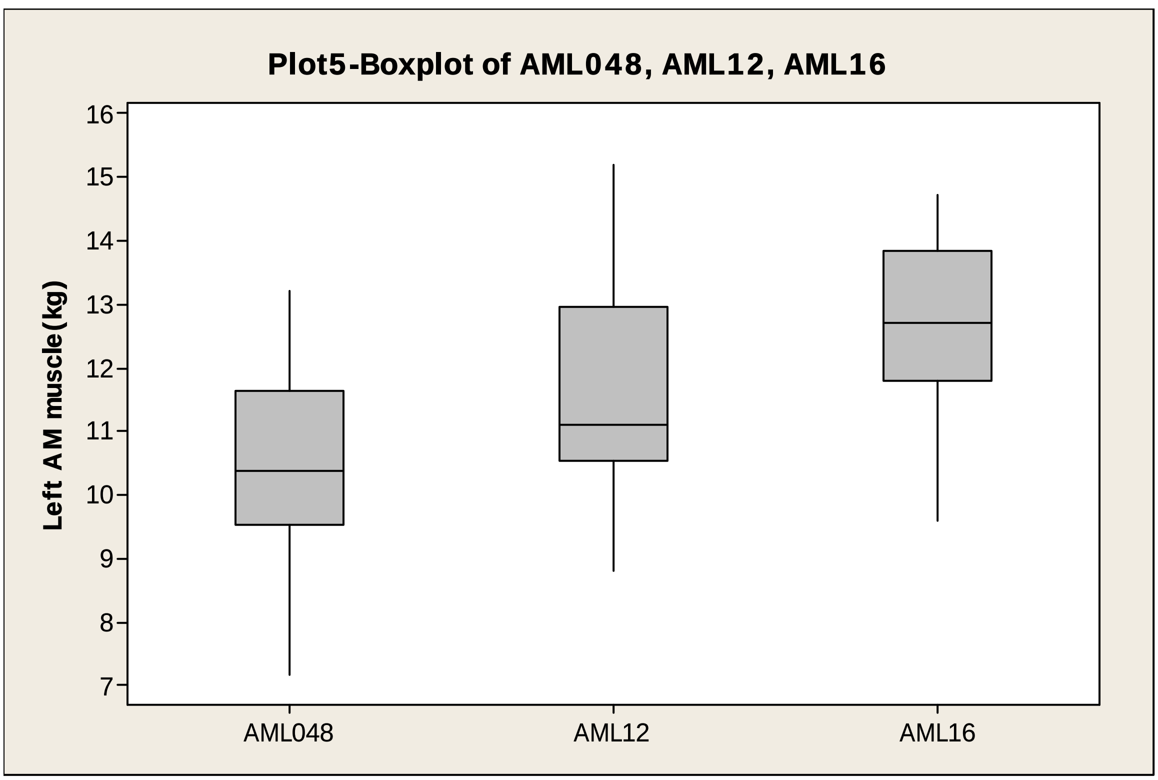


Figure 29: Left Adductor Magnus-LAM

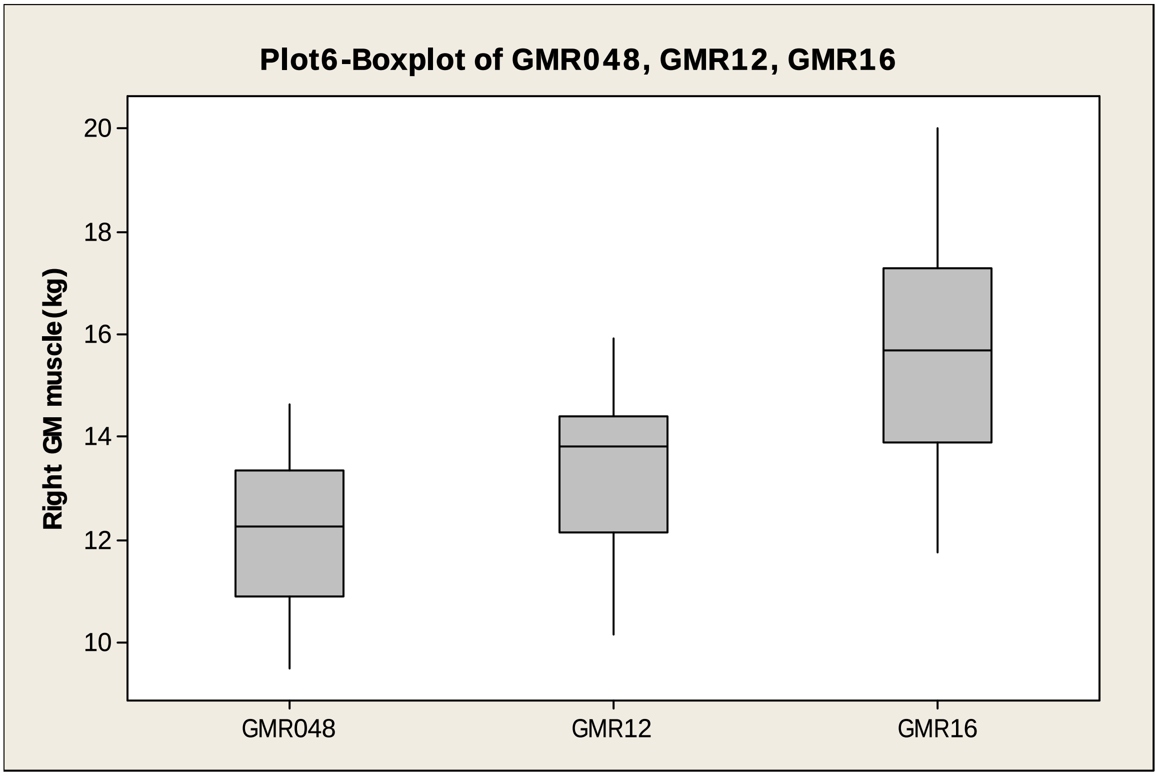


Figure 30: Right Gluteus Medius-RGM

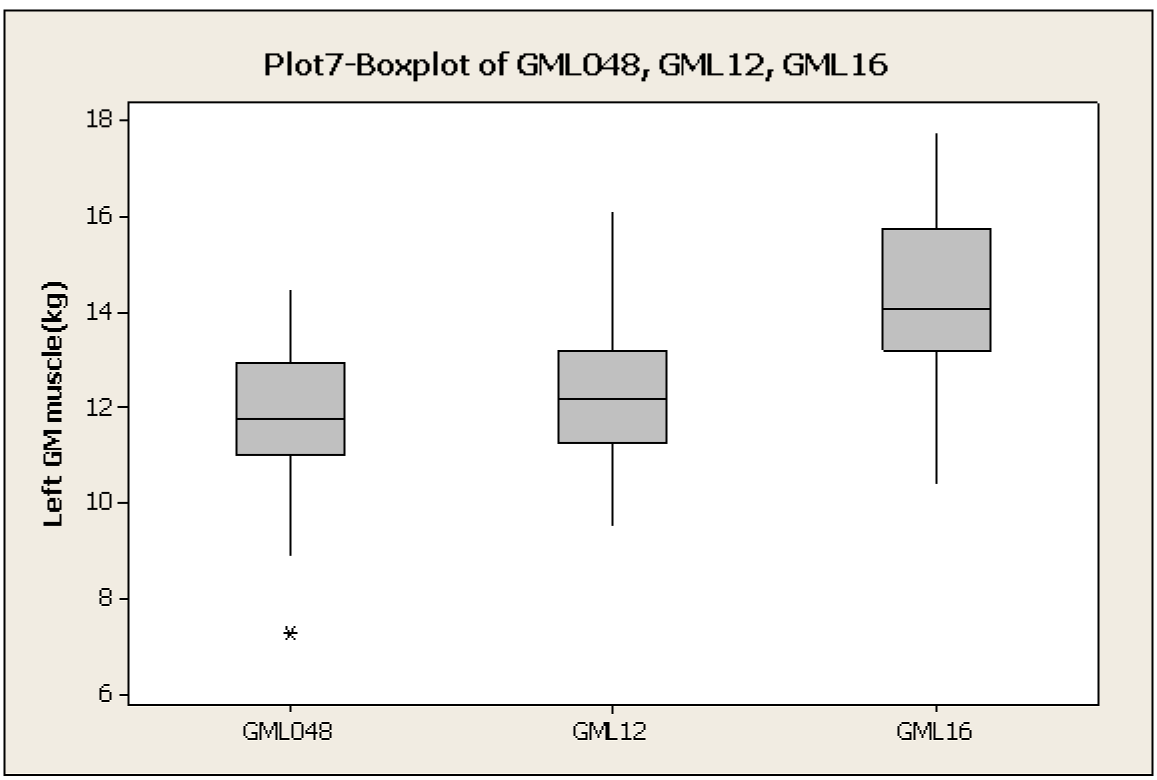


Figure 31: Left Gluteus Medius-LGM

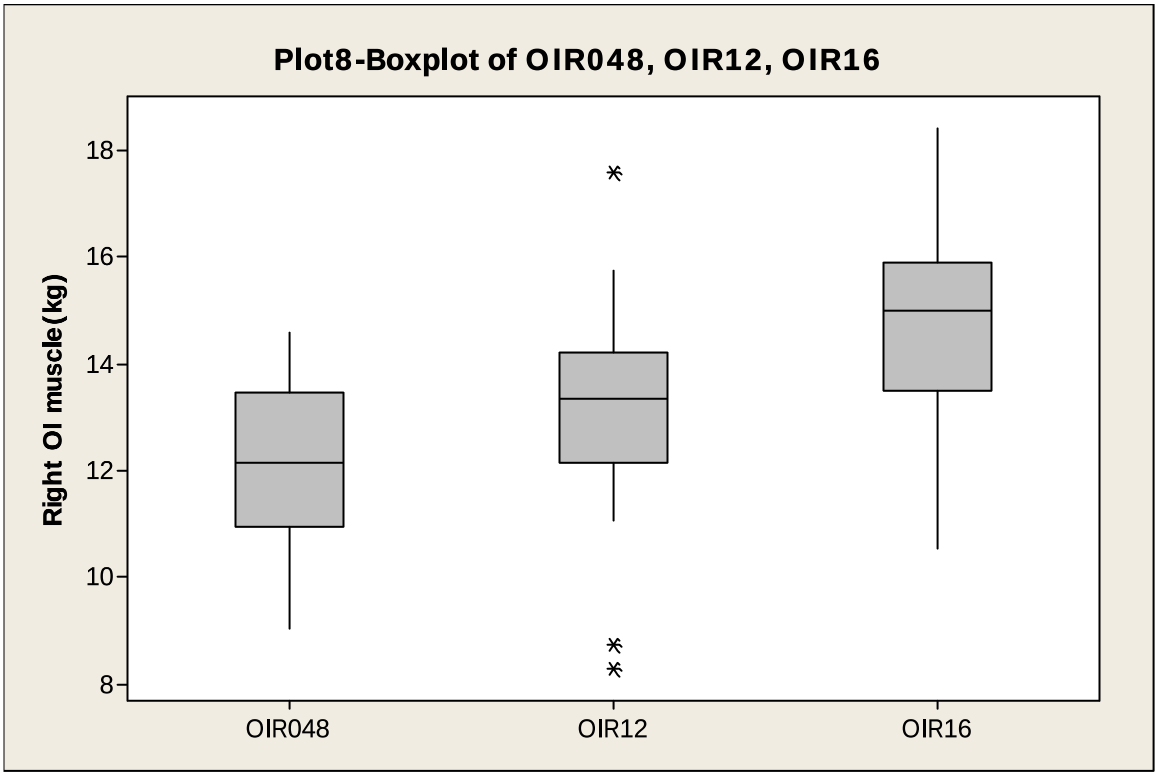


Figure 32: Right Obturator Internus-ROI

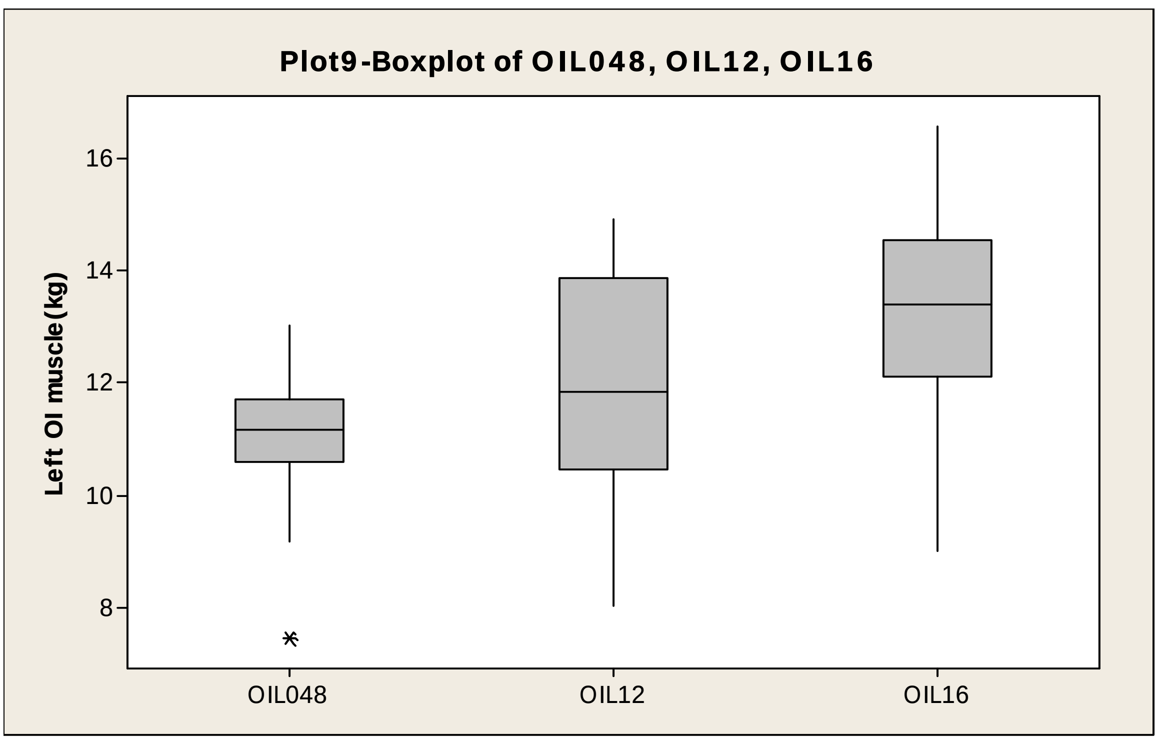


Figure 33: Left Obturator Internus-LOI

5.5.2. COMPARING WEEK ZERO THROUGH WEEK SIXTEEN

The statistician ran the same models as previously discussed but instead of comparing change from the pre-treatment to the study period, the statistician examined changes over all weeks. These results are summarized in Table 6**.** (Duquette, personal communication, February 24, 2009) and change in muscle strength is shown in Figure 34 and Figure 35.

Table 6. shows that for four of five muscles there is some evidence that increases in muscle tone occurs before the treatment period begins. The exception is the obturator internus, the strength of which does not change throughout the pre-treatment period. These results call into question the validity of using the average of week zero, four and eight as a measure of the pre-treatment period. Taken together with the previous results, these data suggest that at least some of the improvement in muscle strength measured over the sixteen week period of the study might be due to other reasons.

The evidence in support of a treatment effect is greatest for the obturator internus muscle because the increase in strength began in week twelve, but the evidence of a treatment effect is least for the gluteus medius muscles since increases in both the right and left muscles began before week twelve.

Table: 6. Results of 10 within-subject mixed models for the effect of predictors on muscle strength on the right and left sides of the body from week 0 through to week 16.

Mixed model results				
Outcome		Predictor (p-value)	Post-hoc comparisons (p-value)	
	Muscle	Week	Week 0 versus week 4	Week 4 versus week 8
Right	AM	<0.000	0.65	0.36
	GM	<0.000	0.71	0.0002
	IL	<0.000	0.02	0.09
	RA [1]	<0.000	0.001	0.62
	OI	<0.000	0.07	0.40
Left	AM	<0.000	0.002	0.09
	GM	<0.000	0.34	0.003
	IL	<0.000	0.85	0.27
	OI	<0.000	0.54	0.62

[1] RA results are based on 2 measurements on the right and left side of the medial line

Figure 34: (Series of five figures). Change from week 0 – Right side

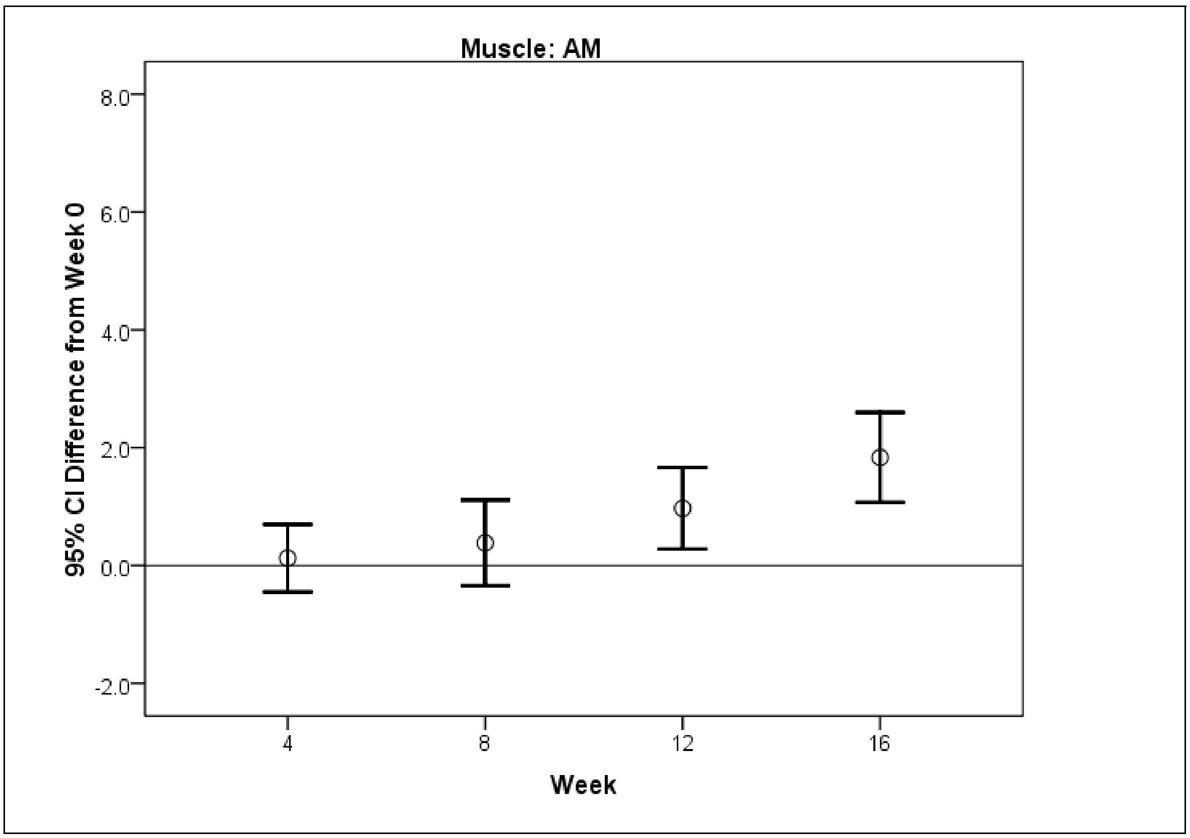


Figure 34.1: Right Adductor Magnus-RAM

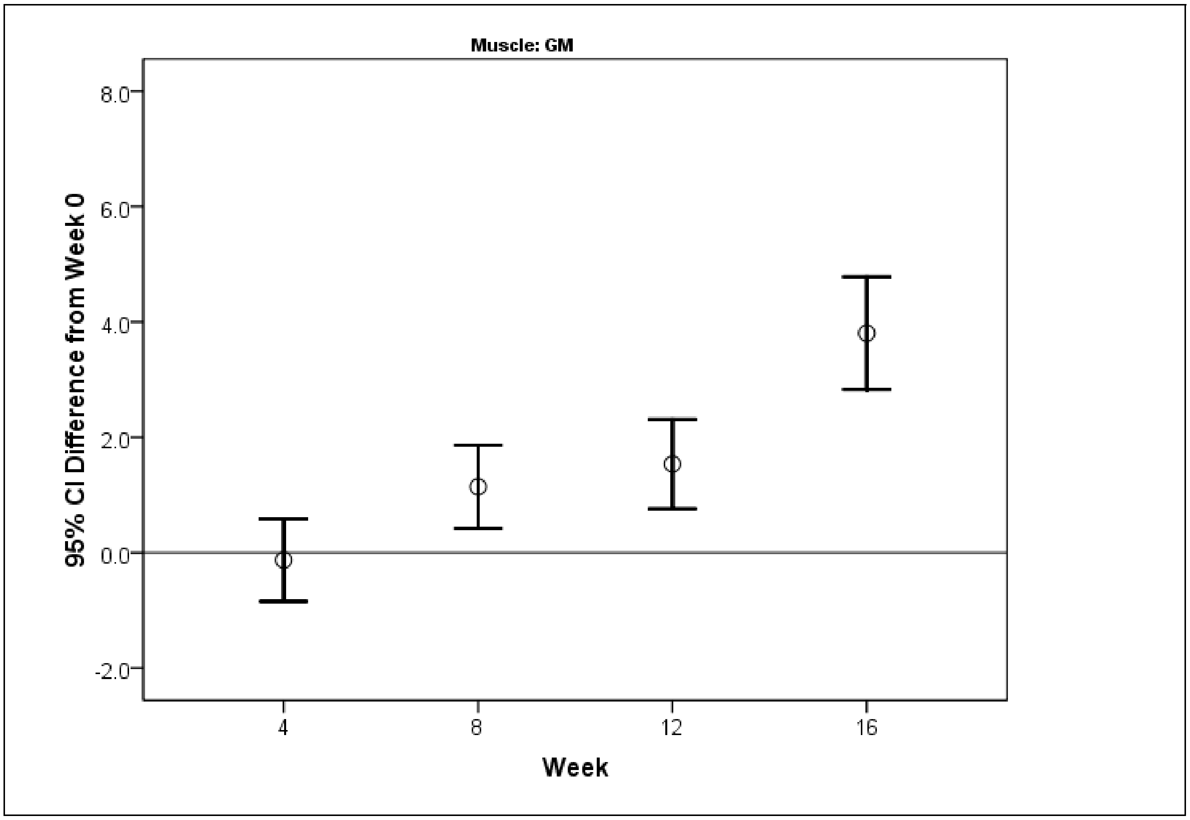


Figure 34.2: Right Gluteus Medius-RGM

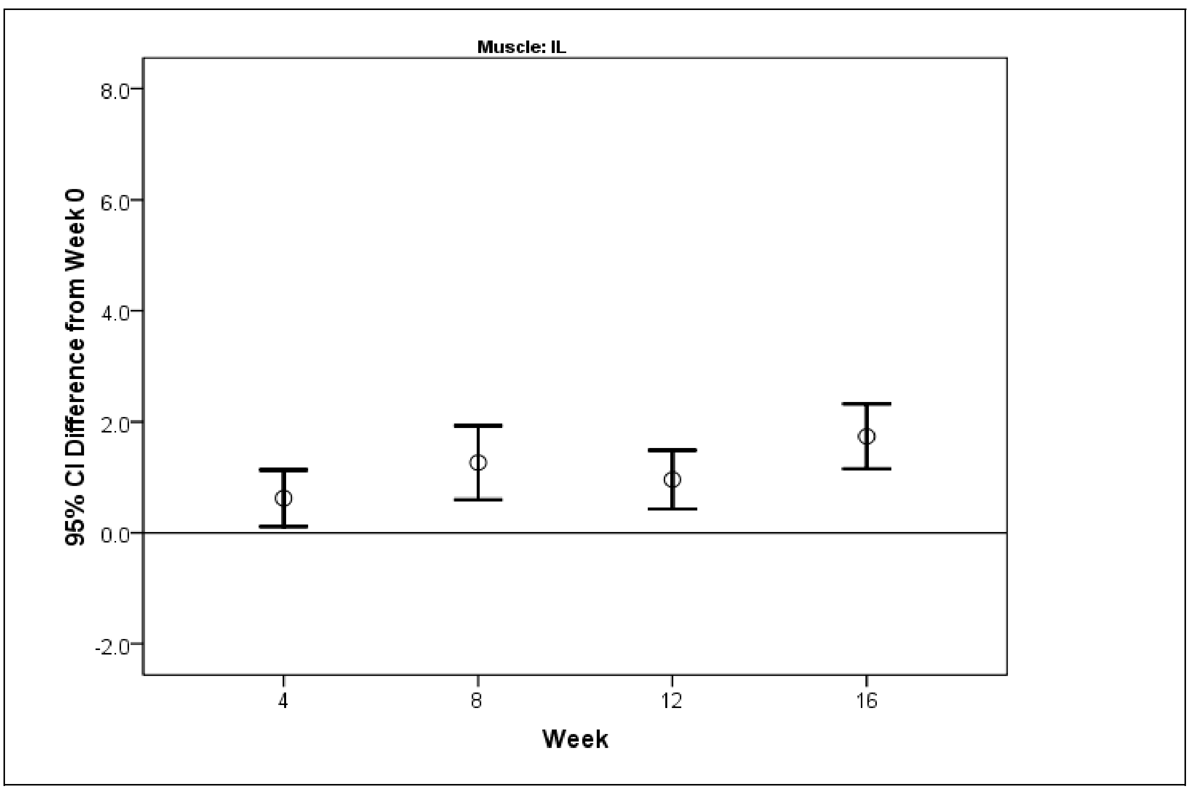


Figure 34.3: Right Iliopsoas-RIL

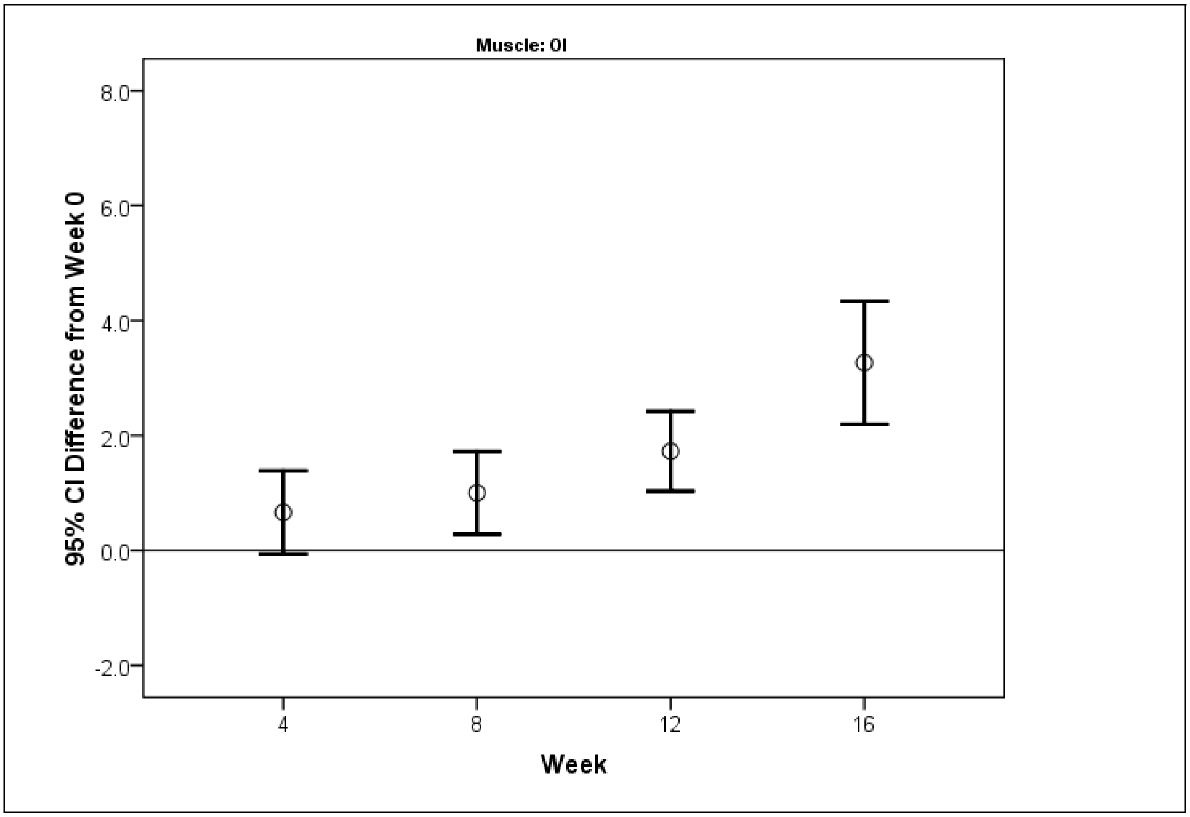


Figure 34.4: Right Obturator Internus-ROI

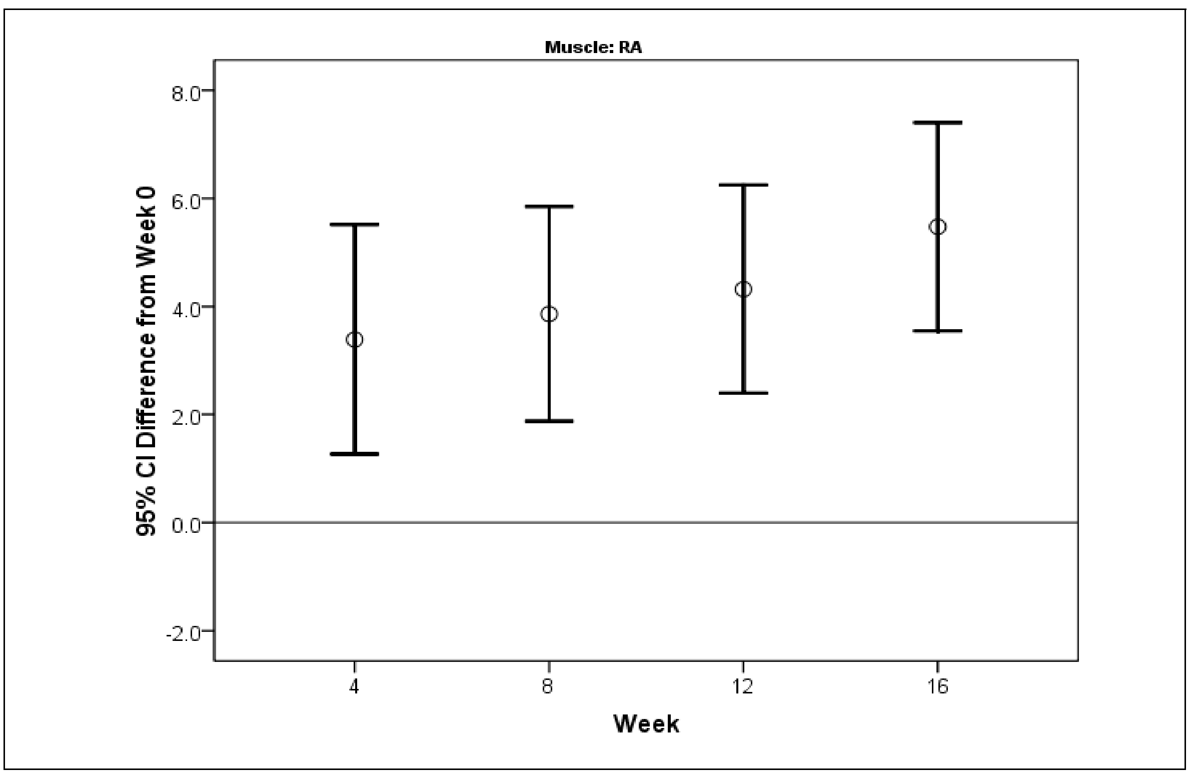


Figure 34.5: Rectus Abdominus-RA

Figure 35: (Series of 5 Figures) Change from week 0 – Left side

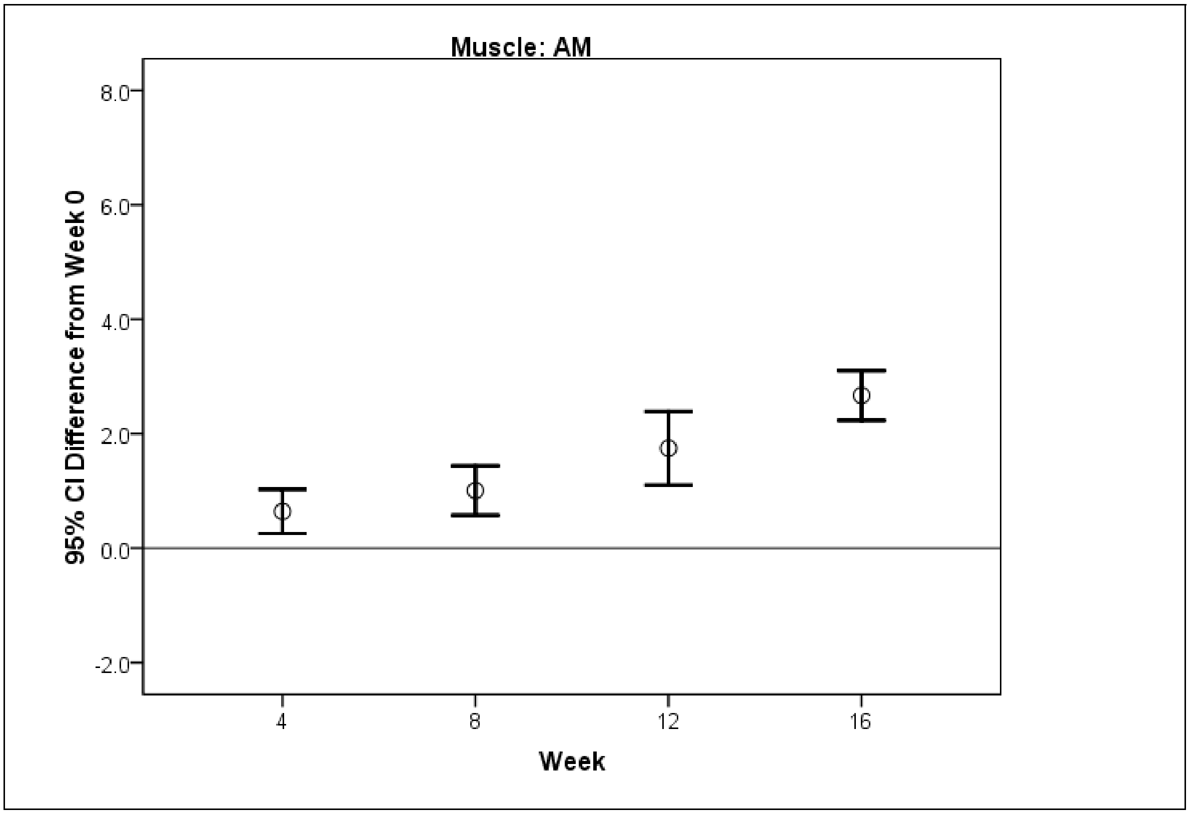


Figure 35.1: Left Adductor Magnus-LAM

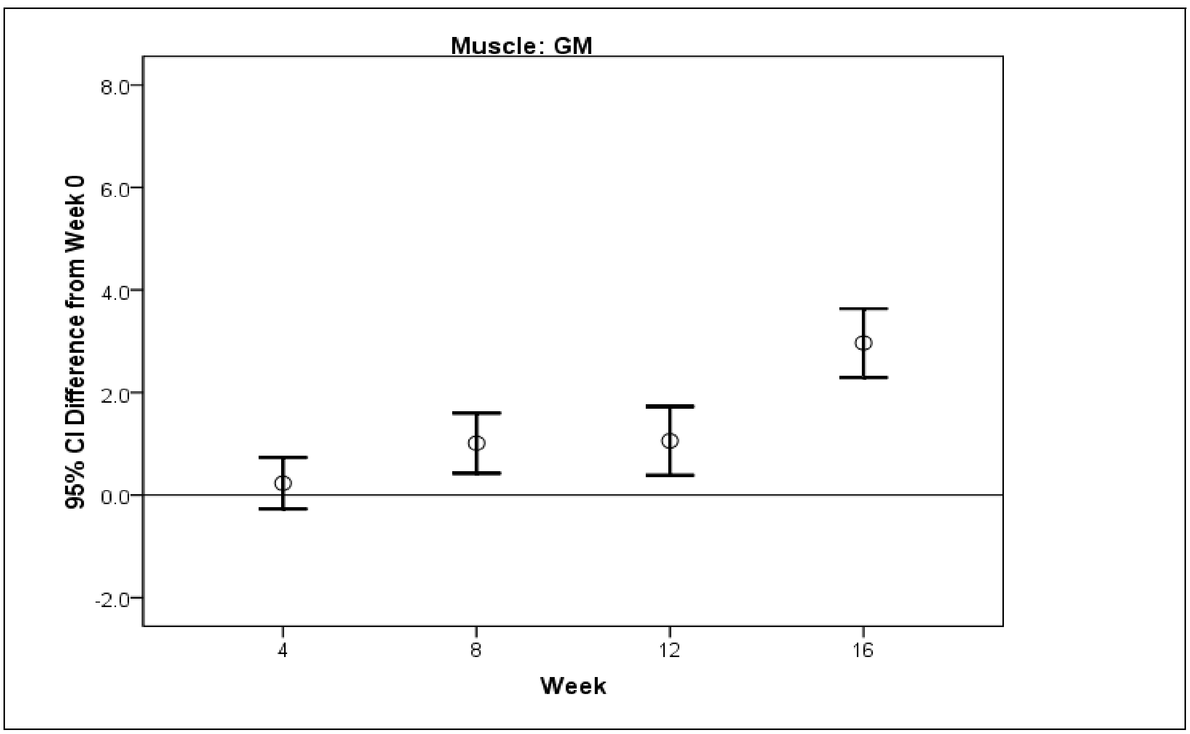


Figure 35.2: Left Gluteus Medius-LGM

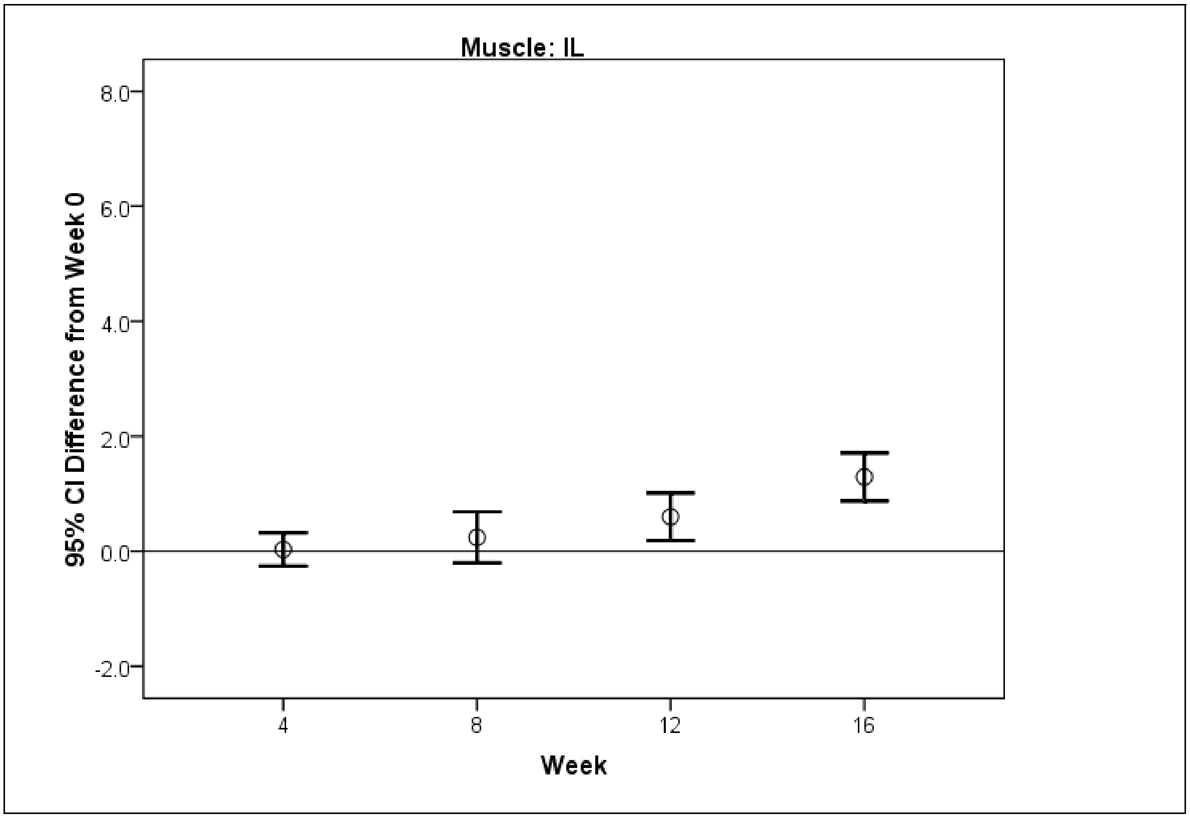


Figure 35.3: Left Iliopsoas-LIL

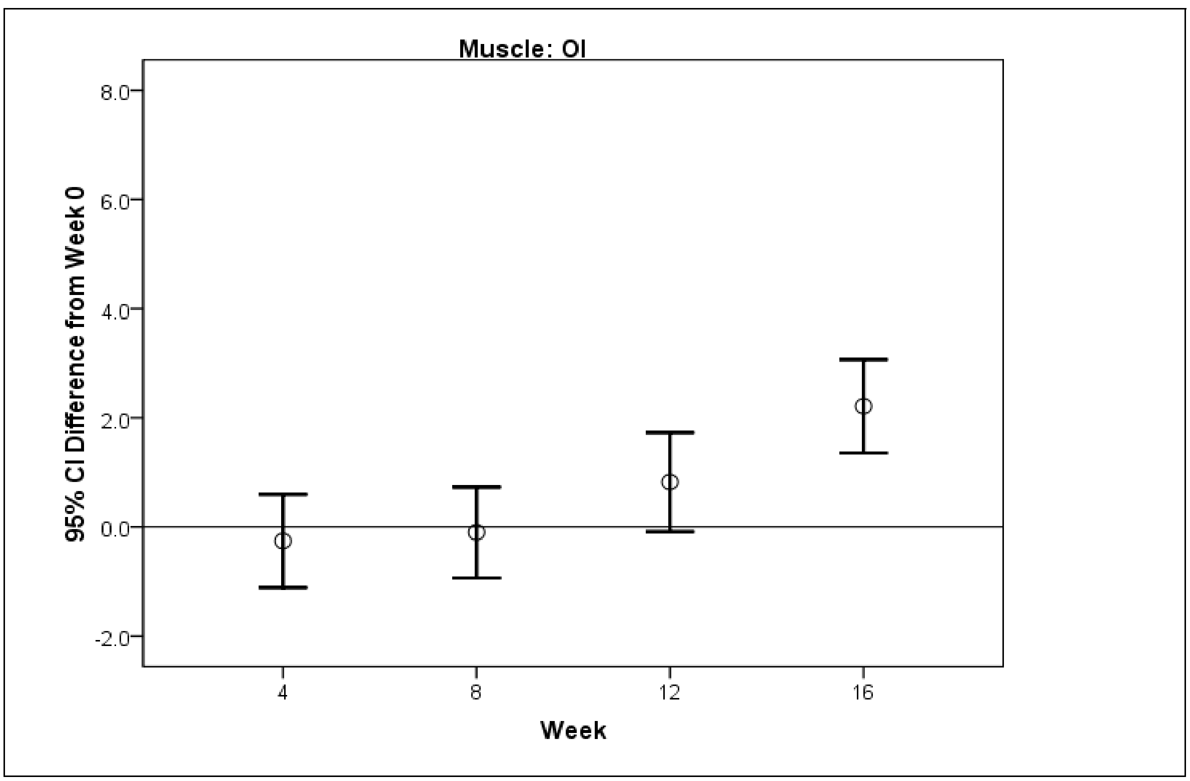


Figure 35.4: Left Obturator Internus-LOI

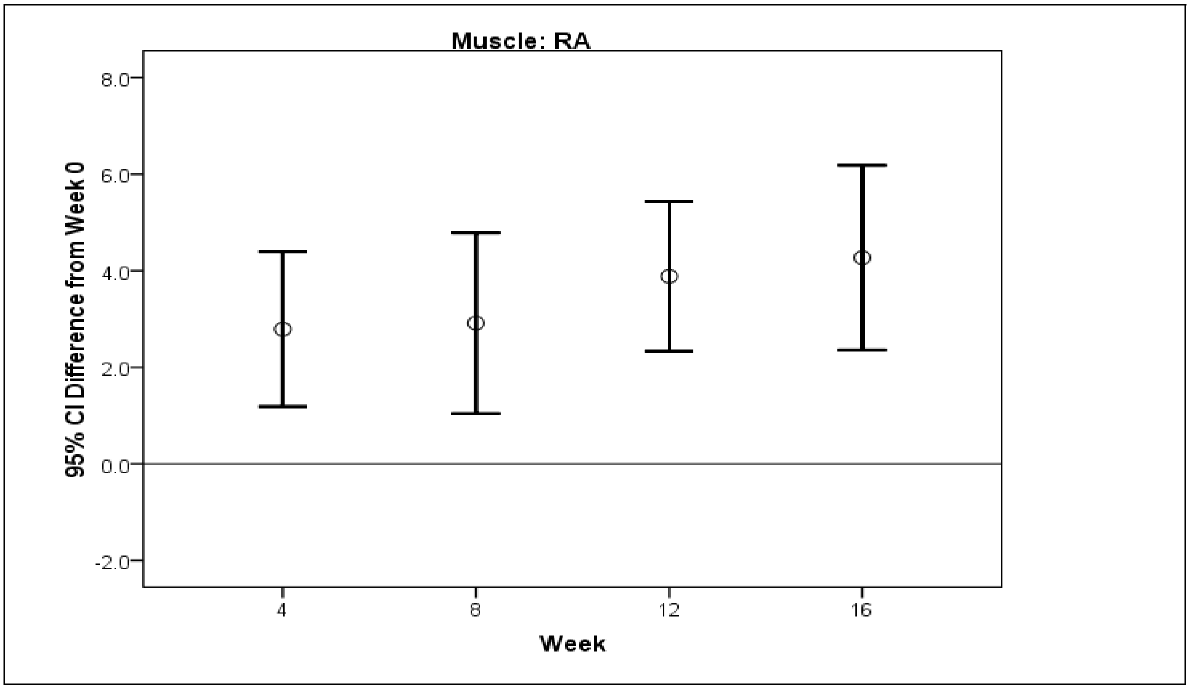


Figure 35.5: Rectus Abdominus-RA

6. CHAPTER SIX: DISCUSSION

This research examines the effects of osteopathic treatment using myofascial release techniques, as described in the Chapter 4 and Appendix T, on transverse caesarean section scars to determine the effects on pelvic muscle strength of five chosen muscles (RA, AM, GM, IL, OI). This examination uses the Lafayette muscle strength gauge dynamometer, as a verifiable tool, to determine changes in muscle strength in kilograms of force.

The evidence measured by the sixteenth week supports significant increases in muscle strength for all the muscles involved. Further evidence shows changes occurred in four of the five muscles in the pre-treatment period with the exception of the obturator internus.

The sample size calculation in the pilot study results in an estimate of a half kilogram (0.5) change in muscle strength with a standard deviation of 1.2 kg. This is converted to a 4% change in muscle strength on average in hopes of finding a statistical significance.

Table 7 provided by the statistician (Duquette, personal communication, February 24, 2009) shows percentage changes in muscle strength from the base line zero, four, eight week period (averaged) to week twelve and sixteen (averaged). The right and left obturator internus muscle shows a 10.4 % and 8.7 % change in week twelve, respectively, to more than doubling the strength, 24.6 % and 21.8 % for the right and left obturator internus, respectively, by week sixteen. There was no evidence of significant changes in muscle strength in the base line pre-treatment group that would cast any doubt of the effects of treatment on the Caesarean scar.

Table: 7. The results in (mean) percentage change of osteopathic treatment of Caesarean scars on pelvic muscle strength.

muscle	Percent change from baseline to week 12 and 16 for right and left measurements	N	Mean (% change)	Std Dev	Maximum	Minimum
AM	rchg12	27	7.0	9.7	20.9	-15.9
	lchg12	27	12.1	14.6	50.2	-15.6
	rchg16	27	14.0	13.0	44.9	-6.1
	lchg16	27	20.8	10.9	38.5	-1.4
GM	rchg12	27	10.7	12.8	51.5	-14.6
	lchg12	27	6.6	13.7	40.4	-23.5
	rchg16	27	29.3	16.6	73.7	4.2
	lchg16	27	22.7	12.2	56.5	-0.5
IL	rchg12	27	5.3	13.8	36.8	-21.0
	lchg12	27	7.4	11.3	33.5	-10.4
	rchg16	27	15.4	15.6	46.2	-23.4
	lchg16	27	17.0	12.2	50.4	0.0
OI	rchg12	27	10.4	13.3	34.9	-11.0
	lchg12	27	8.7	13.5	30.3	-14.9
	rchg16	27	24.6	23.1	85.4	-8.5
	lchg16	27	21.8	13.9	47.1	-1.8
RA	change12	27	10.9	11.9	32.5	-9.3
	change16	27	16.5	16.5	53.8	-13.6

The obturator internus muscle is closely connected to the scar as described in Chapter 3.0, and shown visually in Appendix N. This muscle is part of the pelvic supporting structures for the gynecological organs (Appendix N) and supports the gynecological star (Appendix M). The basic osteopathic principles of the structure governs the function and the body is a functional unit are supported by the affects of the obturator internus muscle locally and globally.

The strength of the obturator internus is influential in the fluid dynamic system of the body with its connection and influence on the pelvic, thoracic and cranial diaphragms. There are at least five domed diaphragms and three bowls (cranial base, pelvic floor and soles of the feet) (Milne, 1995) that are part of the respiratory system (Appendix J).

These structures interact with each other through muscular, osseous, fascial, mobile, motile, interdependent and complex ways (Milne, 1995).

The pelvic diaphragm is connected to the thoracic diaphragm through fascia and the mechanical forces of respiration. The thoracic diaphragm is connected to the psoas muscles, the peritoneum, the abdominal wall, the pleura, the ribs, the mediastinum and the pericardium (Milne, 1995). By significantly improving the strength in the obturator muscle and for that matter, the rectus abdominus and the iliopsoas muscle, the fluid dynamic system of mechanical motion of the diaphragms are optimally improved and, as stated in the Canadian College of Osteopathy (2004) first year GOT course handout, if the diaphragms are synchronized can provide a greater source of nutrition and healing ability.

The right iliopsoas muscle did not show significant changes in week twelve post-treatment test, but did show a statistical significance by week sixteen of 15.4% and 17% increase in muscle strength from the pre-treatment group, respectively. A closer examination of the results of the pre-treatment group shows significant changes starting with an increase to the right iliopsoas in week zero versus week four. It is important to note that no significant changes occurred on the left iliopsoas in week zero versus week four.

Week four versus week eight does not show significant changes in muscle strength for either the right or left iliopsoas pre-treatment group. The right iliopsoas in the pre-treatment group increased in strength significantly in week zero versus four without a treatment. This variability may be produced by factors associated with the reliability of muscle testing in a diagonal plane instead of a single plane as tested with the other muscles. Although the position is harder to control, a study from Hsieh (1990) shows reliability between testers for the iliopsoas muscle. The Hsieh study shows that three testers do not have exactly the same position for the iliopsoas muscle even though each tester applies their position consistently. For this reason the validity of the measurement of the iliopsoas muscle in the Hsieh study may be questioned even though the results are reliable.

In this research, only one tester land-marked with a ruler to determine the diagonal position (Appendix S). The abduction/external rotation and flexion positions are measured with the height parallel to the contralateral patella. Using only one tester ensures a more accurate position for the iliopsoas muscle test and is repeatable for future studies. Generally the iliopsoas muscle shows the lower scale of improvements in strength overall compared to the other four muscles by week sixteen, suggesting this muscle, which crosses the hip, may have a disadvantage in performing an optimal contraction while in a supine position. The other four muscles do not cross the hip joint, and are shorter levers (LaBan, 2004). The iliopsoas muscle is considered to play an important role in stabilizing the spine, initiating walking and is connected with respiration (Richardson, Jull, Hides, Hodges, 1999). This muscle is the only muscle, besides the piriformis, that attaches the vertebral column to the legs, inside to outside, axial to appendicular, and connects respiration to walking (Myers, 2001).

The tester finds that the iliopsoas muscle test is the most challenging for the subjects from the subjective complaints of how difficult it is to contract this muscle received during and after the contraction phase.

The right and left adductor magnus muscle test results shows a statistically significant increase in muscle strength from 7% and 12.1% in week twelve from the pre-treatment group average, respectively, to 14% and 20.8% in week sixteen, respectively, approximately doubling in strength. A closer examination of the pre-treatment group data, shows the left adductor magnus muscle has a significant increase in muscle strength in week zero versus week four. The right adductor magnus did not show significant increase in muscle strength, nor did the right and left adductor magnus show significant change in week four versus eight. The significant increase in strength with the right adductor magnus muscle was prior to any treatment. This suggests other factors have influenced the measurements and that averaging the left adductor magnus muscle measurement for the pre-treatment group for week zero versus week four may influence the final results. It may be that the subjects adapt or better understand the test by the week four pre-treatment test and are better able to meet the expectations required to perform the test. Week four verse week eight shows consistency in expected results (no significant increase in strength) for the pre-treatment group and supports the base line average compared to weeks twelve and sixteen post-treatment group results.

The rectus abdominus muscle tests with statistical significance comparing week twelve with 10.9% and week sixteen with 16.5% increase in muscle strength as compared to the base line pre-treatment group measurements. The rectus abdominus muscle shows significant changes in week zero versus week four in the pre-treatment group, but does not show significant change in week four versus week eight. This measurement does show a consistency with the iliopsoas and adductor magnus, in that, the calibration to testing or understanding the requirements of the muscle test by the subjects starts early on in the pre-treatment times and tapers by week four verse week eight.

The right and left gluteus medius muscle tests significantly in week twelve with a 10.7% and 6.6% increase in strength, respectively, and in week sixteen with a 29.3% and 22.7% increase, respectively, as compared to the base line pre-treatment group average measurement. The mean results in week sixteen show an approximate tripling of muscle strength from that of week twelve. The gluteus medius muscle testing results in the pre-treatment group did show significant increases in strength in the right and left muscle in week four versus eight. These results show that both sides improve in strength without treatment. This muscle is also a challenging muscle to contract, as per the feedback by the tester, starting at a position of thirty degrees of abduction, and then to maximally contract in abduction (Appendix S). The tester recognizes that the subjects need to be motivated to contract the gluteus medius and iliopsoas muscles.

The gluteus medius muscle is a lateral supporting muscle and is postulated that the calibration to understanding how to contract this muscle may have taken longer than some of the other tested muscles that reached unilateral significance in week zero versus week four pre-treatment group. The gluteus medius muscle is the least support of averaging the three (week 0, 4 and 8) pre-treatment group results due to its significant increase in muscle strength prior to any treatment. The results of week sixteen show remarkable improvement in strength compared to any of the weeks measured, even without averaging of the pre-treatment weeks.

A study by Niemuth et al. (2005) examines hip muscle weakness and overuse injuries in runners, and speculates that a strong adductor magnus muscle compensates partially for a weakness in the gluteus medius. Furthermore, a compensating adductor may result in an increase in foot pronation, leading to Achilles tendonitis, plantar fasciitis and medial tibial stress syndrome (Niemuth et al., 2005). The results of this study show a relationship between adductor and abductor strength: as the subjects receive the treatment protocol, a change in muscle strength is seen as a relative decrease or lower measured force in adductor strength and an increase or greater measured force in abductor strength. This change is noted most prominently in week sixteen of the final measurements. This may support the agonist/antagonist relationship of muscles in the body as Niemuth et al. (2005) speculates when muscles are in an optimal functioning capacity or when the body is in a balanced state**.**

Overall, the increase in strength all five muscles under investigation is significant, in particular, in the week sixteen post-treatment measurements.

The author postulates that adaptability and motivation of subjects may be a factor contributing to achieving maximal muscle contraction and that time between testing may be a variable in affecting the pre-treatment group averaged results. The final results suggest that there was significant change in muscle strength from the pre-treatment period to the post-treatment period. The secondary data examing all the weeks suggests that the cause of the increase in muscle strength may be as a result of factors other than treatment of the scar.

This experimental design is reasonable, recognized by the statistician, and supported in the proposal process of this paper. L. Duquette (personal communication, February 24, 2009) reports that the averaging of data in the pre-treatment group was executed justifiably and any further multiple testing of this data group would increase the probability of a Type 1 error, which may show a difference when there is no difference. To compare each individual week of the pre-treatment data to week twelve and week sixteen post-treatment data is not recommended as it is not part of the experimental design and could potentially distort the results.

The study and practice of osteopathy are based upon four basic concepts, which are supplied by the Canadian College of Osteopathy (2004) first year GOT course handout and found in Kuchera and Kuchera (1994):

1. The structure governs the function
2. The role of the artery is absolute
3. The body is a functional unit
4. The system of auto regulation

An examination of the implications of the caesarean scar in relation to the muscles of interest is explored in relation to the four basic concepts in Chapter 3.0. All the connections that have been described, for example the neurovascular, musculoskeletal, myofascial and hormonal systems are viewed in relation to these four basic concepts. The Canadian College of Osteopathy (2004) first year GOT course handout states that the discovery and treatment of the primary lesion and its compensations will help to bring resolution of the affected area(s) and improve health.

This study examines and treats the caesarean scar tissue, showing an effect on the muscle strength of five muscles. The scar treatment protocol is developed with the intention of treating the lumbar vertebrae and sacrum in order to release any associated restriction related to the caesarean scar so that all the systems communicating with the muscles of interest will be efficient and in working order. The osteopathic concept of "the structure governs the function"; the "role of the artery is absolute" and "the body is a functional unit" support the impact of releasing the lumbar vertebrae and sacrum.

The following is a summary of common disorders associated with lumbar vertebrae and sacrum lesions as a result of compression or irritation on the neurovascular network (from these lesions) thus affecting the drainage and nutrition of the spinal nerve cells and associated pathways and connections (Clark, 1999):

L-1	Lumbago, kidney problems (albuminuria, Bright's diseases), bowel (constipation and diarrhea) and bladder disorders.
L-2	Lumbago, uterine tumors, retro-deviated uterus, bladder afflictions (cystitis, bed wetting), hemorrhoids, constipation, menstruation (dysmenorrhea and "cramps") and parturition problems (inhibition of uterine muscle contraction).
L-3	Backache, lower bowel disorders (constipation, hemorrhoids, ulcers and prolapse), pelvic organs (uterus, bladder and impotence) and lower limb disturbances (hip joint, knee joint, leg and foot disorders).
L-4	Diarrhea, constipation, fibroid tumors of the uterus, inflammation and congestion of the uterus, sexual disorders (impotence and nocturnal emissions), lower limb and joint disturbances (pain, varicose veins, inflammation and atrophy).
L-5	Rectal disorders (prolapse, ulcers, hemorrhoids, itching piles), uterine disorders (dysmenorrheal), backache, bladder problems (frequent and painful micturition, cystitis, stones), ureter and urethra diameter afflictions caused by inflammation.
Sacrum	Sacro-iliac disorders (sciatic nerves compressions and hip joint pain), decreased size of true pelvic inlet impacting parturition due to delayed engagement of the fetus, influence on spinal column posture, sacro-coccygeal articulation disorders (constipation, ulcers, hemorrhoids and diarrhea), pruritus ani, increased sexual passion (sometimes excessive due to a disturbance of the pudendal nerve or its branches).

(A detailed description of the reason of these conditions is provided in Clark, 1999, pages 241 to 332).

The connection of the lumbar vertebrae (figure 36) through the nervous system

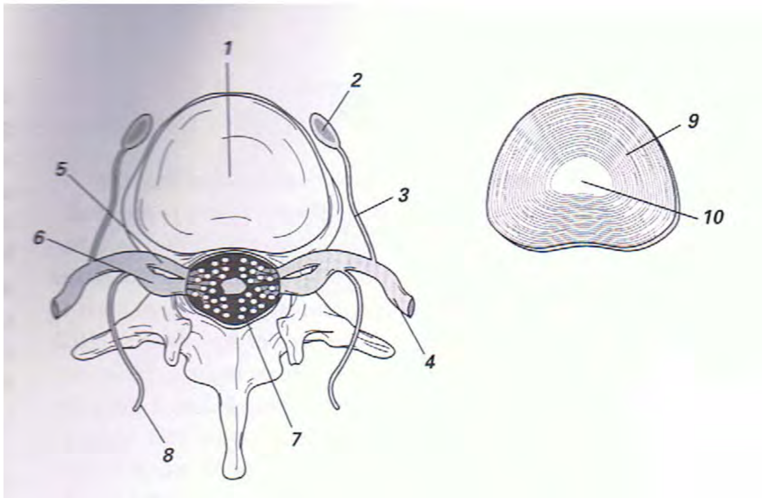


Figure 36: Superior view of second lumbar vertebra and intervertebral disc (Milne, 1995 volume 2).

1 Vertebral body
2 Sympathetic ganglion
3 Gray ramus communicans
4 Ventral ramus of spinal nerve
5 Ventral root of spinal nerve
6 Dorsal root of spinal nerve
7 Cauda equine
8 Dorsal ramus of spinal nerve
9 Annuular rings
10 Nucleus pulpossus

can implicate the web of structures affecting the function of all five muscles. For example, the structure of the lumbar spine might be pulled anterior because of tension linked to the scar, creating postural changes and affecting typology (Appendix K), gait, and lines of gravity, and potentially producing pelvic, lower limb and feet troubles. This type of postural change may alter the vasculature of the body by tension in the solar plexus, and thoracic diaphragm in relation to the lumbar vertebrae. A tension on the myofascial chains due to this change in posture may influence many areas of the body as described in Chapter 3.3. These changes in the lumbar vertebrae may compromise the dura and the spinal cord, which can impact the reciprocal tension membrane system and the motion of the sphenobasilar symphysis creating changes in the PRM (Appendix H). PRM changes can affect fluid (chemical) movement and vitality, producing changes in the hormonal system (pituitary) and affecting the ability of the body to auto regulate.

Through this example, profound effects of the caesarean scar can be demonstrated throughout the entire body. Release of the scar from all surrounding structures, such as the lumbar vertebrae and the sacrum, can help to improve, sustain health and prevent disease conditions in the body. The release of the lumbar vertebrae and sacrum with the caesarean scar may have been a factor in achieving significance in muscle strength in the final outcome as compared to treating the scar locally (Appendix T), which futures studies may be done to discover this variable.

7. CHAPTER SEVEN: SELF CRITIQUE

7.1. PILOT STUDY

The pilot study in this research is performed to understand the required number of subjects to obtain in this study. The data is collected to estimate the amount of variability in measures of kilograms of force between muscle testing times. The subjects for this pilot study do not have caesarean scars, although they have laboured children more than one year ago. The subjects meet the inclusion and exclusion criteria with the exception of the caesarean scar. The reason for not having subjects with caesarean sections for the Pilot Study was due to a shortage in time for recruiting subjects, as this was suggested during the protocol thesis deadlines. The fact that the calculations are based on subjects without caesarean sections could be a source of error and affect the results of the data and the quantity of subjects required for this study.

7.2. TESTING

Feedback from the FC who performed the muscle test with the dynamometer suggests that it was imperative that the women in this study are continuously motivated to contract each muscle maximally. Without this encouragement, it is suggested that the results of the study may be affected. The subjects are tested three times prior to treatment so that a baseline can be attained and allow an opportunity for the subject to learn how to contract each muscle properly. The baseline of the control group shows a gradual increase in strength prior to any treatment in some muscles.

With the exception of the obturator internus, the other four muscles show increases prior to treatment between periods zero, four and eight weeks. Reasons for this discrepancy could be due to subject adaptation to the muscle testing because the subjects learn to maximally contract more than once over a period of time. Studies citied in

Chapter 2.2 support the dynamometer as a verifiable tool. On further investigation the FC notes that motivation is a factor for contracting maximally. Should the Pilot Study be replicated, the subjects would be required to meet the complete inclusion and exclusion criteria and that all five muscles of interest be tested for the guidelines set out by the methodology in Chapter 4.0. This would provide a clearer variability of the data and number of subjects to be recruited.

To improve the maximum measures, it is critical that the tester maintain consistency with respect to the point of application, magnitude, and direction of force. Ideally, the line of application should be at right angles to the long axis of the segment. Varying these characteristics will significantly alter the measurement of strength of the muscles under investigation (Smidt & Rogers, 1982).

A study from Hsieh (1990) uses a warm-up prior to the muscle testing procedure including,

> … circumduction of the shoulders 10 times; hands pushing against each other above the head as hard as possible 3 times; forward and backward swings of each leg 10 times; forward straight-leg raise as high as possible 3 times for each leg; and then raising the leg upward and outward 3 times for each leg (Hsieh, 1990, p. 73).

The warm-up benefits the subject by acclimatizing her to the testing protocol, but this warm-up may induce physiological changes (Smidt & Rogers, 1982) that may positively or negatively affect muscle strength. A study to compare warm up exercises prior to muscle testing is indicated.

Future studies could include a comparison of women that have had children, are within the age criteria, but have had no caesarean sections, and women that have had caesarean sections. This provides an opportunity to compare and analyze the muscle strength of both groups. The women with no caesarean sections act as a control group, as opposed to this study utilizing the same group for the pre and post treatment sessions. Alternatively, the control group without caesarean sections could be an exercise group. An exercise protocol for the muscles of interest in this study would be developed and provided to the control group for a period of the study, while utilizing the same pre-treatment assessment protocol as the caesarean group. Possible problems with the exercise group would be compliance.

7.3. TREATMENT

During the treatment protocol, the myofascial unwinding techniques were specific to connections with the lumbar vertebrae and the sacrum anchors and a general myofascial unwinding of the scar. The treatment protocol did not include, specifically, organ adherence. Organ adherence with the caesarean scar is possible with the small and large intestine, bladder and ovaries. Investigation of organ adherence by way of testing the position, mobility and vitality of the organs in reference to the scar with an inhibition technique would have provided information about possible organ adherence. A variance to the treatment protocol would have been advisable at this point. The treatment time-line would have to be longer, possibly up to one hour.

The results may be complicated if the treatment does not release the lumbar and sacrum areas effectively. This would significantly affect the results given the connections to the muscle of interest.

"The role of an Osteopath is to remove the obstacles that will allow the body to regain its normal functions (health) (Sicotte, 2003, p. 170)." Future studies could include global treatments prior to the caesarean scar treatments and measurement of the muscle strength after each treatment. The potential of a variety of lesions throughout the body are threats regionally to the balance of the sacral and lumbar spheres and the optimal function of the muscles of interest. A more specifically osteopathic approach would be to examine the patient globally from a structural point of view and treat major lesions prior to implementing the scar treatment protocol. This type of treatment protocol would take more treatment sessions with a more detailed and global assessment recorded with each visit.

Palpation of uterus position, mobility, and vitality with a sacral hand position after the scar treatment is completed could be added to this treatment protocol. The movement of the sacrum can be palpated while the uterus is under examination for its freedom of movement. The movement of the sacrum will give greater confidence to the results of the study because of the cranial and sacral connections through the reciprocal membrane tension system and the vast influences locally, regionally and globally.

The psychological and emotional impact of the caesarean scar may remain as a trauma held in the tissues, even years later (Brennan, 1987). The emotional condition of the subject may need to be approached, with great sensitivity and skillfulness by the practitioner, so that this work not be a barrier for the release of the tissues and structures involved. Some subjects express sensitivity and pain, or a lack of connection in the caesarean area in the first treatment. This study does not treat the emotional impact of the scar of the subject and for those who reported such symptoms, a release of the scar was not achieved until the second treatment, if at all. An emotional type of trauma, if present, may influence the results because more treatment sessions may be required in order to achieve a release at the physical level.

Treatment scheduling causing practitioner fatigue is also a consideration for this study. During the treatment protocol approximately twenty-four of the twenty-seven subjects were scheduled for treatment back to back each half hour during a two day weekend, with a break for lunch. Although, the practitioner has approximately nineteen years experience with soft tissue treatment and is able to meet the demands of the schedule, he reports fatigue in the hands and fingers during the treatment schedule and does not advise treatment for a study like this within this time frame. This type of fatigue could be a source of error in the ability to focus and to perform the outlined treatment. A recommended treatment schedule for the subjects is four to seven days for this group size.

7.4. QUESTIONNAIRE

The questionnaire in this study is basic and is only interested in ensuring the subjects fulfill the criteria. The questionnaire could include more detail questions including a pain scale indicating location and other pain factors. Although conversation with the subjects is limited, subjects did express positive changes to lower back pain and that some even reported improved menstrual cycles, indicating lighter flow.

This study does not focus directly on the uterus, but a future investigation of the treatment of caesarean sections scars could include effect on uterine health. Changes in uterine health could be measured by hysterosalpingography and a questionnaire. A connection to abnormal uterine bleeding and infertility in woman with caesarean scars was found in a study by Surapaneni & Silberzweig (2008). This study examines148 women with caesarean scars using hysterosalpingography to discover any diverticulum defects and finds that a diverticulum is common at the lower uterine cavity, uterine isthmus or upper endocervical canal. The study suggests that a caesarean scar may be a reason for abnormal uterine bleeding and carry a risk of infertility due to a diverticulum in the uterine area, shown in figures 37-41 from the Surapaneni and Silberzqeig study. The study suggests that the diverticulum may be related to suturing techniques, suture materials used or a combination of both during the healing phase.

Figure 37: Hysterosalpingogram in 40-year-old woman shows medium-sized Caesarean scar defect arising from left lower uterine cavity wall (*arrow*).

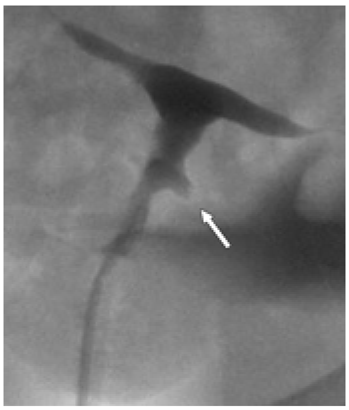


Figure 38: Hysterosalpingogram in 40-year-old woman shows large Caesarean scar defect at uterine isthmus (*arrows*).

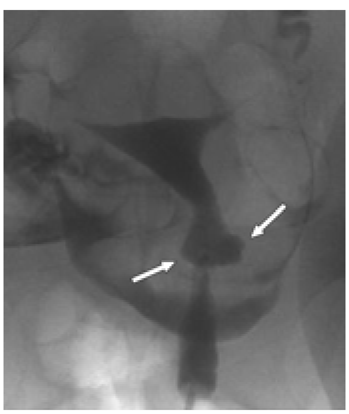


Figure 39: Hysterosalpingogram in 43-year-old woman with anteverted uterus shows large Caesarean scar defect at upper endocervical canal (*arrow*).

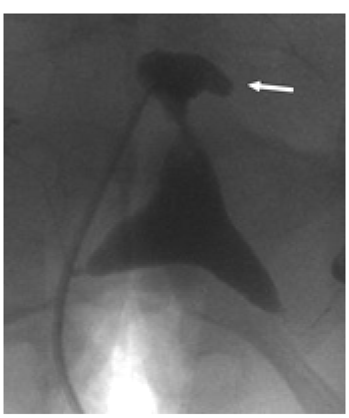


Figure 40: Hysterosalpingogram in 37-year-old woman shows linear Caesarean scar defect at uterine isthmus (*arrows*).

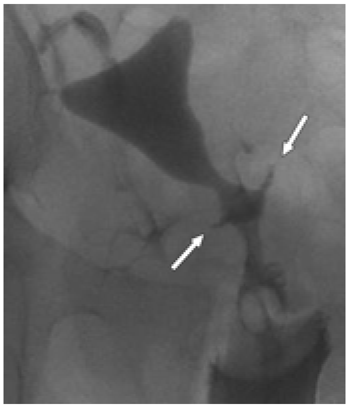
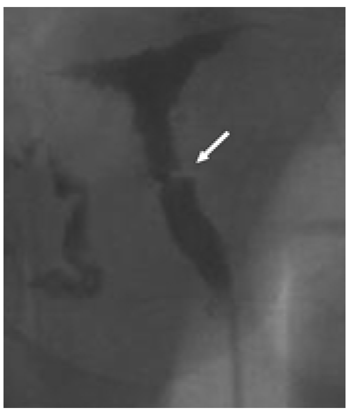


Figure 41: Hysterosalpingogram in 42-year-old woman with small defect in upper right endocervical canal with associated prominence of superior aspect of defect, resulting in narrowing at uterine isthmus (*arrow*).



The alternative investigations suggested in this critique will help to produce a body of knowledge on effective osteopathic treatment for some of the consequences of a caesarean scar.

7.5. POSITIVE FINDINGS

The study was well supported by participants, volunteers, and family. Twenty-seven subjects were available from a large population of women with caesarean surgeries and all the participants committed to completing the 16 week study. Volunteers assisted with the measuring of data and testing of muscles.

The study had statistical significance in that the subjects' muscles of interest improved with strength. Obtaining a scientifically verifiable measuring tool for the study was a key for the success of data collection and completion of the 16-week program. The study was completed in a timely manner.

On completion of this study, the author obtained a deeper understanding of how the effects of scar tissue can impact the body and the possible effects on all the various physiological systems. The author subsequently improved treatment techniques on scar tissue for patients requiring such treatments in his clinic.

8. CHAPTER EIGHT: CONCLUSION

This thesis investigates the limitations of a caesarean scar and how it affects the strength of particular muscles in a patient. The impact such a scar may have on the body through the various anatomical connections result in complications of the optimal performance of strength of the muscles of interest as measured with the hand held strength gauge dynamometer.

The results show significant changes in muscle strength of twenty-seven women with caesarean scars after a treatment protocol consisting of myofascial unwinding with the lumbar vertebrae and sacrum boney anchors. The results reached greater significance after the second treatment, which was measured four weeks later. Some discrepancy did arise in the pre-treatment group data, with changes that infer that the strength of some of the muscles did improve prior to the application of treatment. However, the end results clearly provide a substantial and consistent increase in muscle strength after the caesarean scar was treated.

Although scientific studies may not always prove the continued self-discoveries that are found in general practice, attempting to study them may provide further understanding of the scope of the osteopathic profession and improve the disease resolution process in our communities.

Flow and movement of all living cells in the body must be present for the greatness of life to be experienced in full. All systems of the human body working in harmony will help it to achieve its full potential. Communication is the key to achieving peace and harmony for all that live in this world. We all have movements that flow with the currents of life and express the true nature of our being. We are all perfectly made in order to fully express our true nature and reach our true potential. Thus the four basic osteopathic principles can be ascerned through this expression.

The four basic osteopathic principles are justified in this thesis through an examination of a caesarean scar, and lumbar and sacrum boney anchors and how they relate to the five muscles of interest (RA, AM, GM, IL, OI). This relationship is shown through an examination of the neurovascular system, which provides an intimate connection through the nerves and arterial, venous and lymphatic fluids. The osteopathic treatment of caesarean scars and lumbar and sacral restrictions was applied in order to alleviate obstructions to the flow of these fluids, to improved physiology and offer the potential re-emergence of cellular growth.

The five muscles of interest and connection with the caesarean scar have an important relationship with the nervous system for their function and that a release of tension and improved mobility of the lumbar and sacrum boney anchors, in relation to the scar, with myofascial release techniques, will greatly impact the strength of the muscles involved as shown in the results of this study.

To further justify and support the four osteopathic principles, this thesis provides a detailed description of the myofascial system utilizing the fascial chains as an avenue of connection. This web of fascia, although continuous, is broken down into 5 myofascial chains. Through this pathway of these fascial chains, it can be shown that the caesarean scar is implicated and connected with any part or function in the body. The significant changes of muscle strength in the 5 muscles chosen for this study are all shown to be connected to the caesarean scar and the lumbar and sacrum boney anchors with the myofascial system. This is one reason that the practice of osteopathy is of great benefit to patients that require myofascial release.

The energy fields, only as a brief introduction, is examined for the creation of awareness to the reader that a scar impacts the body, not only at the physical level, but potentially at the emotional and other energy fields mentioned. The totality of the patient, from an osteopathic point of view, is not limited to the physical field level but does require great sensitivity and intuition from the practitioner to investigate other human dimensional fields.

This thesis provides a review of literature in regards to caesarean procedures, operations and standards in order to understand what structures are implicated.

An examination of literature provided for the instrumentation tool used in this study supports this tool as acceptable within the scientific community for measurement of muscle strength. The literature provided also supports the muscles chosen for this study.

An examination of applied kinesiology (AK) muscle testing and the “make test” (study) verse “break test”(AK) procedures were provided to outline the variety of ways dysfunction in a patient’s body can be discovered by using muscle testing.

The literature also provides current trends in how the world is moving towards a greater number of caesarean surgery births and the possible psychological and physiological implication that may arise in this population. The increasing numbers are higher than the acceptable world health organization (WHO) standards.

The potential benefit of osteopathic antepartum treatments for women could be in the prevention of emergency caesarean sections. Osteopathic antepartum treatments of the lumbar spine may improve labour by removing and relieving obstructions of the nerves and blood supply to the parturition centre (Clark, 1999). As A. T. Still once said: “When you want more power, turn on the artery…” (Conner, 2005, p. 23). Potentially osteopathic treatment can be useful in the prevention of caesarean births by freeing any lesions or impediments to the position, mobility and vitality of the structures involved and required in the birth process.

For women who have undergone a caesarean section, this study does outlines a treatment protocol that may provide a solution to caesarean scar tissue implications that affect the body’s physiological systems and more specifically the strength of the five examined muscles that are attached to the pelvis.

BIBLIOGRAPHY

Alderdice, F., Mckenna, D., & Dornan, J. (2003). Techniques and materials for skin closure in caesarean. The Cochrane Library, (2), 1-15.

Anderson, E. R., & Gates, S. (2004). Techniques and material for closure of the abdominal wall in caesarean. The Cochrane Library, (4), 1-15.

Anderson, G. (2004). Making sense of rising caesarean rates. Retrieved January 20, 2009, BMJ 2004; 329:696-697 (25 September), doi:10.1136/bmj.329.7468.696.

Bamigboyee, A. A., & Hufmeyr, G. J. (2003). Closure versus non-closure of the peritoneum at caesarean. The Cochrane Library, (2), 1-39.

Bennett, T.J., (1960). A new clinical basis for the correction of abnormal physiology. Burlingame, CA: Self-published.

Bohannon, R. W. (1986). Test-retest reliability of hand-held dynamometry during a single session of strength assessment. Department of Physical Therapy, volume 66, number2, February 1986, 206-209.

Bohannon, R. W. (1990). Hand-held compared with isokinetic dynamometry for measurement of static knee extension torque (parallel reliability of dynamometers). Clinical Physics and Physiological Measurement, 11(3), 217–222.

Bohannon, R. W. (2005). Manual muscle testing: Does it meet the standards of an adequate screening test? Clinical Rehabilitation, 19 (6), 662–667.

Boyle, K., & James, K. (2002). Osteopathic ease treatment of the transverse caesarean scar and its effect on the mobility of the bladder, the mesentery, the pericardial bands, and the sphenobasilar symphysis (Thesis presentation, Canadian College of Osteopathy, 2005)

Brennan, B.A., (1987). Hands of light—A guide to healing through the human energy field. New York: A Bantam Book Publishing Group Inc.

Canadian College of Osteopathy (2004). Definition of Osteopathy. 1st year GOT binder information package. Course presented by P. Durelle: Canadian College of Osteopathy.

Canadian College of Osteopathy-Laflamme (2006). Bones of the face course handouts. Course presented by D. Laflamme, Toronto: Canadian College of Osteopathy

Canadian College of Osteopathy-Laflamme (2007). Internal gynecology course handouts. Course presented by D. Laflamme, Toronto: Canadian College of Osteopathy.

Canadian College of Osteopathy (2008). Autoregulation course lecture on February 27, 2008 presented by P. Durelle: Canadian College of Osteopathy.

Canadian Institute For Health Information. (2007). Giving birth in Canada: The costs. Retrieved January 20, 2009, from www.fims.uwo.ca/newnedia2007/page5051281.aspx#giving_birth_in_canada.

Clark, M. E. (1999). Applied anatomy: Tradition and research in osteopathy. Montreal: Editions Spirales.

Clemente, C. (1981). Anatomy: A regional atlas of the human body (2nd ed.). Baltimore: Urban & Schwarzenberg.

Chikly, B. (1998). Is human cerebrospinal fluid reabsorbed by lymph? Lymph drainage therapy (LDT) and manual drainage of the central nervous system. American Association of Osteopathic Journal, winter 1998, 30-34.

Conner, W. J. (2005). The mechanics of labour. Montreal: Editions Spirales.

Danto, J. B. (2003). Review of integrated neuromusculoskeletal release and the novel application of a segmental anterior/posterior approach in the thoracic, lumbar, and sacral regions. Journal of the American Osteopathic Association, 103 (12), 583-596.

deGroot, J., & Chusid, J. G. (1988). Correlative neuroanatomy (12th ed.). East Norwalk, Connecticut: Appleton and Lange.

Dicle, O., Kucukler, C., Pirnar, T., Erata, Y., & Posaci, C., (1996). Magnetic resonance imaging evaluation of incision healing after Caesarean s. European Radiology, 7, 31-34.

Dishman, J.D. & Bulbulian, R. (2000). Spinal reflex attenuation with spinal manipulation. Spine, 25, 2519-2525.

Druelle, P. (2004). Osteopathic assessment and treatment. Osteopathic Therapy. Retrieved January 20, 2009 from http://www.visceralyoga.com/osteopathy_treatment.html.

Druelle, P. (2007). Canadian College of Osteopathy web page information. Retrieved January 20, 2009 from http://www.osteopathiecollege.com.

Dunn, J. C., & Iversen, M. D. (2003). Interrater reliability of knee muscle forces obtained by hand held dynamometer from elderly subjects with degenerative back pain. Journal of Geriatric Physical Therapy, 26(3), 23–29.

Fosang, A., & Baker, R. (2006). Gait and posture, a method for comparing manual muscle strength measurements with joint movements during walking. National Athletic Trainers Association, 24(4), 406–411.

Fredericson, M., Cookingham, C., Chaudhari, A., Dowdell, B., Oestreicher, N., & Sahrmann, S. (2000). Hip abductor weakness in distance runners with iliotibial band syndrome. Clinical Journal of Sport Medicine, 10(3), 169–175.

Frymann, V. (1980). The whole patient needs a whole physician. Journal of Holistic Medicine, 2(1), 1-18.

Garten, H., (1996). The mechanism of muscle test reactions and challenge in applied kinesiology: an attempt to explain the test phenomena. Townsend Letter for Doctors and Patients, (161), 58.

Gilles Roy, M. A. & Doherty, T. J. (2004). Reliability of hand-held dynamometry in assessment of knee extensor strength after hip fracture. American Journal of Physical Medicine and Rehabilitation, 83(11), 813–818.

Goodheart, G.J. (1989). Applied kinesiology: the beginning. Digest of Chiropractic Economics, 31(6): 15-23.

Goodheart, G.J. (1972). The cervical challenge. Digest of Chiropractic Economics, 15(2), 134-137.

Green, B.N. & Gin, R.H. (1997). George Goodheart, Jr., DC., and a history of applied kinesiology. Journal of Manipulative and Physiological Therapeutics, 20(5), 331-337.

Grey, A., Wilber, K., & McCormick, C. (1990). Sacred mirrors: The visionary art of Alex Grey. Rochester: VT: Inner Traditions International.

Hammer, W. (2001). Collagen fibers are embedded in a colloidal gel. Chiroweb/DC Archives. Retrieved December 1, 2007 from http://www.chiroweb.com/archives/19/08/21.html.

Hanrahan, S., Van Lunen, B. L., Tamburello, M., & Walker, M. L. (2005). The short-term effects of joint mobilizations on acute mechanical low back dysfunction in collegiate athletes. Journal of Athletic Training, 40(2), 88–93.

Hass, M., Cooperstein, R., & Peterson, D. (2007). Disentangling manual muscle testing and applied kinesiology: Critique and reinterpretation of a literature review. Chiropractic and Osteopathy 15(11), 1-23.

Heese, N. (1991). Major Bertrand De Jarnette: Six decades of sacro occipital research, 1924-1984. Chiropractic History, 11(1), 13-5.

Hitti, M. (2005). Elective Caesarean delivery rising. Retrieved July 2, 2008 from www.webmd.com/baby/news/20050422/elective-Caesarean--deliveries-rising.

Hofmeyr, G. J. & Mathai, M. (2004). Techniques for caesarean. The Cochrane Library, (1), 1-9.

Hole, J.W. (1987). Human anatomy and physiology (4th ed). Iowa: Brown Publishers.

Hsieh, Chang-Yu, (1990). Reliability of manual muscle testing with a computerized dynamometer. Journal of Manipulative and Physiological Therapeutics, 13,(2), 72-82.

Isings, E. & Taylor, S. (2007). Elective caesarean sections on the rise. Retrieved January 20, 2009 from www.fims.uwo.ca/newnedia2007/page298181613.aspx.

Jovanouski, K. (2007). Do doctors have a financial incentive to perform caesarean sections? Retrieved January 20, 2009. www.fims.uwo.ca/newnedia2007/page29842545.aspx.

Jelsema, R., Wittingen, J., & Vandenkolk, K. (1993). Continuous, non locking, single layer repair of the low transverse uterine incision. Journal of Reproductive Medicine, (38), 393–396.

Karumpuzha, R. H., & Johanson, R. (2001). Techniques for performing caesarean. Best Practice and Research Clinical Obstetrics and Gynecology, 15(1), 17–47.

Keller TS, Colloca DC, (2000). Mechanical force spinal manipulation increases trunk muscle strength assessed by electromyography: a comparative clinical trial. Journal of Manipulative and Physiological Therapeutics, 23, 585-595.

Kendall, F. P. & Kendall McCreary, E. (1983). Muscles testing and function (3rd ed.). Baltimore: Williams and Wilkins.

Kinakin, K. (2004). Optimal muscle training. Colombia: Ken Kinakin.

Kirkey, S. (2008). Canada’s caesarean rate at record high…Older, obese and choosy women drive rates. Retrieved July 7, 2008 from www.canada.com/components/print.aspx.?id=08172640-55d7-46.

Koo, V., Lynch, J., & Cooper, S. (2003). Risk of postnatal depression after emergency delivery. Journal of Obstetrics and Gynecology, 29(4), 246–250.

Korr, I.M. (1994, June). Segmental Facilitation. Paper presented at the meeting of the Canadian College of Osteopathy’s Montreal International Osteopathic Symposium, Montreal.

Kuchera, M. L., & Kuchera, W. A. (1994). Osteopathic principles in practice (2nd ed.). Columbus: Greyden Press.

LaBan, M. M. (2006). Atrophy and clinical weakness of the iliopsoas muscle: A manifestation of hip osteoarthritis. American Journal of Physical Medicine & Rehabilitation by Lippincott Williams and Wilkings. DOI: 10.1097.phm.0000223222.55943.9a. page 629.

LaBan, M. M. (2004). Iliopsoas weakness, a clinical sign of lumbar spinal stenosis. American Journal of Physical Medicine & Rehabilitation, 83, 224–225.

Lafayette Instrument Company (2003). Lafayette Instrument® manual muscle test system user's manual: Model 01163. 3700. Lafayette, IN: Lafayette Instrument Company.

Lurie, S., & Glezerman, M. (2003). The history of Caesarean technique. The department of Obstetrics and Gynecology, Edith Wolfson medical Centre and the Sackler School of Medicine, Tel Aviv University. Mobsy. Inc. 0002-9378/2003/ DOI.: 10.1016/S0002-9378(03)00856-1. American Journal of Obstetrics and Gynecology, 2003: 189: 1803-1806.

Magoun, H.I. (1976). Osteopathy in the cranial field (3rd ed.). Indianapolis, IN: The Cranial Academy.

Manheim, C. J. (2001). Myofascial release manual (3rd ed.). Thorofare, NJ: Slack Incorporated.

Mann, F. (1962). The ancient Chinese art of healing. London: William Heinemann Medical Books.

Marcus, A. (2004). Foundations for integrative musculoskeletal medicine: An east-west approach. Berkeley, CA: North Atlantic Books.

Martin, H. J., Yule, V., Syddall, H. E., Dennison, E. M., Cooper, C., & Sayer, A. A. (2006). Is hand-held dynamometry useful for the measurement of quadriceps strength in older people? A comparison with the gold standard biodex dynamometry. Gerontology, 53(2), 154–159.

Martin, RJ. (1977). Dynamics of correction of abnormal function. Sierra Madre, CA: Self-published.

Mathai, M., & Hofmeyr, G. J. (2007). Abdominal surgical incisions for the caesarean. The Cochrane Library, (1), 1-25.

McCord, KM. (1991). Applied Kinesiology: an historical overview. Digest of Chiropractic Economics, 34(2), 20-27.

Milne, H. (1995). The heart of listening: A visionary approach to craniosacral work. (Vols 1-2). Berkeley, CA: North Atlantic Books.

Moore, K. L. (1985). Clinically oriented anatomy (2nd ed.). Baltimore: Williams & Wilkins.

Morling, G. (2009). Understanding iliopsoas: clinical implications for the massage therapist. Journal of the Australian Traditional Medicine Society 2009;15(1):7-12.

Myers, T. W. (2001). Anatomy trains, myofascial meridians for manual and movement therapists. London, ON: Churchill Livingstone.

Myers, T. W. (2003). The opinionated psoas, part 2. (serial on the internet). Retrieved May 9, 2009. Cited on 12.12.08. Available from http://www.massagetherapy.com.

Netter, F. H. (1997). Atlas of human anatomy (2nd ed.). East Hanover: Novarits.

Niemuth, P. E., Johnson, R. J., Myers, M. J., & Thieman, T. J. (2005). Hip muscle weakness and overuse injuries in recreational runners. Rocky Mountain University of Health Professions, UT. Copyright by Lippincott Williams & Wilkins. Clinical Journal of Sport Medicine, volume 15, number1, January 2005, 14-21.

O’Connell, J. A. (1998). Bioelectric fascial activation and release: The physician’s guide to hunting with Dr. Still. Indianapolis, IN: American Academy of Osteopathy.

O’Connor, J. & Bensky, D. (1994). Acupuncture: Shanghai college of traditional medicine (11th ed.). Seattle, WA: Eastland Press, Incorporated.

Owens C. (1937). An endocrine interpretation of Chapman’s reflexes (2nd ed.). Newark OH: American Academy of Osteopathy.

Paoletti, S. (2006). The fascias: Anatomy, dysfunction and treatment. Seattle, WA: Eastland Press, Inc.

Perry, J., Weiss, W. B., Brunfield, J. M., & Gronley, J. K. (2004). The supine hip extensor manual muscle test: A reliability and validity study. Archives of Physical Medicine and Rehabilitation, 85(8), 1345–1350.

Pollard, H., Lakay, B., Tucker, F., Watson, B., & Balbis, P. (2005). Interexaminer reliability of the deltoid and psoas muscle test. By the National University of Health Sciences. Doi: 10.10161j.jmpt.2004.12.008. 52-56.

Richardson, C., Jull, G., Hides, J., Hodges, P. (1999). Therapeutic exercise for spinal stabilization: scientific basics and practical techniques. Churchill Livingston, 1999.

Ryding, E. L., Wijma, K., & Wijman, B. (1998). Psychological impact of emergency Caesarean in comparison with elective Caesarean, instrumental and normal vaginal delivery. Journal of Psychosomatic Obstetrics and Gynecology, 19(3), 135–44.

Schleip, R., Klingler, W., & Lehmann-Horn, F. (2005). Active fascial contractility: Fascia may be able to contract in a smooth muscle-like manner and thereby influence musculoskeletal dynamics. Medical Hypotheses, 65, 273–277.

Smidt, G. L., & Rogers, M. W. (1982). Factors contributing to the regulation and clinical assessment of muscular strength. Physical Therapy, 62, 1283–1290.

Schmitt, W.H. & Yanuck, S.F. (1999). Expanding the neurological examination using functional neurologic assessment: part II neurologic basis of applied kinesiology. The International Journal of Neuroscience, 97 (1-2), 77-108.

Sicotte, J.G. (2003). Myofascial Release according to the Counterstrain method manual. Quebec. Jean Guy Sicotte self published.

Stanton, C.K. & Holt, S.A. (2006). Levels and trends in Caesarean birth in the developing world, *studies in family planning*, 37(1), 41-48.

Surpapaneni, K., Silberzweig, J.E. (2008). Caesarean scar diverticulum: Appearance on hysterosalpingography. American Journal of Roentgenology 2008; 190:870-874.

Sutherland, A.S. (1962). With thinking fingers. Indianapolis, IN: The Cranial Academy.

Sutherland, W.G., (1994). The cranial bowl. Minnesota: Free Press Company, USA.

Taber, C. W. (1985). Taber's cyclopedic medical dictionary (4th ed.). Philadelphia: F.A. Davis Company.

Taylor, S. (2007). Here's what professional organizations have to say about elective caesarean sections. Retrieved January 20, 2009 from www.fims.uwo.ca/newnedia2007/298163346.aspx.

Taylor, S. (2007). Map of world caesarean rates. Retrieved January 20, 2009 from www.fims.uwo.ca/newnedia2007/298223136.aspx

Thie, J. F. (1973). Touch for health (3rd ed.). Pasadena, CA: T.H. Enterprises.

Travell, J. G. & Simons, D. G. (1983). Myofascial pain and dysfunction: The trigger point manual. Baltimore, MD: Williams and Wilkins.

Tsiaras, A. (2005). The InVision Guide to a Healthy Heart. New York: HarperCollins.

VanDeGraaf, K. M. (1984). Human anatomy. Dubuque, IA: William. C. Brown Publishers.

Vander, A. J., Sherman, J. H., & Luciano, D. S. (1985). Human physiology: The mechanisms of body function (4th ed.). Columbus, OH: McGraw-Hill.

Van Rees, D., Bernstine, R.L. & Crawford W. (1981). Involution of the postpartum uterus: An ultrasonic study. Journal of Clinical Ultrasound, 9, 55.

Varano, L. (2007). Women afraid of childbirth and uncertain delivery date are turning to caesarean sections. Retrieved January 20, 2009 from www.fims.uwo.ca/newnedia2007/page298183714.aspx.

Wang, T. J., Belza, B., Thompson, F. E., Whitney, J. D., & Bennet, K. (2007). Effects of aquatic exercise on flexibility, strength and aerobic fitness in adults with osteoarthritis of the hip or knee. Journal of Advanced Nursing, 57(2), 141–152.

Ward, R.C., Hruby, R. J., Jerome, J. A., Jones, J. M., & Kappler, R. E. (2003). Foundations for osteopathic medicine (2nd ed.). Philadelphia, PA: Lippincott Williams and Wilkins.

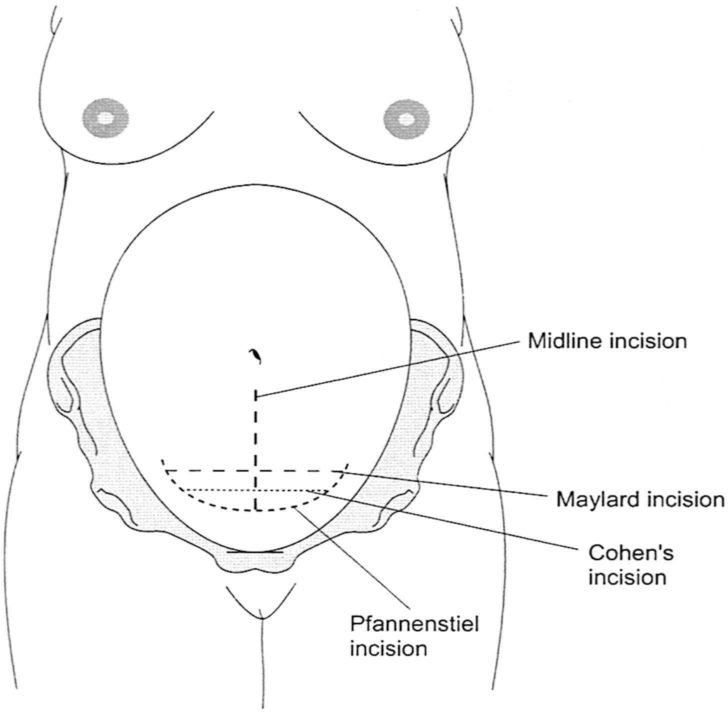
Williams, R. (2006). What you don't know about scar tissue. *Osteopathic Therapy*. Retrieved September 2, 2007 from http://www.visceralyoga.com/scartissue.html.

Willms, A.B., Brown, E., Kettritz, U.I., Kuller, J.A. & Semelka, R.C. (1995). Anatomic changes in the pelvis after uncomplicated vaginal delivery: evaluation with serial MR imaging. Radiology 195, 91.

Woodall, P. H., (2005). *Intra-pelvic technique or manipulative surgery of the pelvic organs.* Montreal, QC: Editions Spirales.

Zink, J.G. (1973). Expanding lymphatic technique to include the respiratory/circulatory model. 1939-1998 AAO Yearbook, 42.

APPENDIX A: CAESAREAN INCISIONS



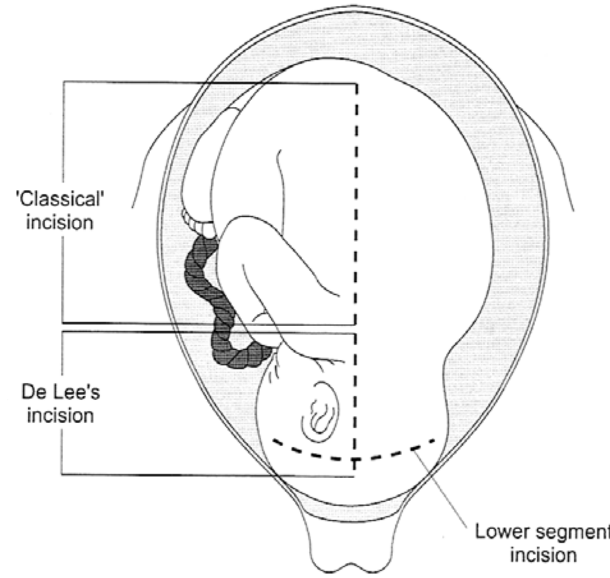


Figure A-1 (above, left): Position of various skin incisions (Karumpuzha & Johanson, 2001). **Figure A-2** (above, right): Position of various skin incisions (Karumpuzha & Johanson, 2001). **Figure A-3** (below): Neuropathways in parturition (Netter, 1997, plate 394) as a reference for incision.

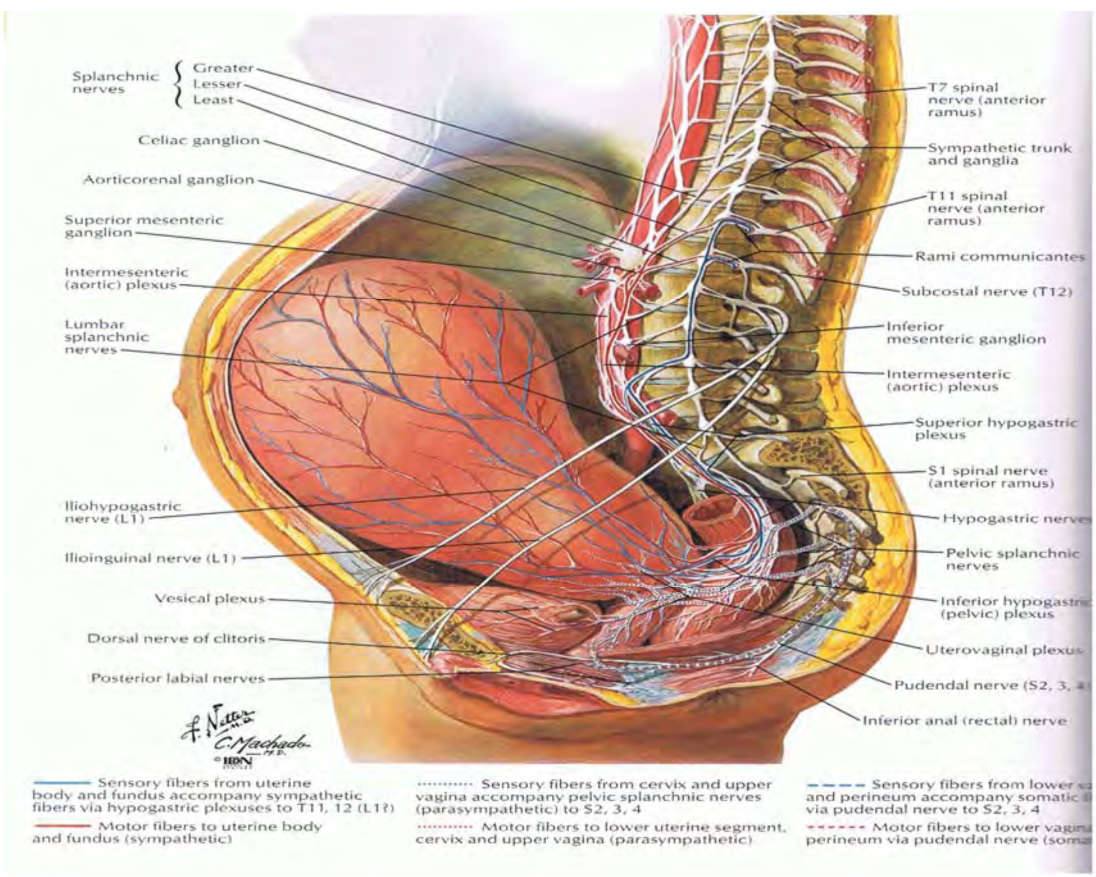


Figure A-4: Internal view of fetus (Tsiaras, 2005).

APPENDIX B: SUTURES OF THE UTERUS

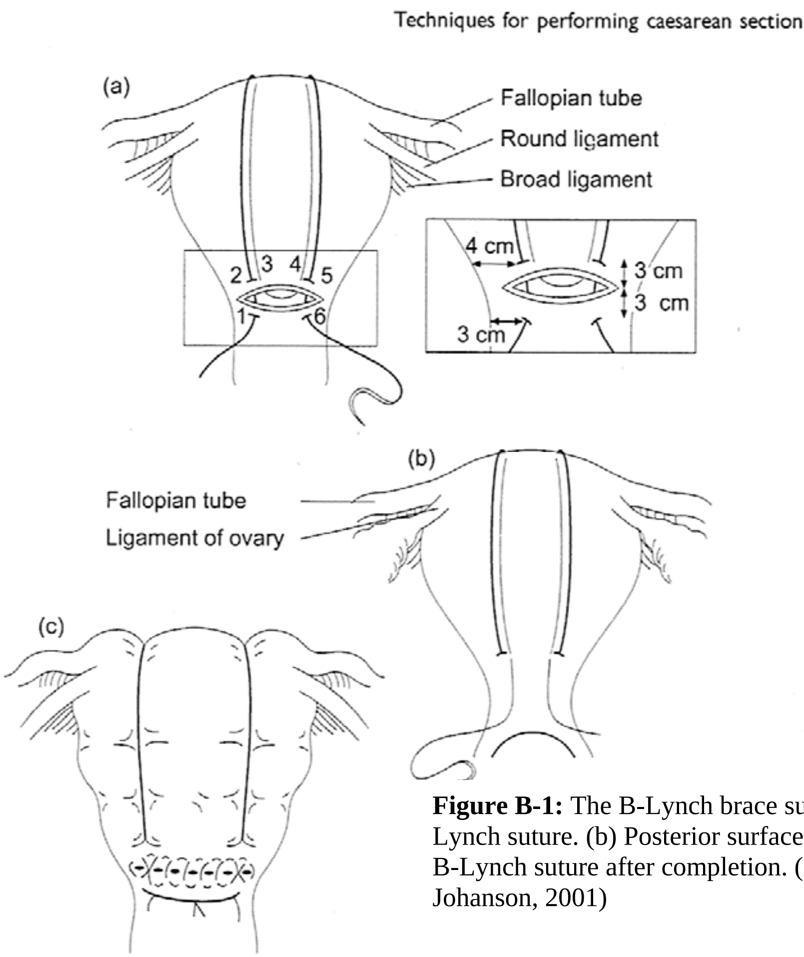


Figure B-1: The B-Lynch brace suture. (a) Method of B-Lynch suture. (b) Posterior surface of the uterus. (c) The B-Lynch suture after completion. (Karumpuzha & Johanson, 2001)

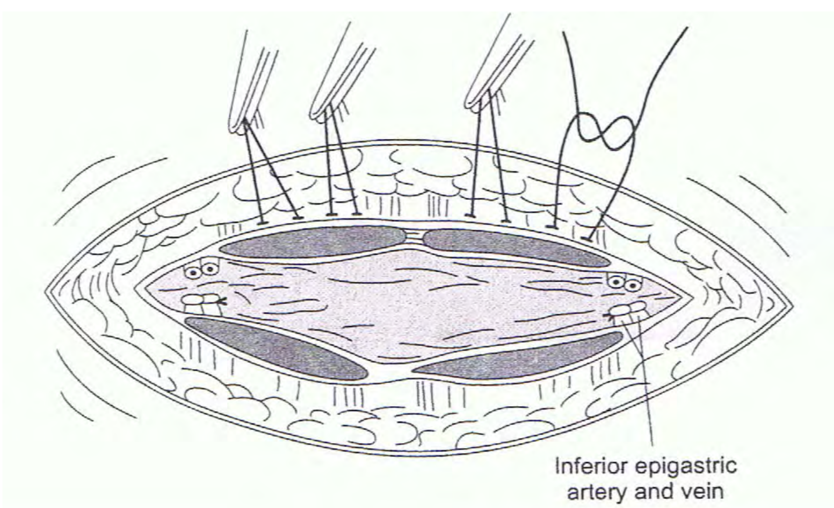
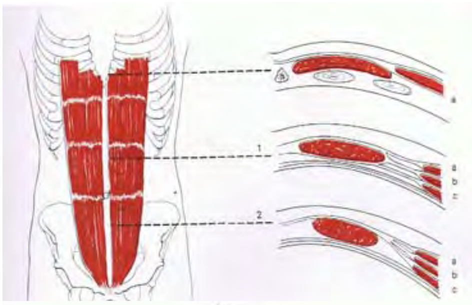
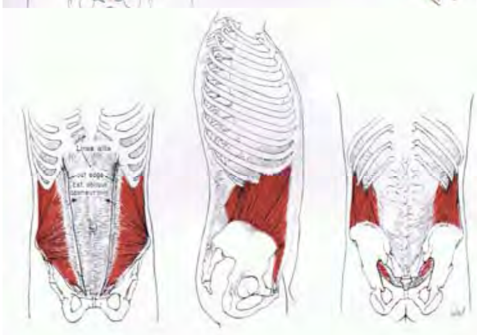


Figure B-2: Maynard incision. Inferior epigastric vessels ligated and recti muscles cut (Karumpuzha & Johanson, 2001)

APPENDIX C: MUSCLES OF INTEREST





RECTUS ABDOMINUS MUSCLE

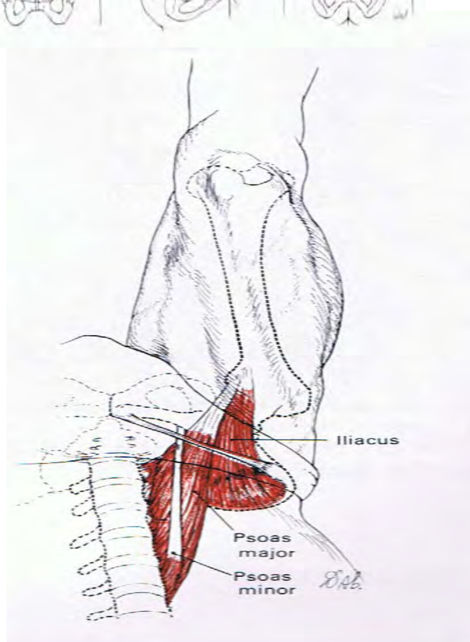
Origin: Pubic crest and symphysis.

Insertion: Costal cartilages of fifth, sixth, and seventh ribs, and xiphoid process of sternum.

Function: Flexes the vertebral column by approximating the thorax and pelvis anteriorly. With the pelvis fixed, the thorax will move toward the pelvis; with the thorax fixed, the pelvis will move toward the thorax.

Nerve: T5-12, ventral rami.

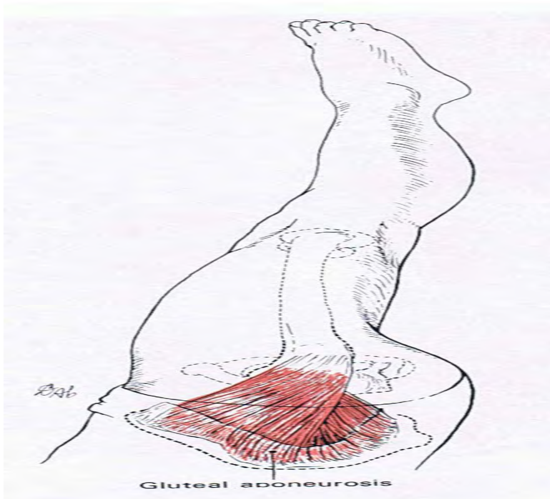
Other related muscles: External and internal obliques and transversus abdominus (shown at left).



ILIOPSOAS MUSCLE

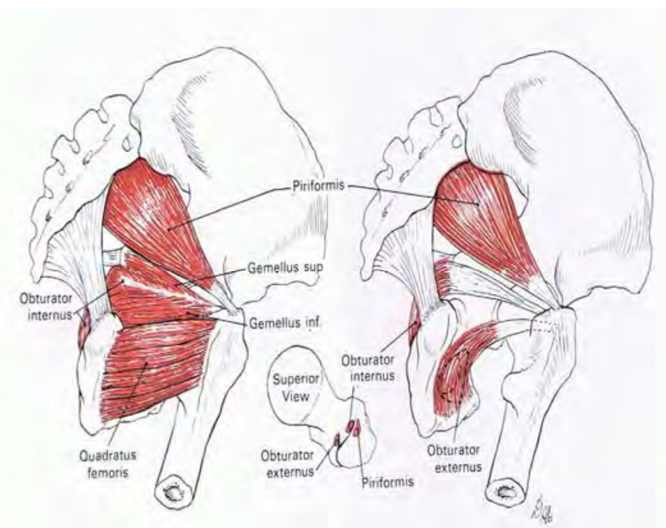
Psoas major:
Origin: Ventral surfaces of transverse processes of all lumbar vertebrae, sides of bodies and corresponding intervertebral discs of the last thoracic and all lumbar vertebrae and membranous arches that extend over the sides of the bodies of the lumbar vertebrae.
Insertion: Lesser trochanter of the femur.
Nerve: Lumbar plexus, L1, 2, 3, 4.

Iliacus:
Origin: Superior two-thirds of iliac fossa, internal lip of iliac crest, iliolumbar and ventral sacroiliac ligaments, and ala of sacrum.
Insertion: Lateral sides of tendon of psoas major and just distal to the lesser trochanter.
Nerve: Femoral, L (1), 2, 3, 4.
Action: With the origin fixed, the iliopsoas flexes the hip joint by flexing the femur on the trunk as in supine alternate leg raising, and may assist in lateral (external) rotation and abduction of the hip joint. With the insertion fixed and acting bilaterally, the iliopsoas flexes the hip joint by flexing the trunk on the femur as in the sit-up from supine position. The psoas major, acting bilaterally with the insertion fixed, will increase the lumbar lordosis; acting unilaterally, it assists in lateral flexion of the trunk toward the same side.



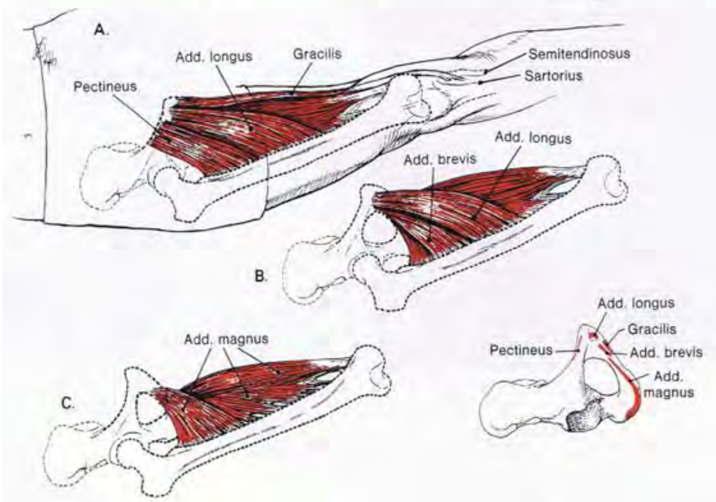
GLUTEUS MEDIUS MUSCLE

Origin: External surface of ilium between anterior and inferior gluteal lines, and margin of greater sciatic notch.
Insertion: Anterior border of greater trochanter of femur, and hip joint capsule.
Nerve: Superior gluteal, L4, 5, S1.
Action: Abducts, medially (internally) rotates, and may assist in flexion of the hip joint.



OBTURATOR INTERNUS MUSCLE

Origin: Internal or pelvic surface of obturator membrane and margin of obturator foramen, and pelvic surface of ischium posterior and proximal to obturator foramen, and, to a slight extent, from the obturator fascia.
Insertion: Medial surface of greater trochanter of femur proximal to trochanteric fossa.
Nerve: Sacral plexus, L5, S1, 2.
Action: Laterally (externally) rotates the hip joint, may assist in abduction when the hip is flexed.



ADDUCTOR MAGNUS MUSCLE

Origin: Inferior pubic ramus, ramus of ischium (anterior fibers), and ischial tuberosity (posterior fibers).
Insertion: Medial to gluteal tuberosity, middle of linea aspera, medial supracondylar line, and adductor tubercle of medial condyle of femur.
Nerve: Obturator, L2, 3, 4, Sciatic, L4, 5 S1.

Source for Appendix C: Kendall & Kendall McCreary, 1983, pp.189, 164, 170, 172, 176.

APPLIED KINESIOLOGY CHARTS

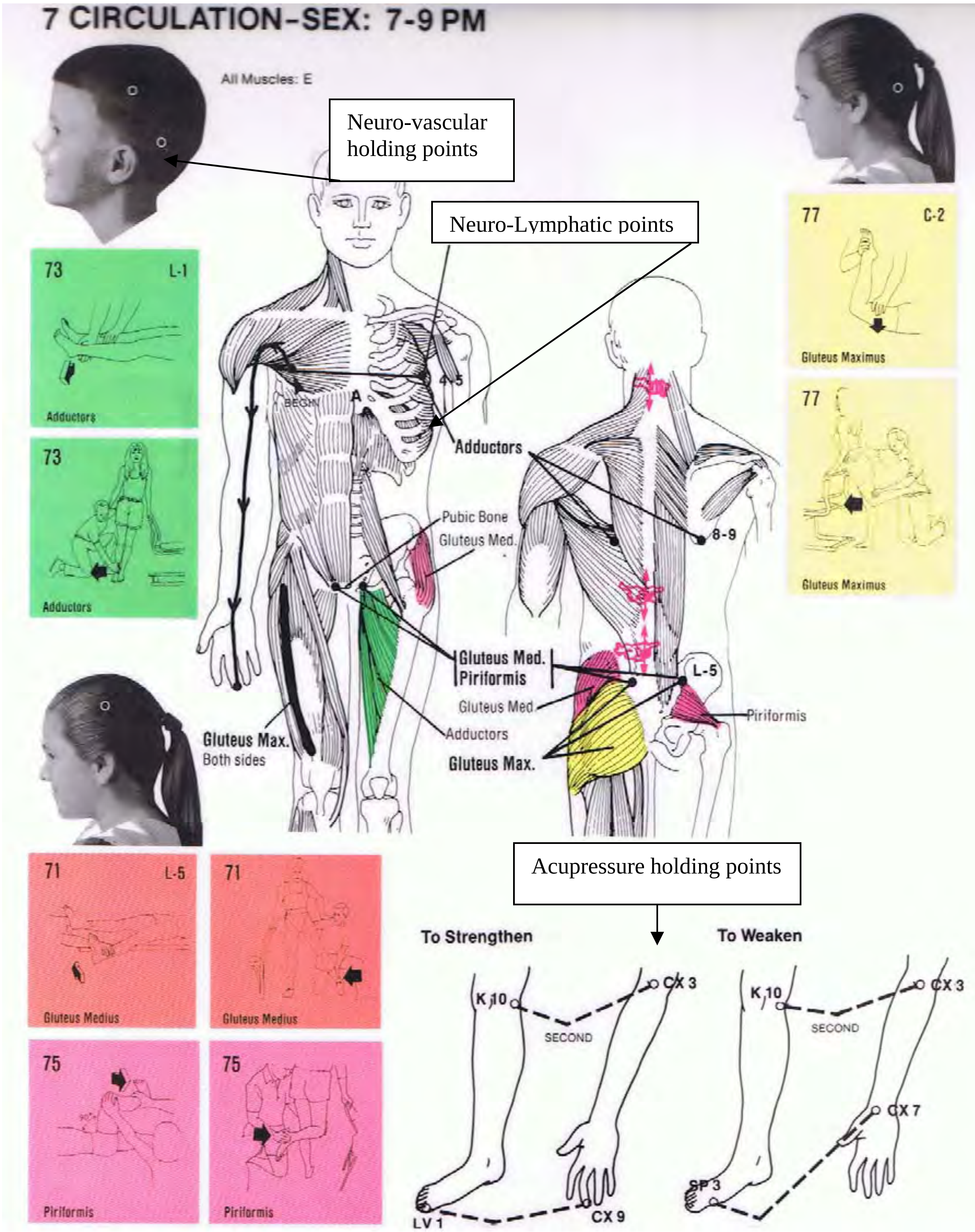


Figure CAESAREAN1: Circulation meridian Touch For Health charting system. Includes Neuro-vascular, Neuro-Lymphatic, and Acupressure holding points and related muscles/muscle strength tests and vertebrae (Thie, 1987).

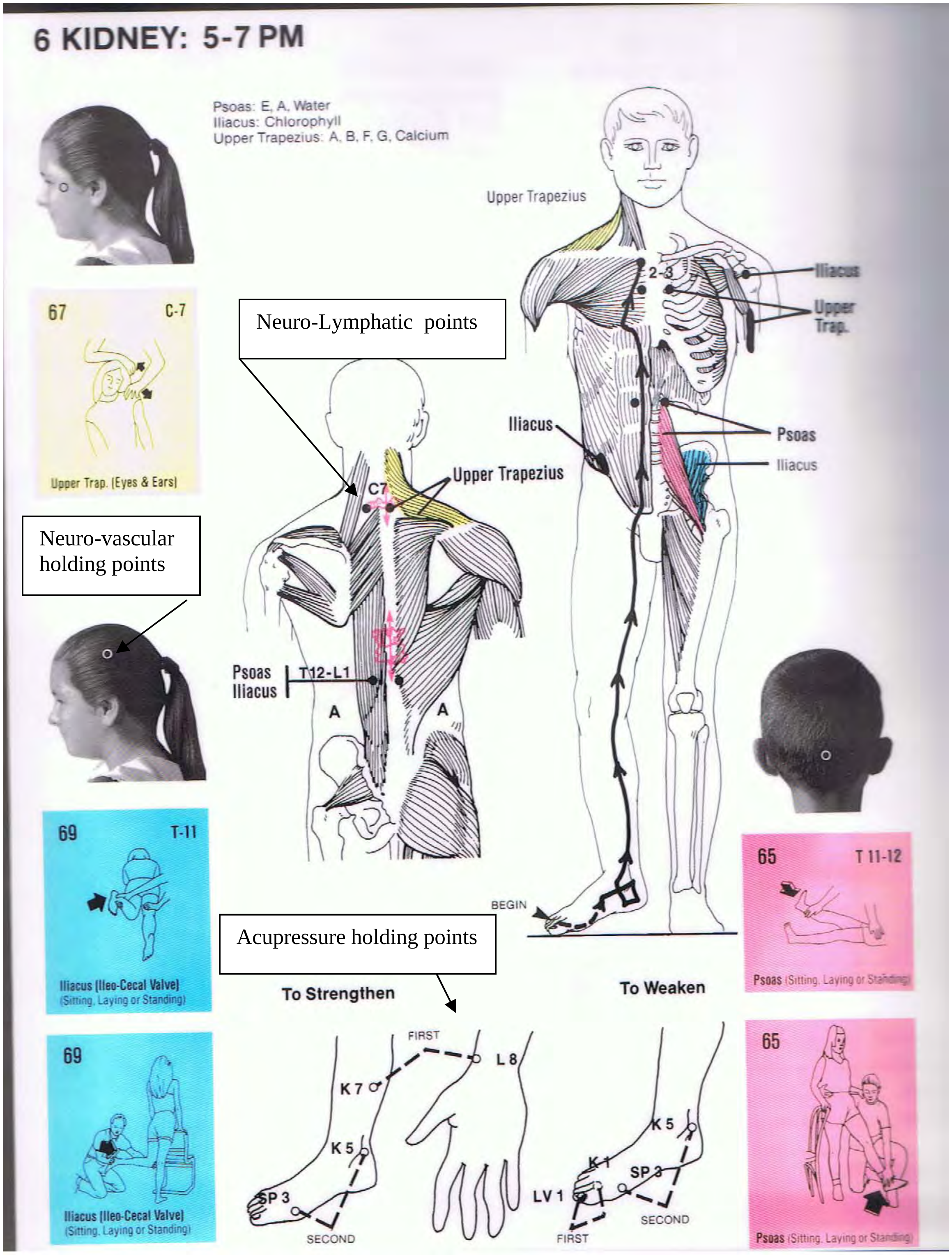


Figure CAESAREAN2: Kidney meridian Touch For Health charting system. Includes Neuro-vascular, Neuro-Lymphatic, and Acupressure holding points and related muscles/muscle strength tests and vertebrae (Thie, 1987).

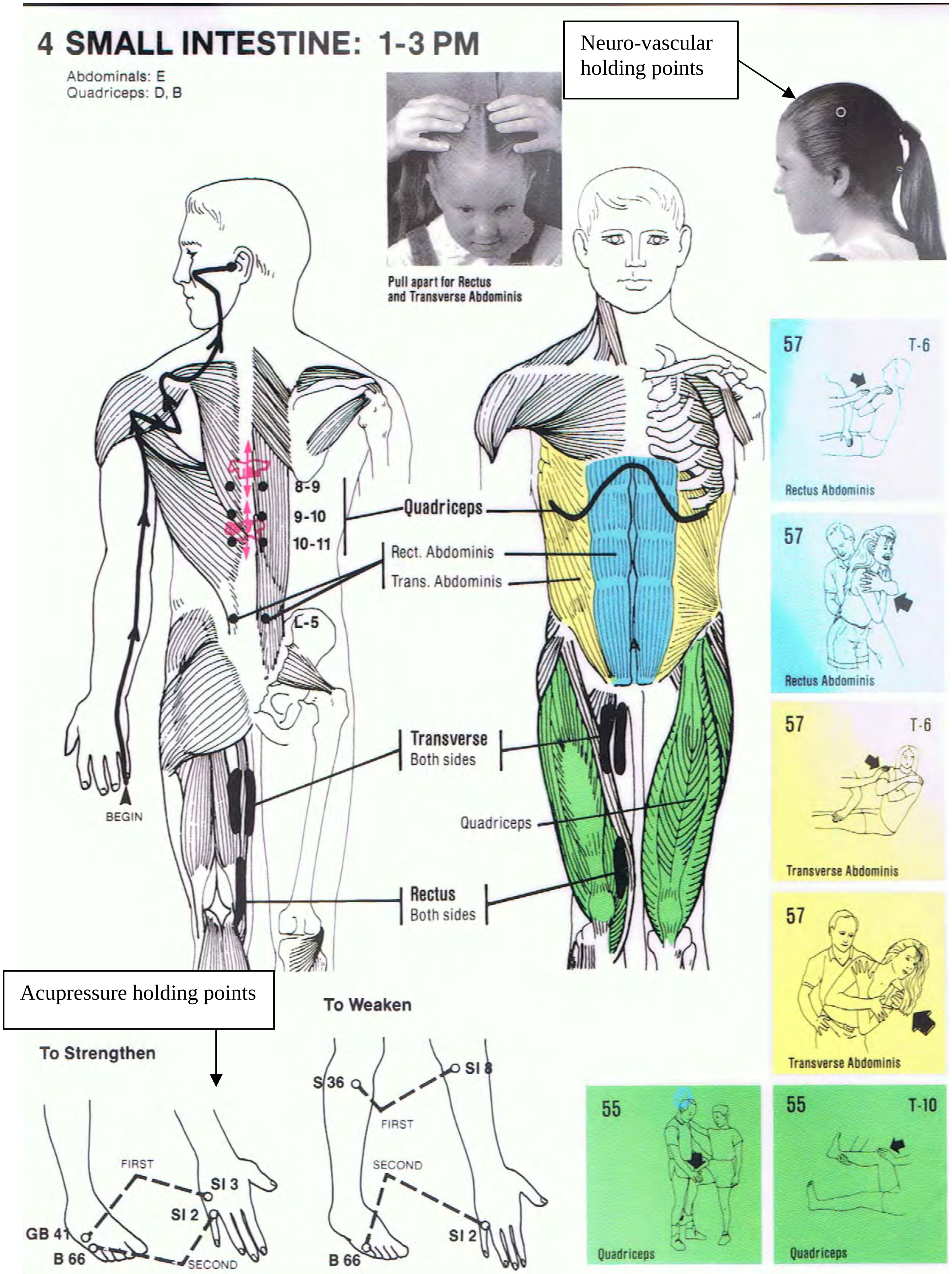


Figure C-3: Small Intestine meridian Touch For Health charting system. Includes Neuro-vascular, Neuro-Lymphatic, and Acupressure holding points and related muscles/muscle strength tests and vertebrae (Thie, 1987).

APPENDIX D: AUTONOMIC NERVOUS SYSTEM

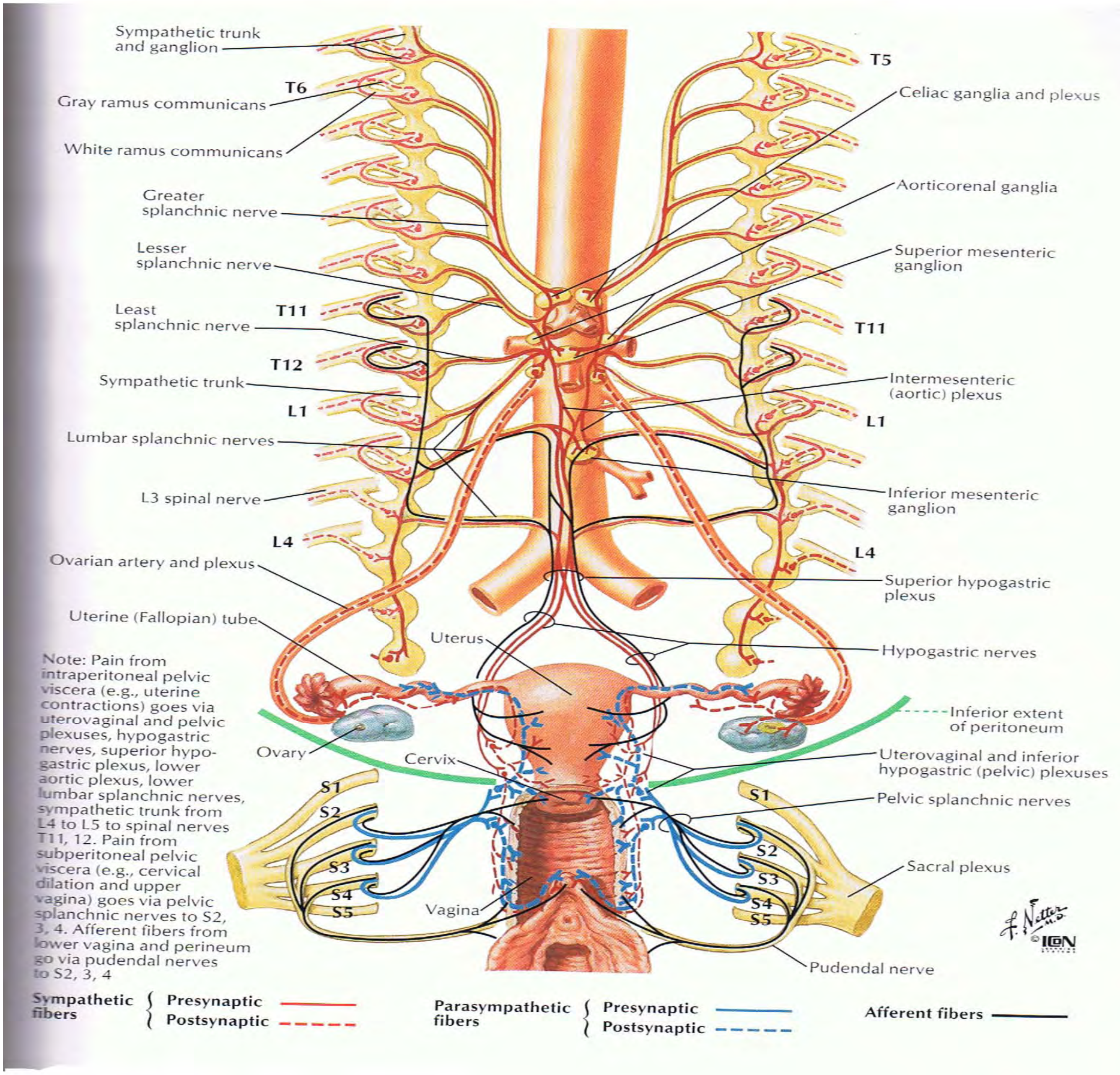


Figure D-1: Innervation of the female reproductive organs (Netter, 1997, plate 395).

KEY: Blue= PNS; Red= SNS; Solid lines= Presynaptic neurons; Broken lines=Postsynaptic neurons

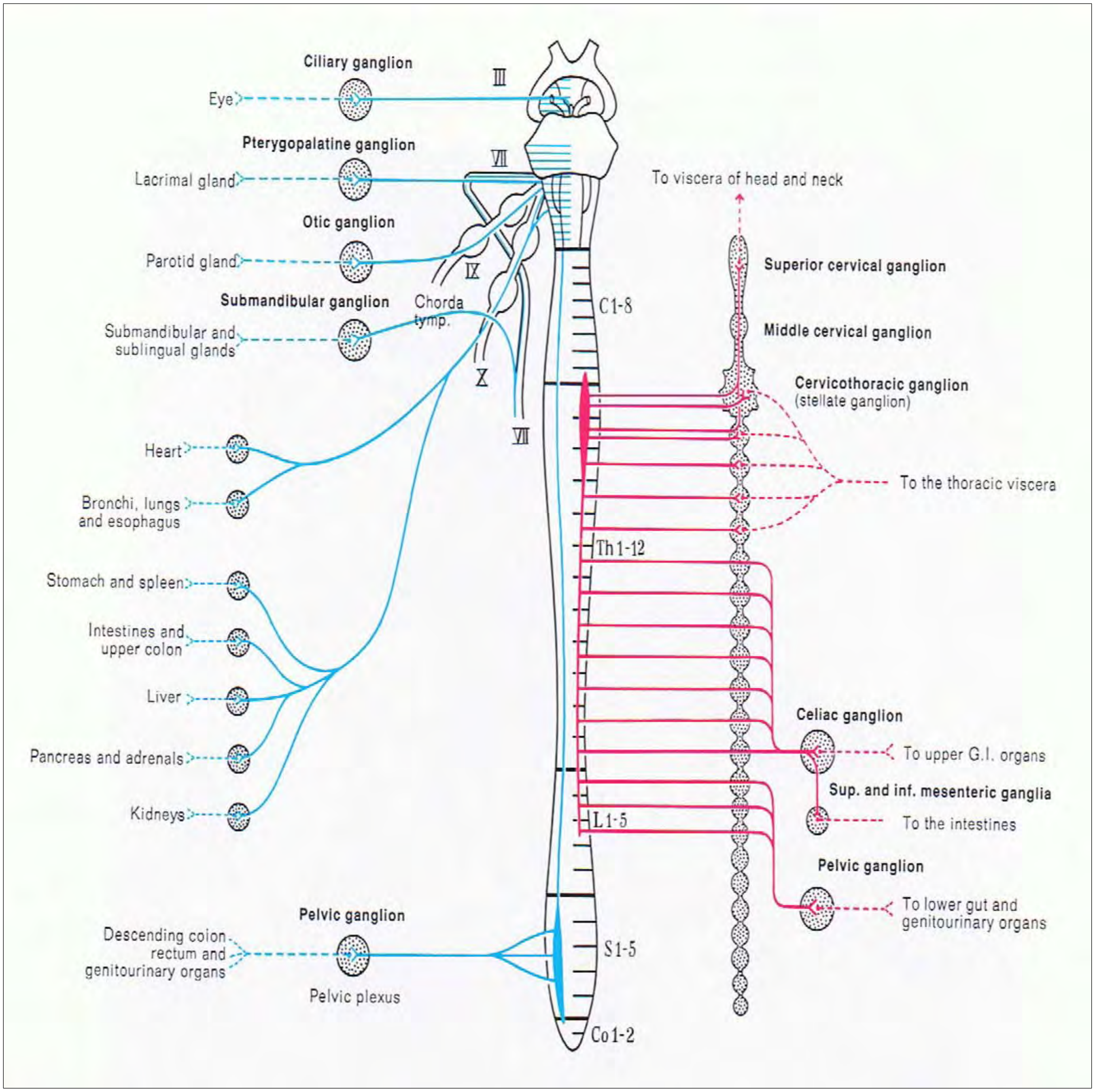


Figure D-2: The autonomic nervous system (Clemente, 1981).

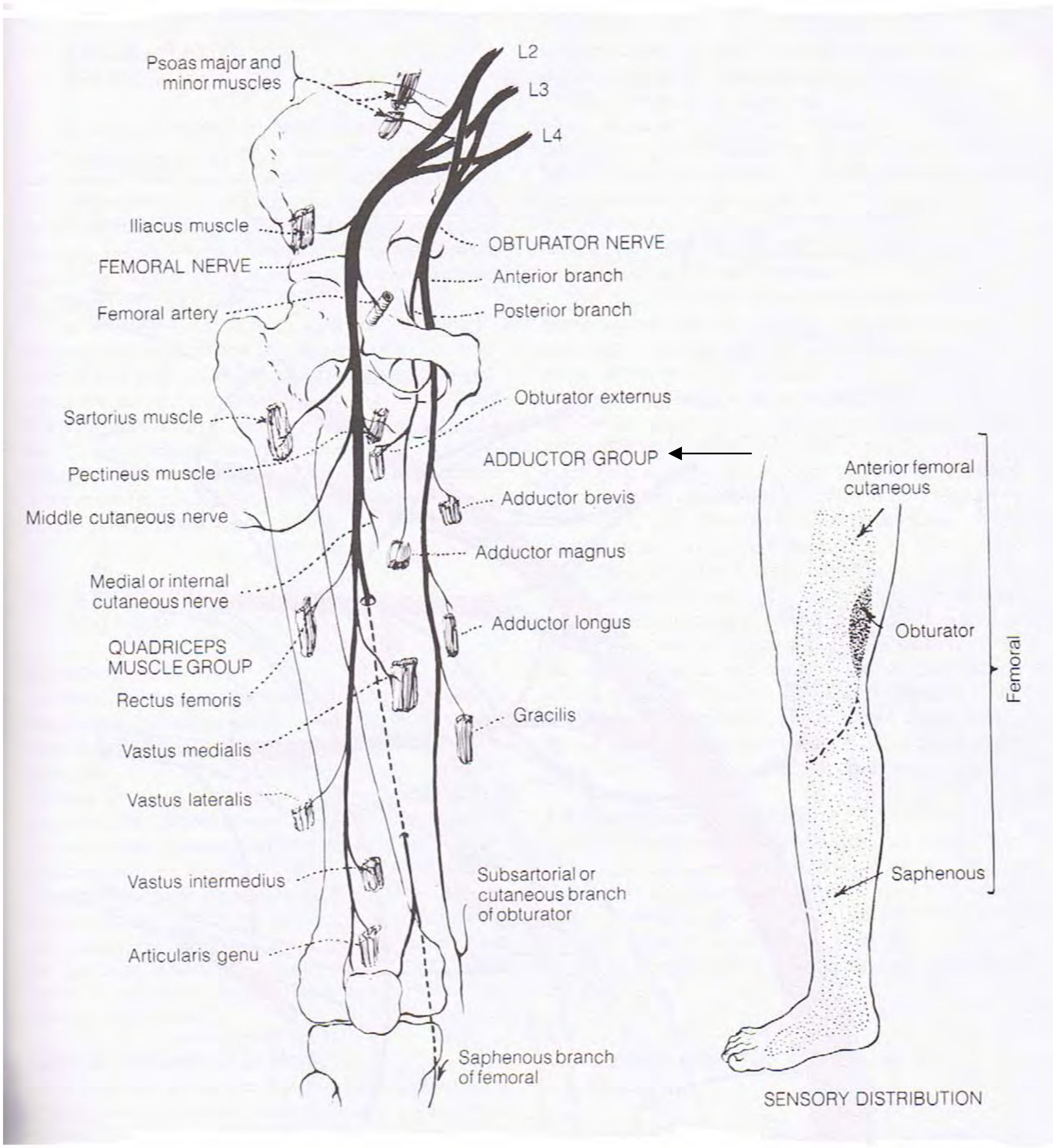
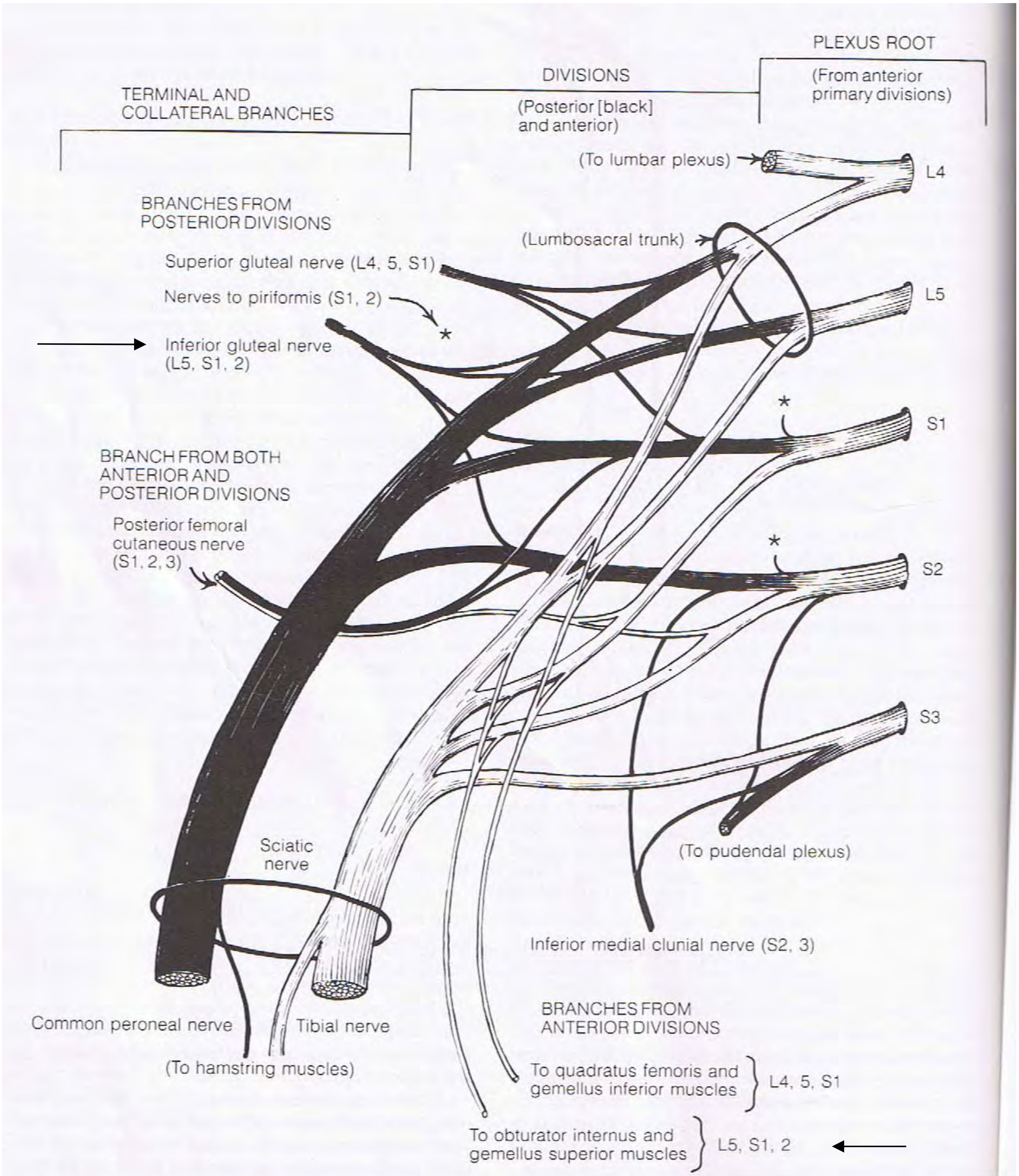


Figure D-3: The femoral (L2-4) and obturator (L2-4) nerves (deGroot & Chusid, 1988). Note the shared neural innervations between the organs and muscles (of the previous page).



FigureD-4: The sacral plexus (deGroot & Chusid, 1988).

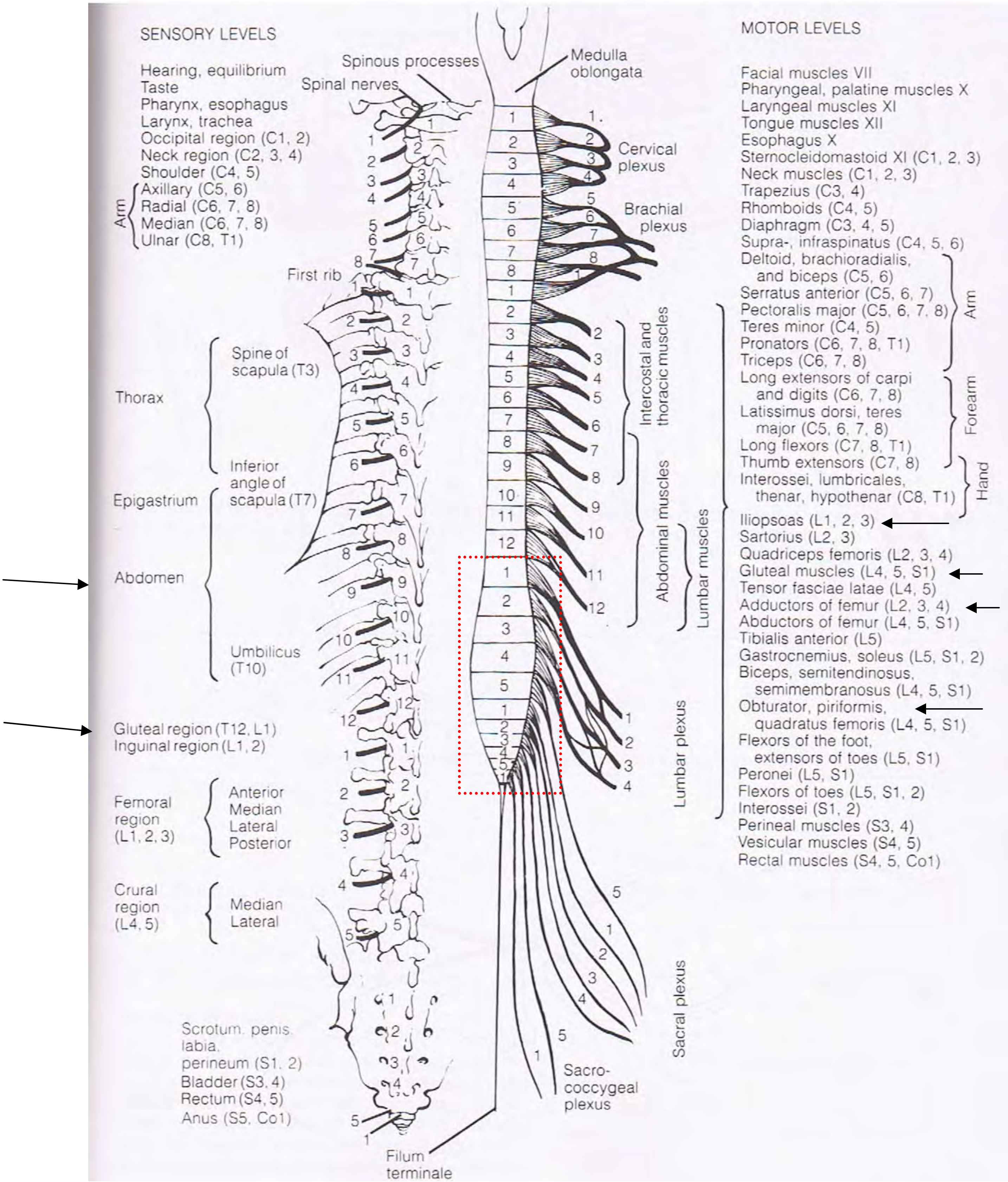


Figure D-5: Motor and sensory levels of the spinal cord (deGroot & Chusid, 1988).

APPENDIX E: EMBRYOLOGICAL DEVELOPMENT OF FASCIA

Constituents of Connective Tissue - Fascia (Paoletti, 2006)

To simplify, all fascia tissue is derived from the same embryological layer, which rapidly differentiates into three systems (ecto, endo, and mesoderm), see Figure E-1. The mesenchyme (a division of mesoderm) further differentiates into the mesoblast layer, which originates medially between the ectoblast and endoblast and grows in a cephalo-caudally direction influenced by the primitive neural tube appearing on day 15 of embryological development.

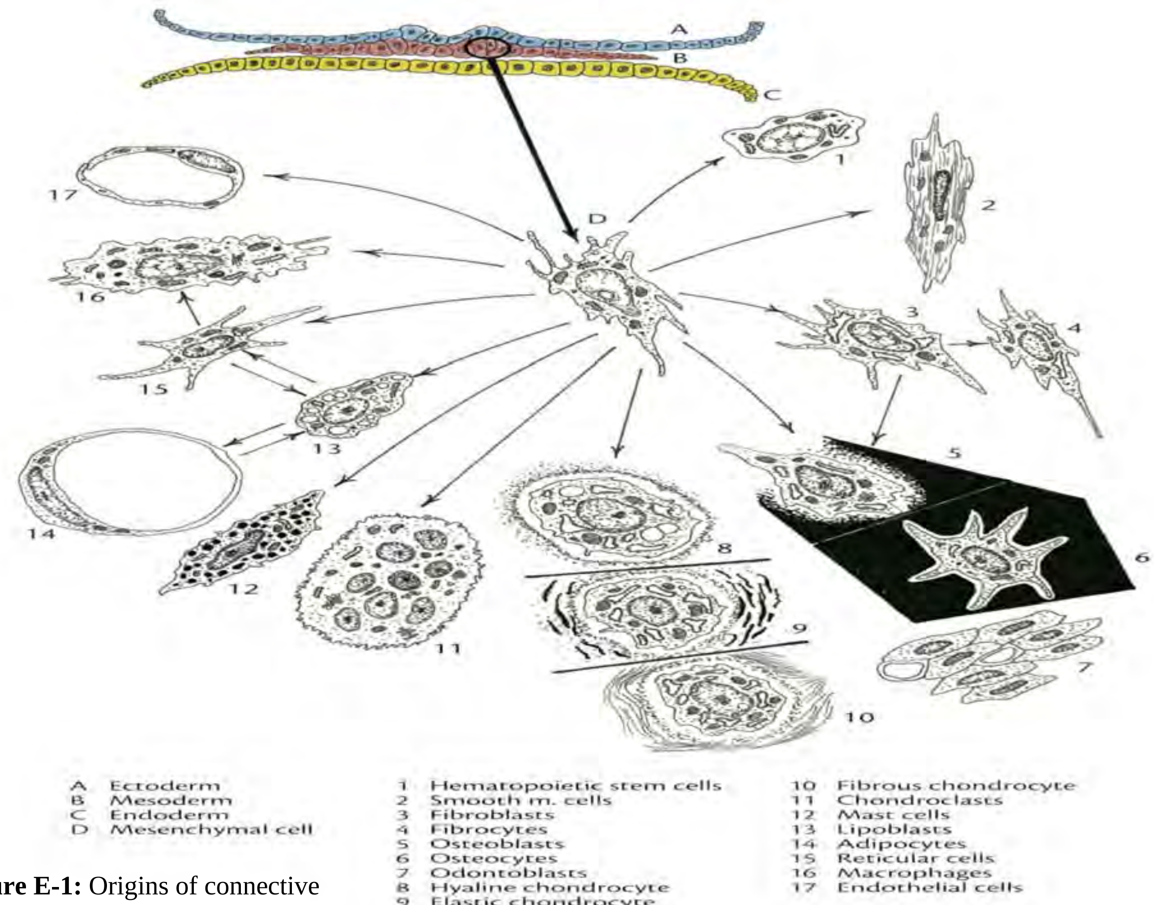


Figure E-1: Origins of connective tissues (Paoletti, 2006).

The mesoblast gives rise to the connective support tissue, cartilage, bones, muscles (striated, smooth, and cardiac), blood and lymphatic cells, kidneys, gonads and their ducts, adrenal glands, and spleen. This matrix includes water (65–75%) and colloid substances (25–35%).

At the cellular level, fascia is further classified as fibroblasts, mastocytes, adipocytes, plasmocytes, and leukocytes.

a. **Fibroblasts** are any cells from which connective tissue is developed (Taber, 1985). The main role of fibroblasts is for **structure, support, and framework of fascia.** For example, any tension or pressure on this system will cause fibroblasts to multiply.

b. **Mastocytes** are connective tissue cells that are important in **cellular defense mechanisms during injury or infection** (Taber, 1985). They secrete histamine (for inflammation and allergies), heparin, dopamine, and serotonin. These cells work on defending against viral mutations (i.e., lymphoid tissue). Secretion occurs with mechanical (trauma) or physical agents such as heat or radiation. Glucocorticoids (anti-inflammatory substances) control mastocyte production and are secreted by the adrenal glands. Mastocytes are all controlled by a hormone specifically released by the anterior pituitary. Thus, influencing the fascia may affect the **hormonal system**.

c. **Adipocytes** (fat) are cells that act as a **thermal insulation**, **mechanical protection**, and **fat reserve for energy**.

d. **Macrophages** have an impact on the **immune system**. They secrete interferon for blocking viral mutation and interleukin forming B-lymphocytes. Macrophages are the first line of immune defense. Leukocytes, which are from white blood cells, are the second line of defense against infection and inflammation.

These constituents of fascia are important to note, so that when fascia is treated one can have a profound affect on a client's general health. See Figures E-2 and E-3.

Fibers of fascia consist of collagen, reticulin, and elastin.

a. Collagen fibers make up 50–60% of fascia, depending on the type of tissue. Collagen fibers are supple and stretch up to 5% in length from traction and mechanical forces. These fibers allow a close-fitting link between the dura mater and deep fasciae, and deep fasciae with the superficial fascia.

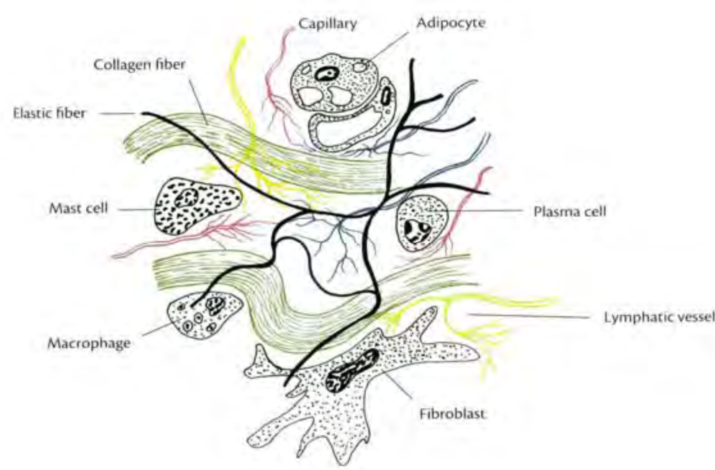


Figure E-2: Fascial components (Paoletti, 2006).

b. Reticulin fibers are loose-knit fibers that assist in scar tissue creation and repair.
c. Elastin fibers create intermolecular bridges to connect all molecules. They can stretch and recoil up to 2.5% in length.

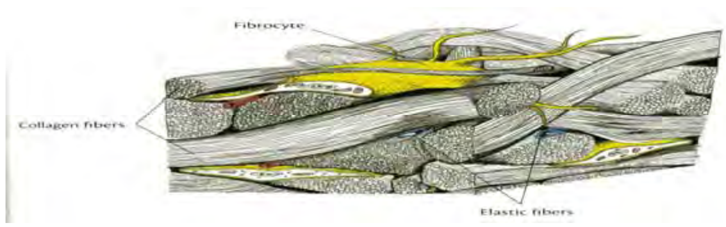


Figure E-3: Dense, Irregular Connective Tissue (Paoletti, 2006).

The Roles of Fascia (Paoletti, 2006)

In basic terms, fascia plays a role in many aspects of the body. It is involved in maintaining structural integrity, support, protection, shock absorption, hemodynamic processes, defense, communication and exchange processes, and biochemical processes.

The function of fascia can be summarized as the 4-P's: Packaging, Protection, Posture, and Passageways (Kuchera & Kuchera, 1994).

APPENDIX F: PELVIC AND LOWER LIMB VASCULATURE

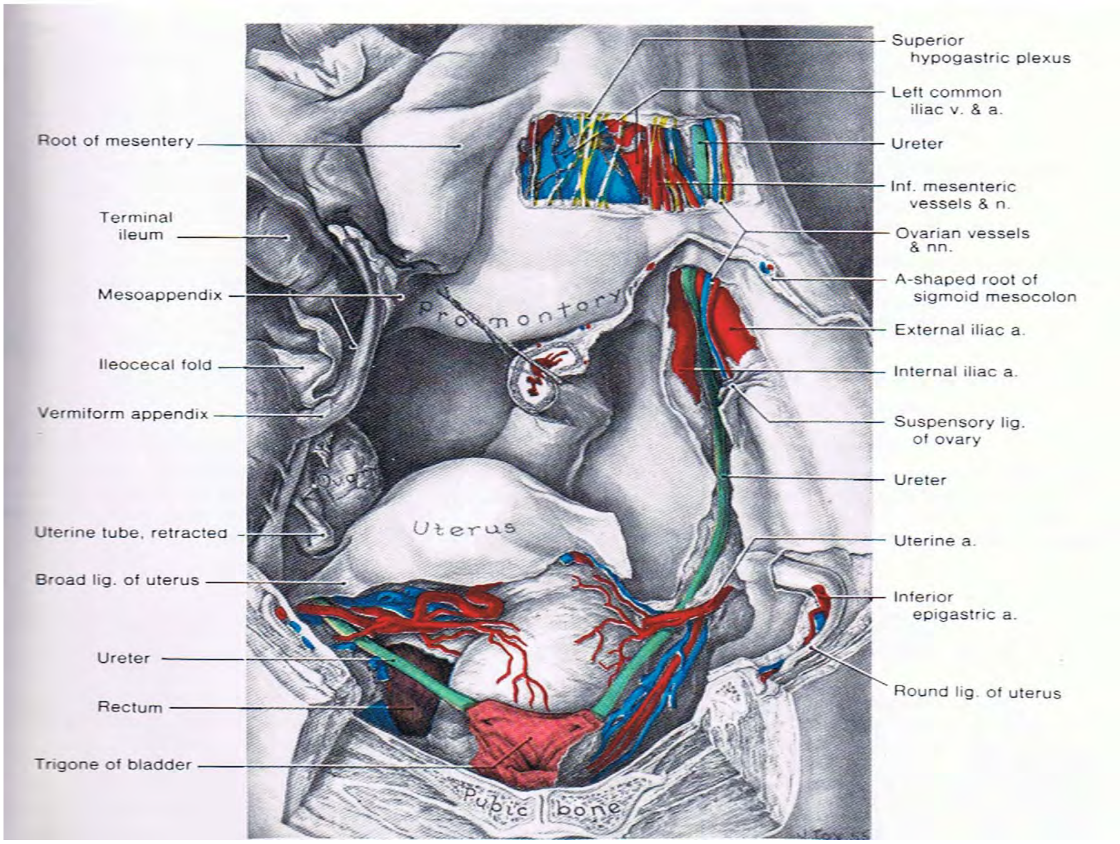


Figure F-1 (above) and **Figure F-2** (below): Circulatory system for the pelvic organs (Moore, 1985).

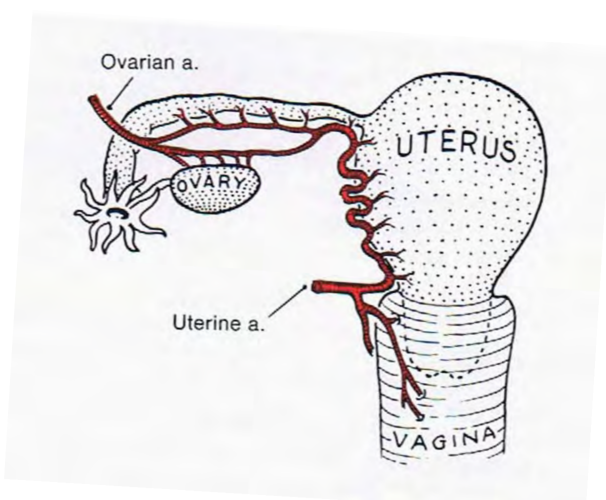
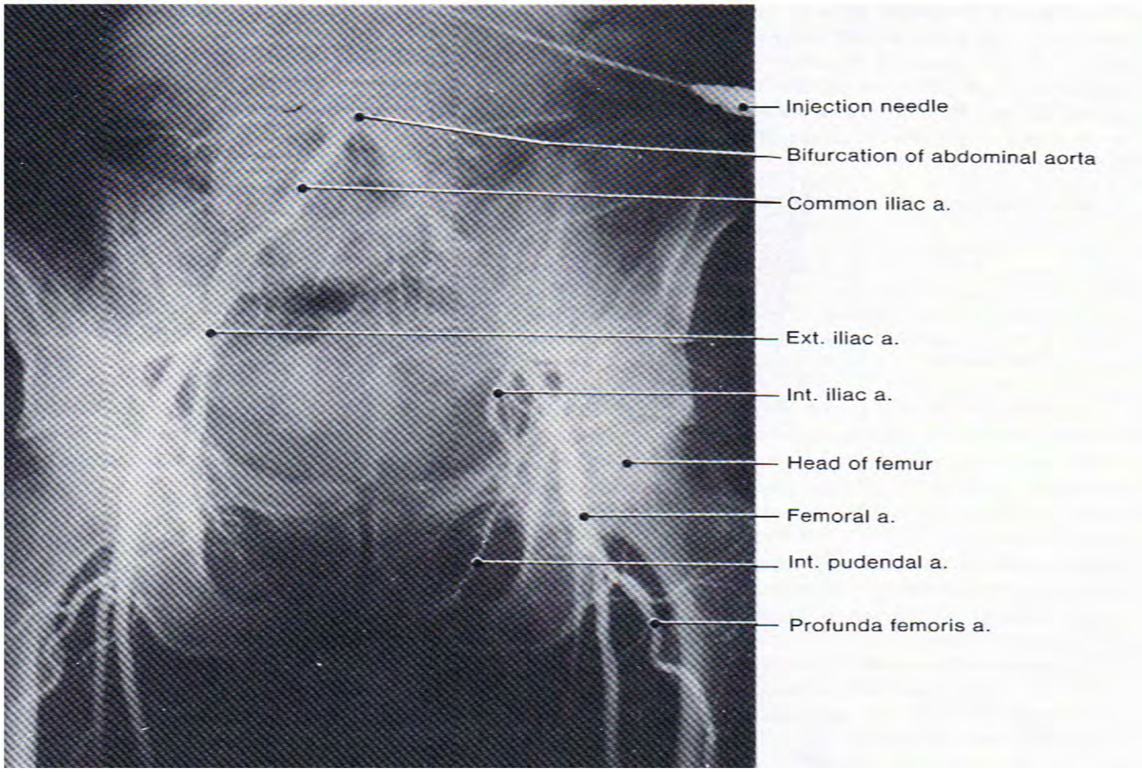


Figure F-3: Iliac arteriogram (Moore, 1985).



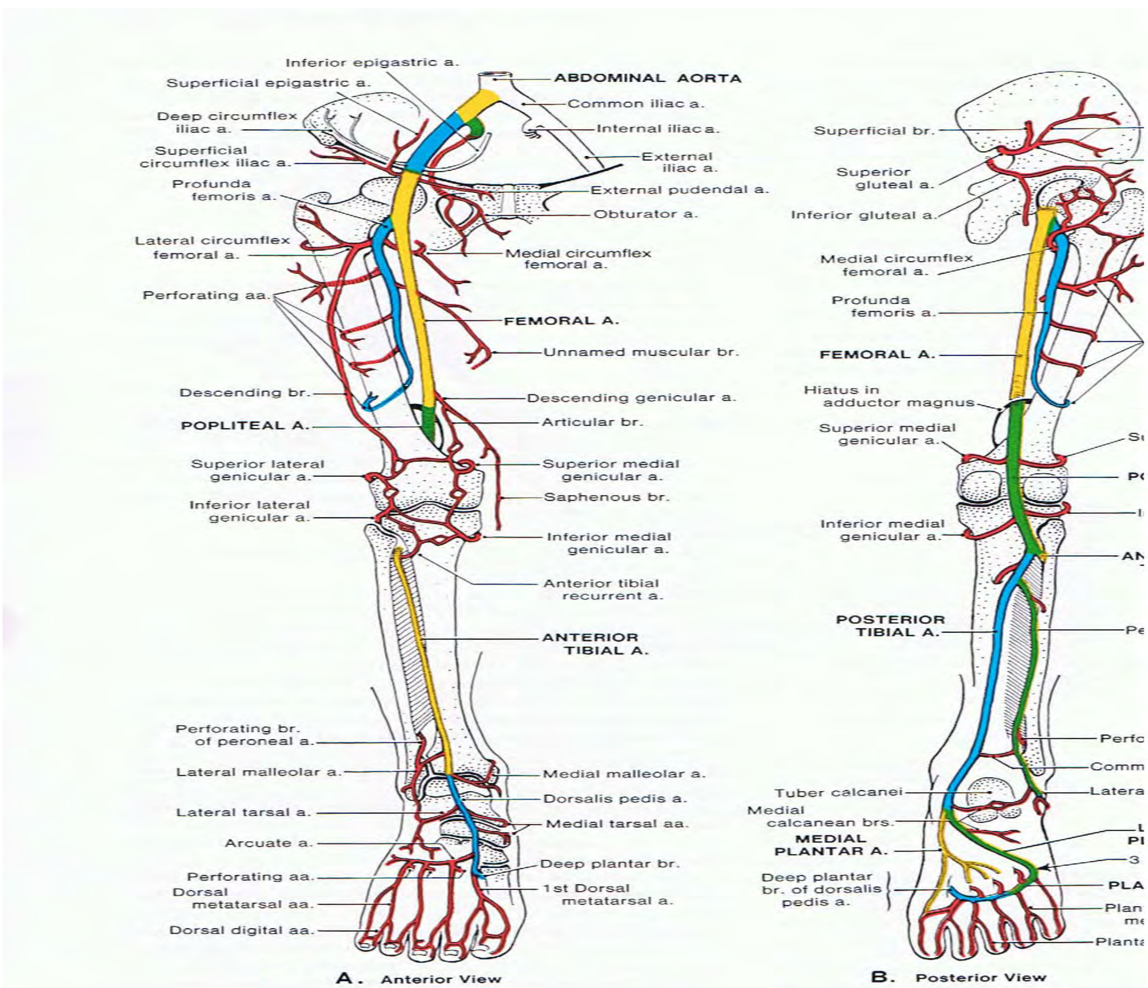


Figure F-4: Drawings of arteries of the lower limbs (Moore, 1985).

APPENDIX G: LYMPHATIC CIRCULATION

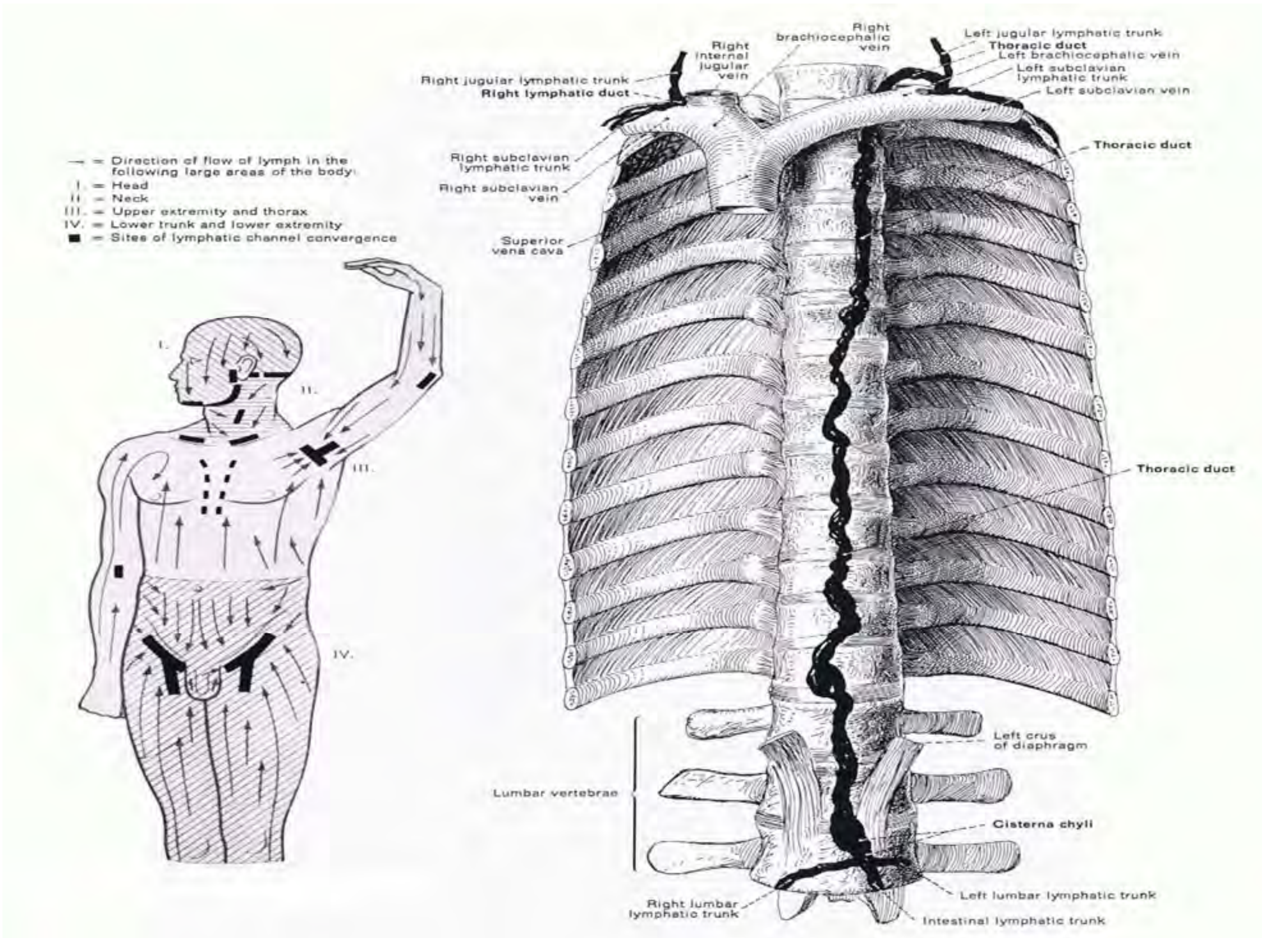
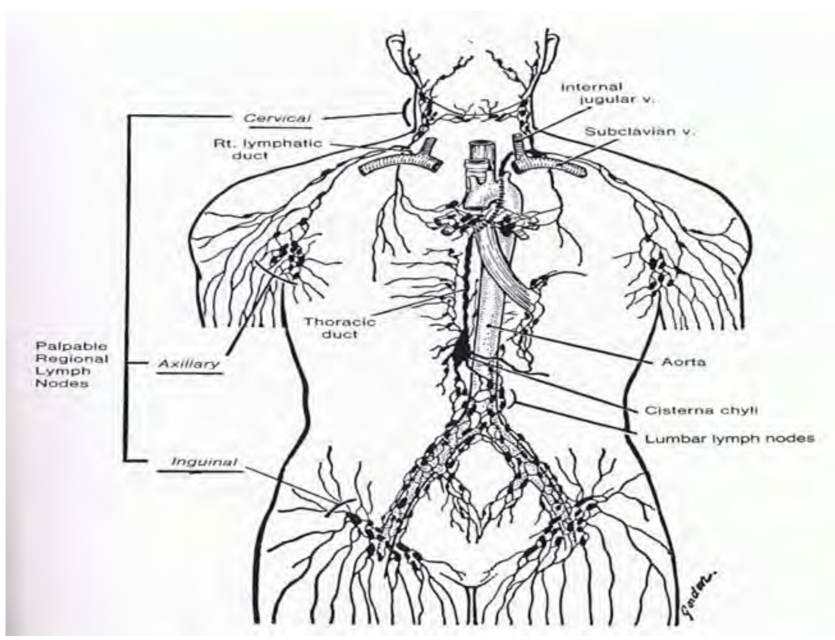


Figure G-1 (above left): Lymphatic channel flow and (above right) Thoracic duct: Origin and course (Clemente, 1981).

Figure G-2 (right): Lymphatic system (Moore, 1985).



APPENDIX H: PRIMARY RESPIRATORY MECHANISM

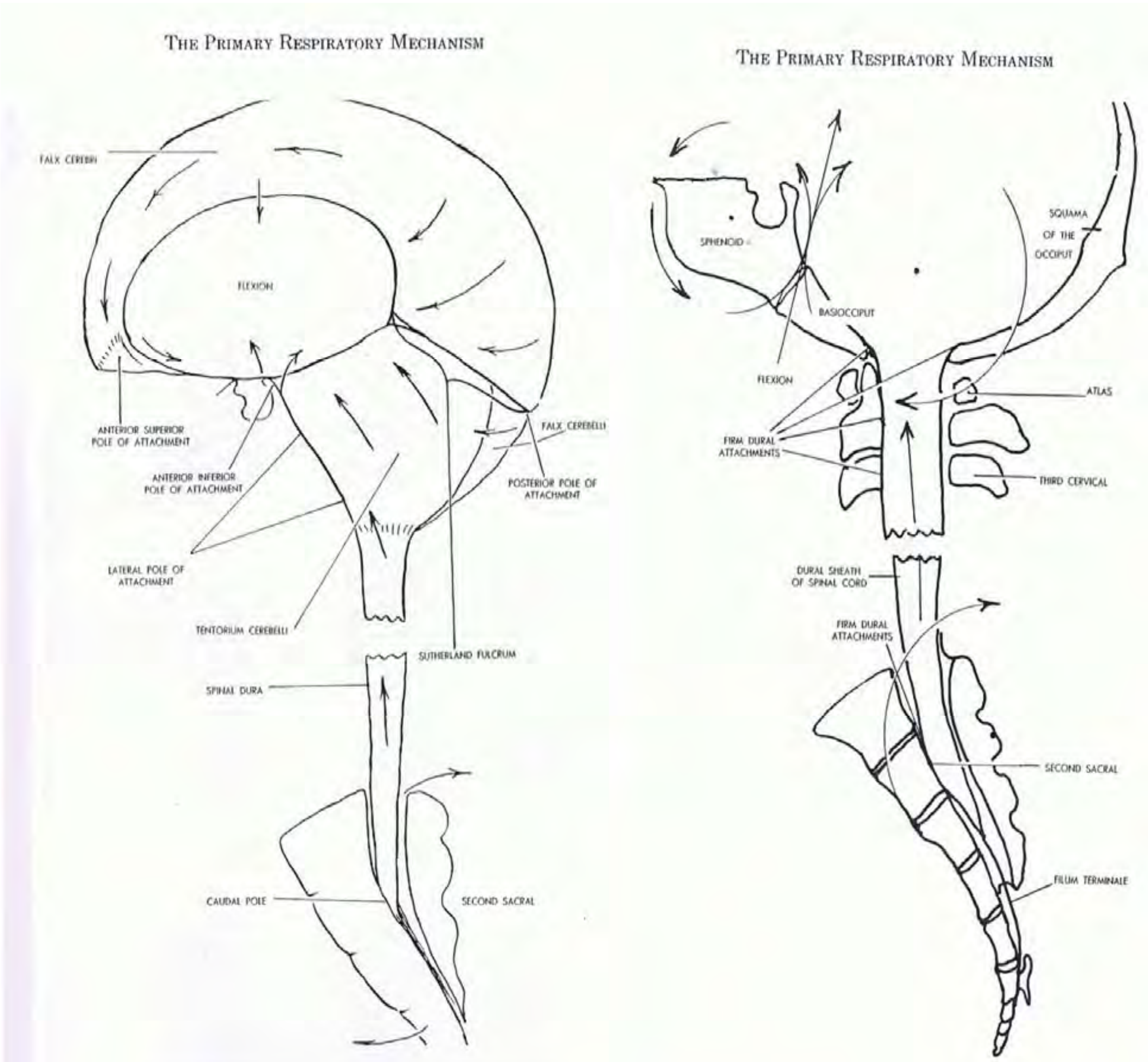


Figure H-1: Reciprocal tension membrane movement in flexion from two views (Magoun, 1976).

APPENDIX H: PRIMARY RESPIRATORY MECHANISM (CONTINUED)

Note: The PRM has 6 anatomical components that are required to maintain this mechanism:

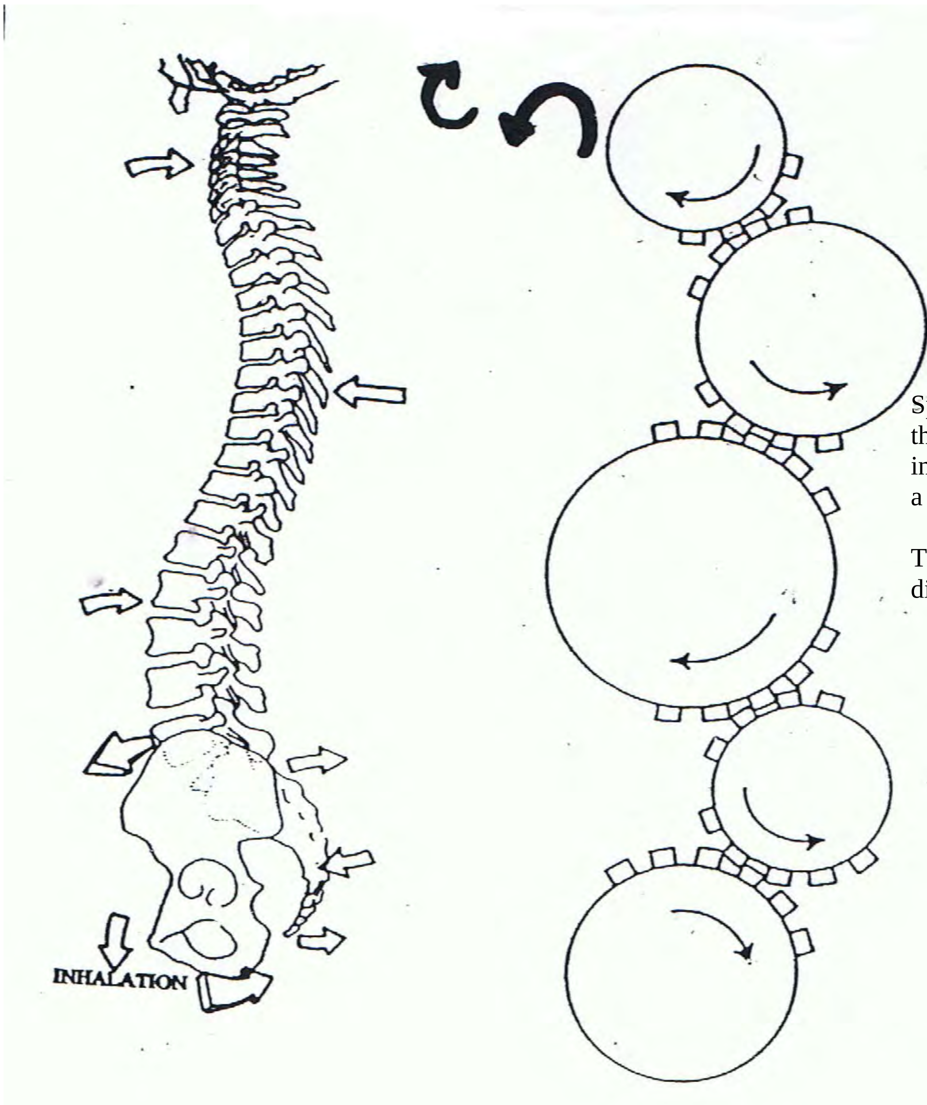
1. The inherent motility of the brain and spinal cord
2. The fluctuation of the cerebrospinal fluid
3. The mobility of the intracranial and intraspinal membrane
4. The mobility of the cranial bones
5. The involuntary motion of the sacrum and ilia
6. All the fascia in the body

(Magoun, 1976)

To further expand on this importance of the need for this mechanism and the movement and expression of the cerebral spinal fluid the following description is of benefit:

> Dr. Dwight J. Kenney, in a paper relating to heart pathology, presented before the Minneapolis Osteopathic Society, called attention to the molecular electromagnetic potency of the blood rather than that of the muscular activity of the heart; and, that the cerebrospinal fluid circulates under the same law.
>
> Doctor Kenney said: The science of our day has demonstrated the fact that our world is a giant magnet, and that electricity is the moving force of the universe. Instruments now used by scientists are able to detect the existence of the forces of that power in rock substances, and all living things. The human brain is now known to be a powerhouse, maintaining a rate of twelve pulsations a second. Each of the brain's millions of molecules is an electric dynamo, and every blood corpuscle carries its millions of electrons, carrying electric power. This is the power factor in the circulation of the blood; and not the muscular action of the heart, which is a regulator of the volume. A very superficial knowledge of hydrodynamics would show that the heart would be incapable of producing the power necessary to send the blood current through all of the tissues involved, and return it through the venous and lymphatic systems. The amount and efficiency of this electromagnetic power is naturally attendant upon our reserve of vitality (Sutherland, 1939, p.56).

APPENDIX I: THE SPHERES



Sphere rotation direction during thoracic inhalation and PRM inhalation, while the spine makes a vertical erection.

The spheres turn in the inverse direction during exhalation

Figure I-1: The position of the 5 spheres corresponds to the cranial inhalation state and thoracic erection during thoracic inhalation. Spheres 1-3-5 turn in the same direction. Spheres 2 and 4 turn together in the opposite direction to 1, 3, and 5 (CCO handout, 2004).

APPENDIX J: DIAPHRAGM CONNECTIONS

Connections of the eight bowls and domes of the body (Milne, 1995a) through the natural respiratory actions, including the dome of the skull and tentorium, hard palate, bowl of the cranial base, dome of the apex of the lungs and respiratory diaphragm, bowl of the perineal diaphragm, and bowl of the soles of the feet.

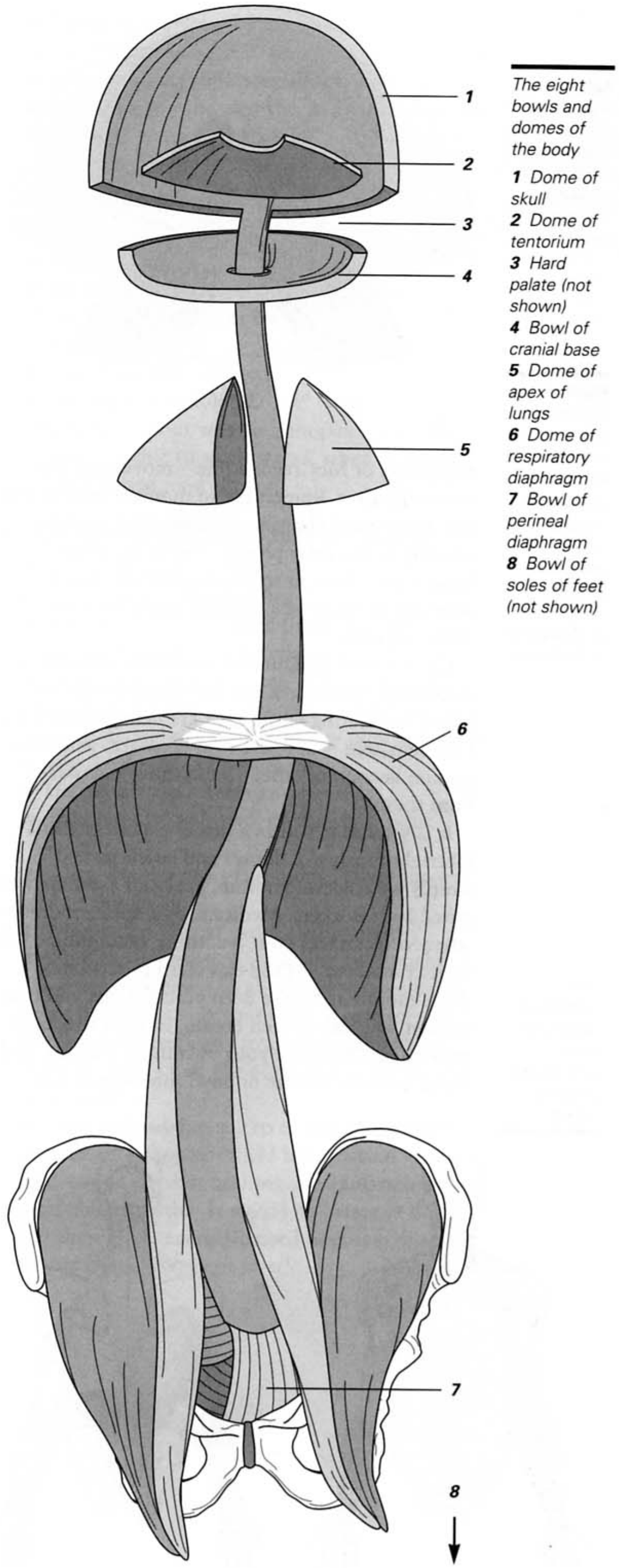


Figure J-1: The eight bowls and domes of the body (Milne, 1995a).

APPENDIX K: TYPES OF POSTURE

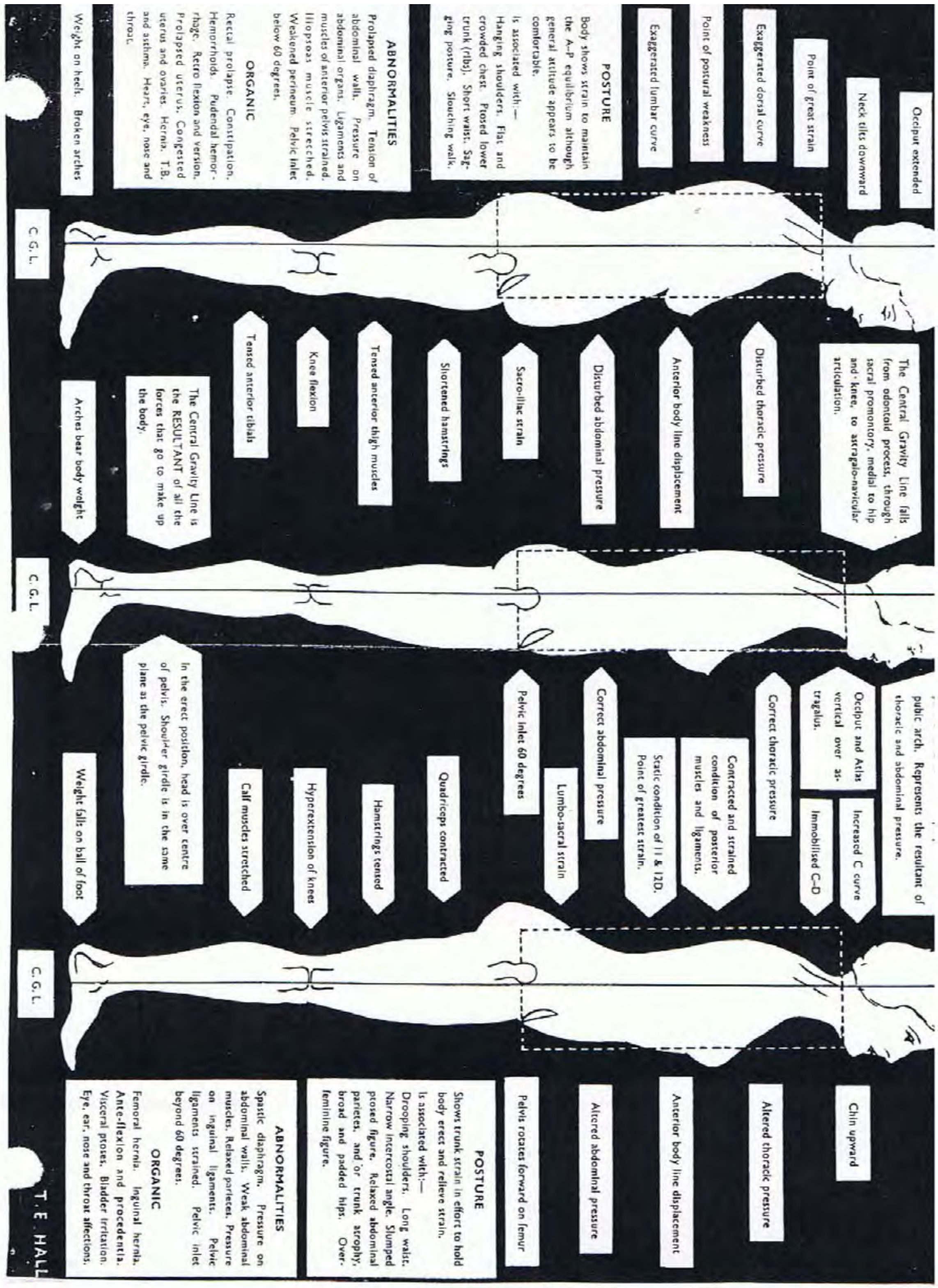
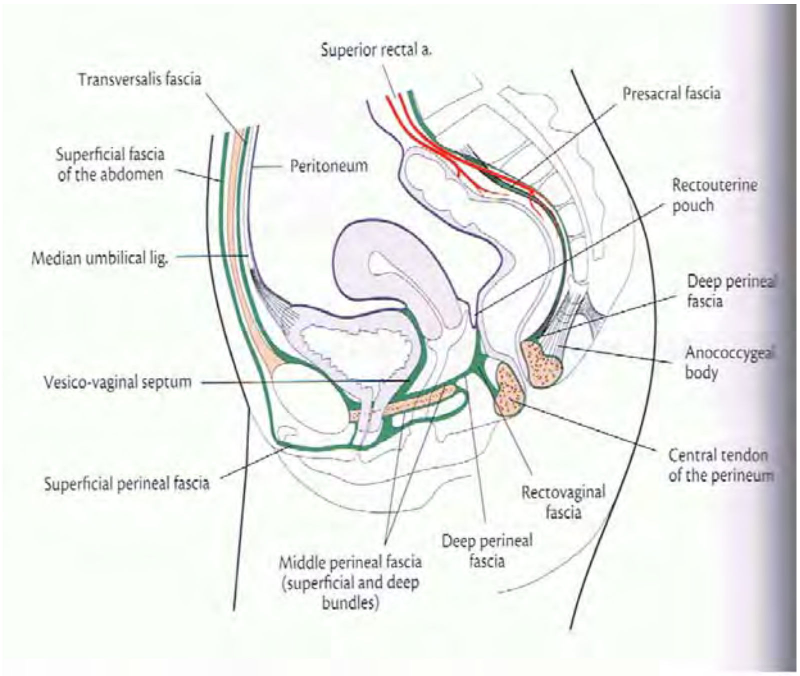


Figure K-1: Posture analysis with the Centre Line of Gravity (CCO handout 2004).

APPENDIX L: FASCIA OF THE PELVIS (FEMALE) AND ABDOMEN



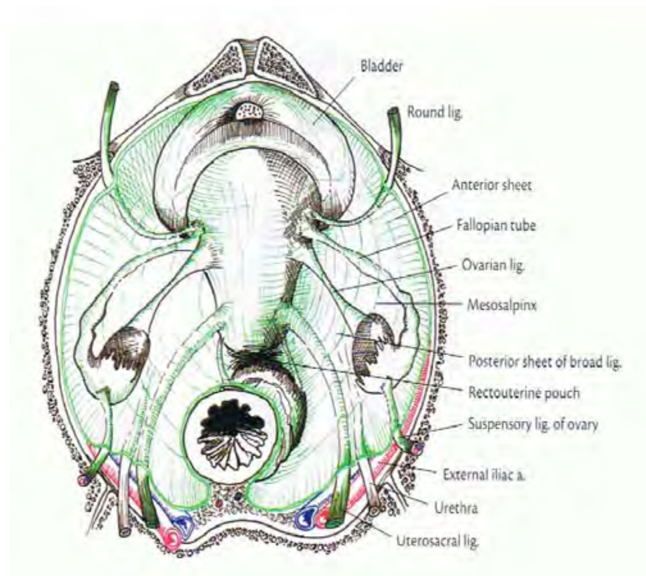


Figure L-1: (left) Fascia of the female pelvis. (right) Superior view of female pelvis (Paoletti, 2006).

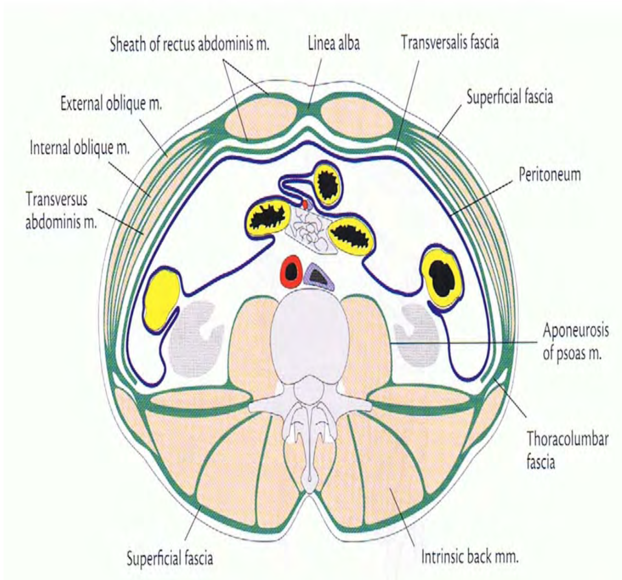


Figure L-2: Cross section of the abdomen (Paoletti, 2006).

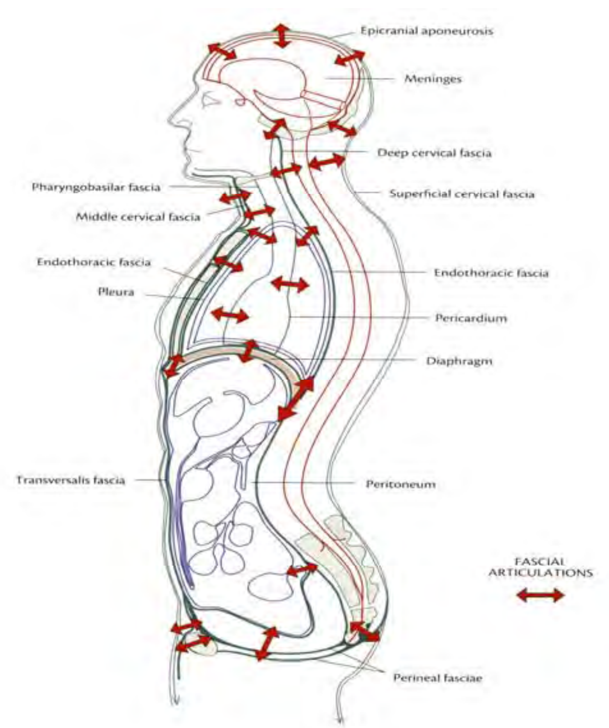


Figure L-3: Overall Arrangement of the Fasciae with Points of Continuity (Paoletti, 2006).

APPENDIX M: GYNAECOLOGICAL STAR

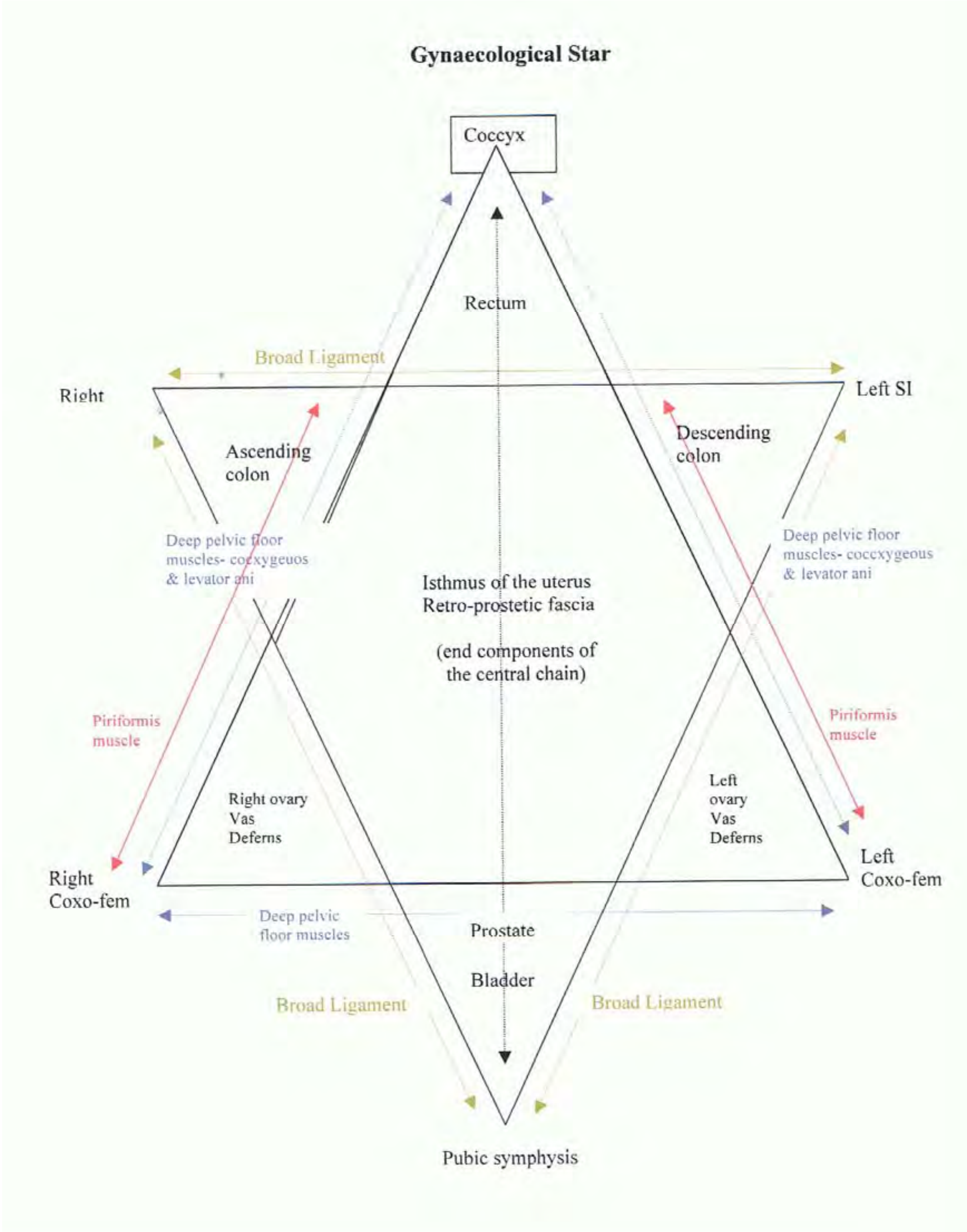


Figure M-1: Gynaecological Star (Canadian College of Osteopathy presented by P. Durelle, 2008)

APPENDIX N: THE OBTURATOR INTERNUS MUSCLE CONNECTIONS

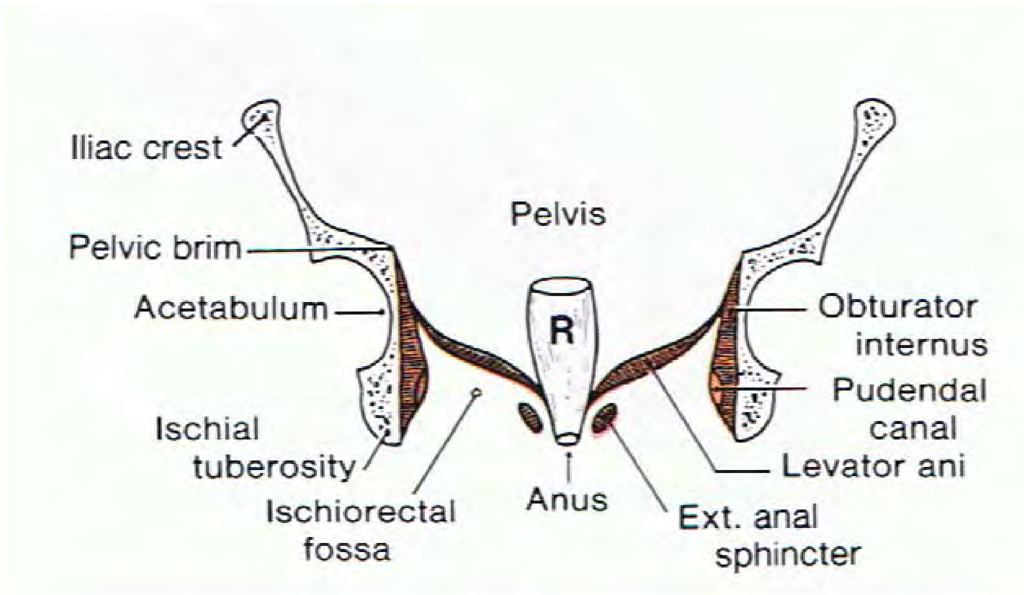


Figure N-1: Schematic drawing of a coronal of the pelvis showing the ischiorectal fossae and the funnel-shaped pelvic diaphragm formed by the two levatores ani and the two coccygeus muscles. The pelvic minor is situated inferior to the superior pelvic aperture (pelvic brim). R indicates the ampulla of the rectum which rests on and is anchored to the pelvic diaphragm (Moore, 1985).

APPENDIX O: ADVERTISEMENT

OSTEOPATHIC RESEARCH STUDY

Graduating Thesis Student of Osteopathy

LOOKING FOR PARTICIPANTS FOR A RESEARCH STUDY

On:

THE EFFECT OF OSTEOPATHIC TREATMENT OF CAESAREAN SCARS ON PELVIC MUSCLE STRENGTH

Women between 20–45 years of age with a transverse (bikini line) Caesarean Scar

Subject selection based on specific criteria

Contact: Georgio Trimarchi, Osteopath Thesis Writer

Phone: (905) 738-6303, extension 51

Email: gtrimarchi@innergetics.ca

APPENDIX P: SUBJECT INFORMATION PACKAGE

INFORMATION LETTER USED TO CONTACT POTENTIAL SUBJECTS FOR RESEARCH IN THE TREATMENT OF CAESAREAN SCARS

Would you like to be part of a study that may strengthen your pelvic muscles, such as you abdominal and gluteus muscles?

The purpose of this letter is to inform you of a research study being conducted by Georgio Trimarchi, who has been a registered massage therapist and certified sports massage therapist since 1990. Georgio has completed five years of osteopathic study at the Canadian College of Osteopathy and is currently seeking participants for his thesis research study, which is a requirement to complete his studies and obtain his Diploma in Osteopathic Manual Therapy.

The Canadian College of Osteopathy defines osteopathy as:

> A natural medicine that aims to restore function in the body by treating the causes of pain and imbalance. To achieve this goal, the Osteopath relies on the quality and finesse of his/her palpation and works with the position, mobility and quality of the tissues. (Druelle, 2007, p. 1 web page)

The study involves the application of an osteopathic treatment to transverse Caesarean scars. The goal of the treatment is to strengthen the pelvic muscles, such as the abdominal muscles, by gently treating the scar. Scars can affect the body in many ways that individuals are often unaware of. A discovery in this area of research may help participants to resolve the numerous problems related to this type of scar.

This is a voluntary study and all information gathered by researchers will remain strictly confidential.

We are looking for women who meet the following criteria:

(Please mark the boxes that apply):

- ☐ Have had one or more transverse (bikini line) Caesarean(s)
- ☐ Are between 20 and 45 years old
- ☐ Are able to invest time for visits during the experimentation
- ☐ Are at least 12 months postpartum
- ☐ Have no pelvic/abdominal related pathologies or related ongoing treatments
- ☐ Have had no other abdominal surgeries
- ☐ Have no major whiplash injuries or head trauma with loss of consciousness
- ☐ Are in good general health
- ☐ Have never previously had an osteopathic treatment of the Caesarean scar
- ☐ Are not currently pregnant
- ☐ Are not using an IUD or similar device
- ☐ ____ # of Caesarean(s)
- ☐ ____ Age

If you agree to participate and meet all of the above prescreening criteria, you may be accepted for participation in this study. You will also be asked to sign a consent form in order to participate in this research.

Should you require further information about this research study, please do not hesitate to contact Georgio Trimarchi at (905) 738-6303, extension 51, or via email at gtrimarchi@innergetics.ca.

APPENDIX Q: SUBJECT CONSENT FORM

NAME: ________________________ DATE: ________________________

ADDRESS: ____

PHONE: (H) __________________________ (W) ______________________________

EMAIL ADDRESS: ____

BY SIGNING THIS DISCLAIMER, I UNDERSTAND THAT:

1. My participation is voluntary.
2. I may withdraw my participation without prejudice. Should withdrawal be necessary, I will inform the researchers.
3. I agree not to discuss any details of my participation in the study with any other subjects or examiners in the study.
4. I fulfill the required participation criteria and I have answered the questions regarding my medical history truthfully and to the best of my knowledge.
5. I will have my muscle strength tested five times and be treated twice for my transverse Caesarean scar. I will be required to expose the caesarean scar to the examiner in order to be treated.
6. All of my information will be kept strictly confidential and used solely for the purpose of this study.

SIGNATURE (SUBJECT) ____

PRINT NAME ____

DATE _______________________

ID# _________________________

APPENDIX R: MUSCLE TESTING FORM

Subject # ____	**Age: ____**	**# C's ____**	**Muscle Test Form (Kg)/3 seconds**			Key: IL=Iliopsoas, RA=Rectus Abdominus, AM=Adductor Magnus, GM=Gluteus Medius, OI=Obturator Internus			
Muscle	Date	Week	Right Measure 1	Right Measure 2	Left Measure 1	Left Measure 2	Right Mean	Left Mean	Weight (kg)
RA		0							
IL		0							
AM		0							
GM		0							
OI		0							
RA		4							
IL		4							
AM		4							
GM		4							
OI		4							
RA		8							
IL		8							
AM		8							
GM		8							
OI		8							
RA		12							
IL		12							
AM		12							
GM		12							
OI		12							
RA		16							
IL		16							
AM		16							
GM		16							
OI		16							

APPENDIX S: MUSCLE TESTING PHOTOS AND PROCEDURES

Lafayette dynamometer (Author's photo, 2009).

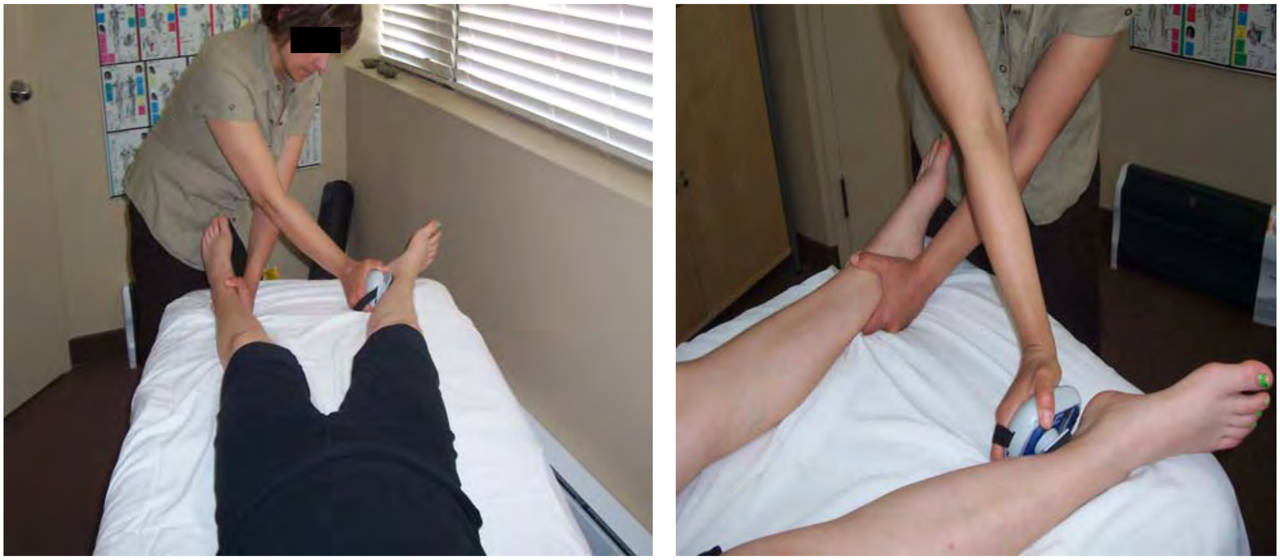
Right leg testing position: The measurement of the beginning position for all muscle testing (except rectus abdominus). The: tested leg is 13 inches away from the medial side of the non-tested leg (author's photo, 2009).

Iliopsoas muscle test position and action. *Position:* Place leg of subject in right hip flexion to level of the left leg patella (see ruler) with external rotation and abduction (13 inches away from the left medial foot). The clinician places the dynamometer above the medial malleolus (right hand of clinician) and stabilizes the left iliac.
Action: The subject maximally contracts to the ceiling (author's photos, 2009).

Rectus abdominus muscle test position and action. *Position:* Subject sits at less than 90-degrees trunk flexion with their arms crossed in front of their chest. The clinician places the dynamometer on the centre of subject's forearms above the wrist joint. The subject's legs are crossed and stabilized by the clinician's leg. *Action:* The subject contracts maximally with trunk flexion (author's photos, 2009).

Adductor muscle test position and action. *Position:* Place the subject's right leg in testing position. The clinician places the dynamometer with their right hand above the right medial malleolus with the other hand stabilizing the left leg above the medial malleolus. *Action:* The subject contracts the right leg maximally toward the left leg (author's photo, 2009).

Gluteus medius muscle test position and action. *Position:* Place the subject's right leg in testing position. The clinician places the dynamometer with their left hand above the right lateral malleolus with the other hand stabilizing the left leg above the medial malleolus. *Action:* The subject contracts the right leg maximally toward the right (toward the clinician) (author's photo, 2009).



Obturator internus muscle test position and action. *Position:* Place the subject's right leg in testing position. The subject abducts the right leg to the testing position and externally rotates. The clinician places the dynamometer with their left hand on the posterior side of the lower leg above the right medial malleolus with the other hand stabilizing the left leg above the medial malleolus. *Action:* The subject contracts the right leg maximally toward the left leg (author's photos, 2009).

APPENDIX T: TREATMENT TECHNIQUES

<u>Step 1:</u> Myofascial unwinding technique of a caesarean scar

Patient Position:

The subject is positioned supine on the table with the knees supported by a pillow to release tension on the abdominals and to allow easier access to the scar.

D.O. Hand Position:

Place all fingers perpendicular to the scar (hands side by side).

Action:

Start with induction to engage the tissues. Then apply direct or indirect myofascial unwinding technique, depending on patient sensitivity and scar rigidity, by stacking the 3 parameters of motion (caudal/cephalic, left/right, left rotation/ right rotation) and wait for the release. Retest to find further restrictions.

Results:

The release is felt with an increase of general motion or ease. The release will follow the balance point, still point and a return of PRM (primary respiratory mechanism).

Setup position for treatment of transverse Caesarean scar. *Position:* Place fingers perpendicular to the scar. *Action:* Myofascial unwinding to release the scar (author's photos, 2008).

Step 2: Myofascial unwinding technique of a caesarean scar with lumbar anchors

Patient Position:

The subject is positioned supine on the table with the knees supported by a pillow to release tension on the abdominals and to allow easier access to the scar.

D.O. Hand Position:

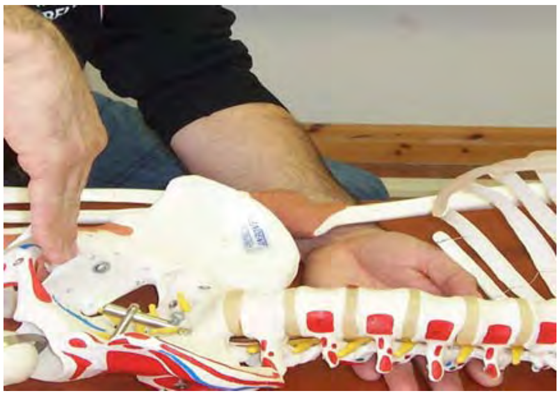
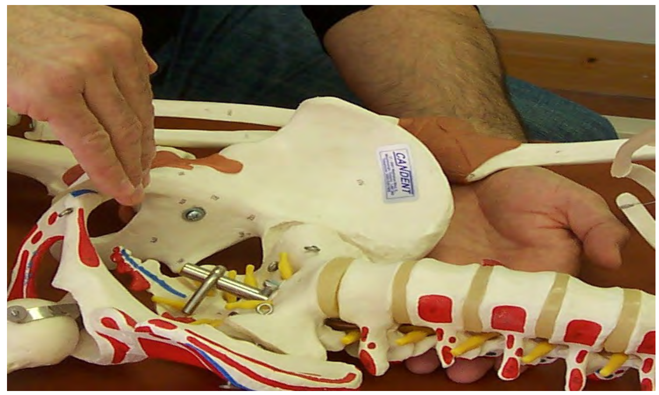
Place the caudal hand fingers (top hand) perpendicular to the scar as in step 1 above with the cephalic hand fingers (1, 2, and 3) over the spinous process of L1, L2 and L3. Follow the same procedure with the cephalic hand fingers (1 and 2) over the spinous process of L4 and L5.

Action:

Begin the treatment starting from one side of the incision with the width of the D.O. fingers (of the caudal hand). Apply slight anterior pressure on the spinous process of L1 to engage the vertebrae with the scar. Follow the Action as above in step 1 for the myofascial unwinding procedure. Repeat this procedure for each lumbar vertebrae (L1 to L5), from the initial caudal hand position. Then reposition the caudal hand fingers along the transverse scar adjacent to the original position and repeat this procedure for L1-L5. This is repeated 2 times (or 3 depending on the width of the D.O. caudal fingers). The goal is to release the entire scar with the lumbar boney anchors. Retest after releasing each lumbar vertebrae to find any further restrictions.

Results:

The release is felt with an increase of general motion or ease. The release will follow the balance point, still point and return of PRM. The lumbar vertebrae's will have a softer or decreased tone and improved mobility in relation to the scar.

Integration using Lumbar boney anchors. *Position:* Place caudal fingers (top hand) in scar treatment position on scar with cephalic fingers (1, 2, and 3) over the spinous process of L1, L2 and L3). Follow the same procedure with the cephalic fingers (1 and 2) over the spinous process of L4 and L5. *Action:* Myofascial unwinding (author's photos, 2008).

Step 3: Myofascial unwinding technique of a caesarean scar with a sacrum anchor

Patient Position:

The subject is positioned supine on the table with the knees supported by a pillow to release tension on the abdominals and to allow easier access to the scar.

D.O. Hand Position:

Place the caudal fingers in scar treatment position as above in step 2 with the cephalic hand cupping the sacrum.

Action:

Begin the treatment starting from one side of the incision with the width of the D.O. fingers (of the caudal hand). Apply slight anterior pressure on the sacrum to engage this boney anchor with the scar. Follow the Action as above in step 1 for the myofascial unwinding procedure. Then reposition the caudal hand fingers along the transverse scar adjacent to the original position and repeat this procedure. This is repeated 2 or 3 times (depending on the width of the D.O.'s caudal fingers). The goal is to release the entire scar with the sacral boney anchor. Retest after each release to find any further restrictions.

Results:

The release will follow the balance point, still point and return of PRM. The sacrum will have decreased tone and improved mobility in relation to the scar.

Integration using sacrum boney anchors. *Position:* Place caudal finger in scar treatment position with cephalic hand cupping the sacrum *Action:* Myofascial unwinding (author's photos, 2008).

APPENDIX U: PILOT STUDY

The following data was collected from a pilot study in order to determine the sample size for this research. The information gathered from this pilot study utilized the same muscle testing procedure and protocol set out in chapter 4.8 and Appendix S, respectively. This data source is collected from four women that fit the inclusion and exclusion criteria set out in chapter 4.1 and 4.2 with the exception of 1 variable. This group of subjects did not have a caesarean which could be a source of error in sample size determination of N=26.

Subject # ____		**Pilot Study / Muscle Test Form (Kg)/3 seconds**				Key: IL=Ilopsoas, RA=Rectus Abdominus, AM=Adductor Magnus, GM=Gluteus Medius, OL=Obturator Internus			
Muscle	Date	Week	Right Measure 1	Right Measure 2	Left Measure 1	Left Measure 2	Right Mean	Left Mean	Weight (kg)
GM	2008-03-15	0	10.9	12.1	10.2	10.1	11.5	10.15	63.2
GM	2008-03-17	0	11.2	10	9.6	11.4	10.6	10.5	63.2
OI	2008-03-15	0	9.9	12.2	12.2	12.1	11.05	12.15	63.2
OI	2008-03-17	0	9.3	9.4	11.5	10.5	9.2	11	63.2
AGE	43	0							
GM	2008-03-18	0	11.4	12.5	13.3	13.1	11.95	13.2	61.6
GM	2008-03-20	0	9.5	8.5	14.3	12.6	9	13.45	61.6
OI	2008-03-18	0	8.5	10.6	10	10.1	9.55	10.05	61.6
OI	2008-03-20	0	8.2	9	10.9	10.7	8.6	10.8	61.6
AGE	41								
GM	2008-03-19	0	16.5	16.4	17.9	18.5	16.45	18.2	87.09
GM	2008-03-20	0	18.4	11.7	19.1	19.7	17.85	19.4	87.09
OI	2008-03-19	0	10.4	11.7	10.2	12.6	11.05	11.4	87.09
OI	2008-03-20	0	11	12.4	12.9	12.1	11.7	12.5	87.09
AGE	26								
GM	2008-03-19	0	11.4	12.3	12.2	13.6	11.85	12.9	58.97
GM	2008-03-20	0	13.4	13.6	12.3	13.6	13.5	12.95	58.97
OI	2008-03-19	0	11.2	11.2	11.9	11.2	11.2	11.55	58.97
OI	2008-03-20	0	12	11.1	13.2	11.1	11.55	12.15	58.97
AGE	33								

APPENDIX V: THESIS RAW DATA COLLECTION

Subject	Muscle	Week	Right - Measure 1	Right-Measure 2	Left-Measure 1	Left-Measure 2	Right Mean	Left Mean	Weight Kg
Age 42--1	**RA**	0	13.4		14.1		13.75		70.2
1c-s 1	**IL**	0	3.4	5.5	4.1	4.1	4.45	4.1	
1	**AM**	0	10.6	10.2	8.3	8.5	10.4	8.4	
1	**GM**	0	12.2	11.9	10.1	11.6	12.05	10.85	
1	**OI**	0	12.3	11.1	10.1	10.3	11.7	10.2	
1	**RA**	4	22.8		22.7		22.75		70.3
1	**IL**	4	7.2	5.9	5.3	4.4	6.55	4.85	
1	**AM**	4	10.7	10.2	8.6	8.5	10.45	8.55	
1	**GM**	4	13.9	14.5	10.9	12.7	10.58	11.8	
1	**OI**	4	10.6	9.8	7.8	8.2	10.2	8	
1	**RA**	8	19.3		18.7		19		69.8
1	**IL**	8	7.3	7.1	5.6	5.2	7.2	5.4	
1	**AM**	8	12.3	11.7	8.4	9.3	12	8.85	
1	**GM**	8	15	14.8	13.3	14.7	14.9	14	
1	**OI**	8	12.5	11.2	9.3	9.3	11.85	9.3	
1	**RA**	12	21.5		22.4		21.95		71.5
1	**IL**	12	8.7	7.9	5.4	4.7	8.3	5.05	
1	**AM**	12	11.3	11.4	9.3	8.3	11.35	8.8	
1	**GM**	12	14.9	15.1	11.2	11.3	15	11.25	
1	**OI**	12	11.1	11	9	8.3	11.05	8.05	
1	**RA**	16	19.9		22.2		21.05		70.1
1	**IL**	16	8.3	7.2	6.2	5.6	7.75	5.9	
1	**AM**	16	13.1	13.5	8.4	11.3	13.3	9.85	
1	**GM**	16	17.4	17.2	14	16	17.3	15	
1	**OI**	16	11.8	12.1	9.4	8.6	11.95	9	
Age 43--2	**RA**	0	23.1		23.6		23.35		58.8
1 c-s 2	**IL**	0	7.6	8.1	9.1	9.2	7.85	9.15	
2	**AM**	0	13.6	15.2	9.8	10.3	14.4	10.05	
2	**GM**	0	11.1	12.1	11.9	12	11.6	11.95	
2	**OI**	0	9.5	9.1	11.1	10.9	9.3	11	
2	**RA**	4	24.1		23		23.55		58.7

2	**IL**	4	6.9	7.7	8.6	9.8	7.3	9.2	
2	**AM**	4	13.6	15.2	9.1	11.1	14.4	10.1	
2	**GM**	4	10.6	13	11.5	11.9	11.8	11.7	
2	**OI**	4	14.1	15.3	10.9	12.5	14.7	11.7	
2	**RA**	8	23.4		23.8		23.6		59.1
2	**IL**	8	14.5	14.7	11.9	12	14.6	11.95	
2	**AM**	8	13.6	15.2	11.7	11.1	14.4	11.4	
2	**GM**	8	15.4	15.3	12.2	11.6	15.35	11.9	
2	**OI**	8	9.1	8.3	11.1	11	8.7	11.05	
2	**RA**	12	24.1		24.2		24.15		59
2	**IL**	12	8.8	9.8	9.2	8.9	9.3	9.05	
2	**AM**	12	15.4	15.7	14	13.2	15.55	13.6	
2	**GM**	12	13.4	11.6	11.1	11.6	12.5	11.35	
2	**OI**	12	13.6	15.8	13.5	14.6	14.7	14.05	
2	**RA**	16	24.1		24.1		24.1		59
2	**IL**	16	11	11.4	9.7	10.7	11.2	10.2	
2	**AM**	16	16.8	16.9	14.5	14.3	16.85	14.4	
2	**GM**	16	13	15.4	15.7	14.8	14.2	15.2	
2	**OI**	16	18.8	18	16.6	16.5	18.4	16.55	
Age 37-- 3	**RA**	0	24.2		24.1		24.15		59.5
1 c-s 3	**IL**	0	7.9	8.1	6.9	7.1	8	7	
3	**AM**	0	14.5	15.1	11.1	11.5	14.8	11.3	
3	**GM**	0	9.5	9.9	11.9	11.7	9.7	11.8	
3	**OI**	0	10.9	11.5	11.6	10.5	11.2	11.05	
3	**RA**	4	24.4		24.5		24.45		59.6
3	**IL**	4	8.5	7.5	7.2	6.2	8	6.7	
3	**AM**	4	16	15	12.8	11.6	15.5	12.2	
3	**GM**	4	9.5	10.9	11.7	10.4	10.2	11.05	
3	**OI**	4	12.2	12.2	13.2	11.3	12.2	12.25	
3	**RA**	8	21.5		23.1		22.3		59
3	**IL**	8	7.5	8	7	6.5	7.75	6.75	
3	**AM**	8	14	13.4	10.9	12.5	13.7	11.7	
3	**GM**	8	9.3	9.5	12.4	11.4	9.4	11.9	
3	**OI**	8	11.5	10.2	10.3	10.7	10.85	10.5	
3	**RA**	12	24.7		24.6		24.65		58.9
3	**IL**	12	9.1	9.4	8.8	9.4	9.25	9.1	
3	**AM**	12	16.3	15.3	14.3	14.6	15.8	14.45	
3	**GM**	12	14.4	15.2	15	14	14.8	14.5	

3	**OI**	12	13.9	15.7	14.3	13.4	14.2	13.85	
3	**RA**	16	24.3		24.4		24.35		58.7
3	**IL**	16	7.9	10.8	8.2	8.8	9.35	8.5	
3	**AM**	16	15.5	14.8	13.1	14.2	15.15	13.65	
3	**GM**	16	13.3	14.4	14.5	14	13.85	14.25	
3	**OI**	16	13.9	13.1	13.3	13.7	13.5	13.5	
Age 45-- 4	**RA**	0	18.5		23.9		21.2		67
1 c-s 4	**IL**	0	6	8.2	8.4	7.6	7.1	8	
4	**AM**	0	12.3	13.1	10.8	10.5	12.7	10.65	
4	**GM**	0	11.3	11.4	12	11.5	11.35	11.75	
4	**OI**	0	13.5	11.8	12.5	12.2	12.65	12.35	
4	**RA**	4	23.4		24.3		23.85		65.8
4	**IL**	4	8.3	9.2	8	8.5	8.75	8.25	
4	**AM**	4	14.8	14.9	12.2	13.8	14.85	13	
4	**GM**	4	10.6	10.2	13.2	11.9	10.4	12.55	
4	**OI**	4	15.6	15.2	12.5	12.2	15.4	12.35	
4	**RA**	8	21.5		22.5		22		65
4	**IL**	8	7.7	8.1	8.2	8.5	7.9	8.35	
4	**AM**	8	12.8	13.6	12.8	11.7	13.2	12.25	
4	**GM**	8	13	12.6	12.5	12.9	12.8	12.7	
4	**OI**	8	14.1	14.1	14.1	14.1	14.1	14.1	
4	**RA**	12	21.9		23.4		22.65		65.8
4	**IL**	12	8.6	8.2	7.2	7.5	8.4	7.35	
4	**AM**	12	13.4	13.5	12.6	13.5	13.45	13.55	
4	**GM**	12	12.6	12.8	11.6	13.1	12.7	12.35	
4	**OI**	12	14.2	14.1	13.1	13.6	14.15	13.35	
4	**RA**	16	23.8		13.8		23.8		66.2
4	**IL**	16	11.2	10.1	10.6	11.3	10.65	10.95	
4	**AM**	16	15.2	14.3	14.3	13.3	14.75	13.8	
4	**GM**	16	13.7	13.5	13.8	12.6	13.6	13.2	
4	**OI**	16	12.4	13.3	14.8	14.3	12.85	14.55	
Age 41-- 5	**RA**	0	23.3		24.4		23.85		71.4
1 c-s 5	**IL**	0	7	7.4	7.2	7.1	7.2	7.15	
5	**AM**	0	12.5	12	9.1	9.3	12.25	9.2	
5	**GM**	0	8.3	9.2	9.8	8.8	8.75	9.3	
5	**OI**	0	11.9	11	11.5	11.7	11.45	11.6	

5	**RA**	4	25.7		26		25.85		71
5	**IL**	4	7.7	8.1	6.6	7.2	7.9	6.9	
5	**AM**	4	11.9	12.5	10.6	10.9	12.2	10.75	
5	**GM**	4	9.3	9.1	9.1	9.1	9.2	9.1	
5	**OI**	4	12.9	11.7	11.4	10.9	12.3	11.5	
5	**RA**	8	24.4		24.4		24.4		70.6
5	**IL**	8	7.2	7.9	7.1	7	7.55	7.05	
5	**AM**	8	11.9	12.3	10.3	10.5	12.1	10.4	
5	**GM**	8	10.5	10.6	9.5	10.1	10.55	9.8	
5	**OI**	8	13.4	12.1	11	11.5	12.75	11.25	
5	**RA**	12	27.2		28.9		28.05		71.6
5	**IL**	12	7.8	8.1	7.7	7.4	7.95	7.55	
5	**AM**	12	12.8	12.8	11.3	10.4	12.8	10.85	
5	**GM**	12	11.9	12.5	9.3	10.7	12.2	10	
5	**OI**	12	13	13.8	14.1	14.8	13.4	14.45	
5	**RA**	16	24.4		24.4		24.4		71
5	**IL**	16	9.7	9.7	8.5	8.5	9.7	8.5	
5	**AM**	16	14.2	14.2	12.5	12.3	14.2	12.4	
5	**GM**	16	11.8…	11.7…	10.7	11	11.75	10.85	
5	**OI**	16	14.6	15.7	15.1	13.6	15.15	14.35	
Age 44 - -6	**RA**	0	24.2		24.2		24.2		80.6
1 c-s 6	**IL**	0	9.1	10.3	7.4	7.9	9.7	7.65	
6	**AM**	0	13.7	16	10.8	8.3	14.85	9.55	
6	**GM**	0	13	13.7	11.5	11.2	13.35	11.35	
6	**OI**	0	13.2	14.1	10.9	11.3	13.65	11.1	
6	**RA**	4	23.8		23.8		23.8		80
6	**IL**	4	8.5	7.5	6.7	7.3	8	7	
6	**AM**	4	13	13	9.5	9.5	13	9.5	
6	**GM**	4	14.6	14.5	12.9	12.6	14.55	12.75	
6	**OI**	4	14.8	13.8	11.4	11.3	14.3	11.35	
6	**RA**	8	23.8		23.8		23.8		80
6	**IL**	8	7.9	7.8	6.8	6.8	13.85	6.8	
6	**AM**	8	13.2	14.5	9.5	9.1	13.85	9.3	
6	**GM**	8	13.9	14.4	10.1	10.8	14.15	10.45	
6	**OI**	8	14.7	13.7	11.7	12.8	14.2	12.25	
6	**RA**	12	24.5		24.5		24.5		80.5
6	**IL**	12	9.7	8.6	7.3	8.2	9.15	7.75	
6	**AM**	12	17.9	15.7	12.9	13	16.8	12.95	
6	**GM**	12	14.9	15.4	14.1	14.5	15.5	14.3	

6	**OI**	12	16	15.5	13.1	12.3	15.75	12.7	
6	**RA**	16	24.1		24.1		24.1		80.3
6	**IL**	16	11.1	10.1	7.6	8.4	10	8	
6	**AM**	16	18.3	19.5	12.6	13.2	18.9	12.9	
6	**GM**	16	14.5	14.7	14.4	15.6	14.6	15	
6	**OI**	16	17.2	18.6	12.7	12.9	17.9	12.8	
Age 37--7	**RA**	0	16.4		15.8		16.1		59.4
2 c-s 7	**IL**	0	5.9	5.9	7.1	5.3	5.9	6.2	
7	**AM**	0	11.2	11.9	11.6	11.2	11.55	11.4	
7	**GM**	0	10.1	10.9	16	13.8	10.5	14.9	
7	**OI**	0	12.2	9.4	11.3	10.6	10.8	10.8	
7	**RA**	4	17.1		16.7		16.9		59.3
7	**IL**	4	6.6	8.4	6.6	6.4	7.5	6.5	
7	**AM**	4	14.1	14.2	11	11	14.15	11	
7	**GM**	4	12.8	11.6	14.6	13.3	12.2	13.95	
7	**OI**	4	9.1	10	11	10.1	9.55	10.55	
7	**RA**	8	15.8		17		16.4		59.3
7	**IL**	8	8.2	8.4	6.7	7.6	8.3	7.15	
7	**AM**	8	12.5	11.6	12.6	12.5	12.05	12.55	
7	**GM**	8	14.3	13.8	14.9	14.2	14.05	14.55	
7	**OI**	8	12.7	12.4	11.8	10.9	12.55	11.35	
7	**RA**	12	18.9		20.9		19.9		59.7
7	**IL**	12	9.2	9	7.8	8.7	9.1	8.25	
7	**AM**	12	13.9	13.4	13.1	12.5	13.65	12.8	
7	**GM**	12	14.9	13.8	15.6	16.6	14.35	16.1	
7	**OI**	12	12	13.3	11.9	11.9	12.65	11.9	
7	**RA**	16	21.3		24.1		22.7		59.6
7	**IL**	16	10.1	10	9.4	10.5	10.05	9.95	
7	**AM**	16	17.2	19.1	14.3	14.6	17.65	14.45	
	GM	16	16	16.9	17.7	15.8	16.45	16.75	
7	**OI**	16	14.9	15.8	13.7	14.9	15.35	14.3	
Age 40--8	**RA**	0	11.5		19.9		15.7		63.7
1 c-s 8	**IL**	0	3.6	5	5.5	5.5	4.3	4.9	
8	**AM**	0	10.1	10.3	10.2	9.5	10.2	9.85	
8	**GM**	0	9.9	9.7	10.1	10	9.8	10.05	
8	**OI**	0	7.7	6.9	9.2	10.6	7.3	9.9	

8	**RA**	4	24.5		24.5		24.5		64.8
8	**IL**	4	8.2	7.6	5.9	6.6	7.9	6.25	
8	**AM**	4	12.2	9	11	11.5	10.6	11.25	
8	**GM**	4	8.7	10	11.7	11.4	9.35	11.55	
8	**OI**	4	7.8	8.8	12	11.2	8.3	11.6	
8	**RA**	8	23.2		19.2		21.2		66.6
8	**IL**	8	7.4	6.9	7.4	7.5	7.15	7.45	
8	**AM**	8	12.3	13.5	12.4	11.5	12.9	11.95	
8	**GM**	8	13.4	12	12	11.4	12.7	11.7	
8	**OI**	8	11.1	12	11.2	10.2	11.55	10.7	
8	**RA**	12	23.7		23.9		23.8		65.7
8	**IL**	12	7	6.8	6.8	8.4	6.9	7.6	
8	**AM**	12	12.4	12.2	11.5	9.6	12.3	10.55	
8	**GM**	12	11.6	13.6	11.3	10.5	12.6	10.9	
8	**OI**	12	11	12.3	12.2	11.5	11.65	11.85	
8	**RA**	16	23.8		23.9		23.85		67.3
8	**IL**	16	6.9	7.5	8.8	8.4	7.2	8.6	
8	**AM**	16	14.2	12.3	14	13.3	13.25	13.65	
8	**GM**	16	17.6	15.6	12.7	13.2	16.6	12.95	
8	**OI**	16	15.6	16.3	13.1	11.8	15.95	12.45	
Age 36-- 9	**RA**	0	24.3		24.1		24.2		79.1
2 c-s 9	**IL**	0	8.60	9.2	8.9	8.3	8.9	8.6	
9	**AM**	0	13.2	14.2	11.3	12.4	13.7	11.85	
9	**GM**	0	14.1	15.2	12.20	12.2	14.65	12.2	
9	**OI**	0	15.7	14.2	11.1	11.1	14.95	11.1	
9	**RA**	4	24.4		24.2		24.2		78.7
9	**IL**	4	9.4	9.3	9.1	9.9	9.35	9.5	
9	**AM**	4	16.1	15	13.3	13.6	15.58	13.45	
9	**GM**	4	12.3	12.4	13.6	13.7	12.35	13.65	
9	**OI**	4	14.7	12.6	11.6	12	13.65	11.8	
9	**RA**	8	22.8		25.6		24.2		79
9	**IL**	8	9.4	10.6	9.1	8.4	10	8.75	
9	**AM**	8	15.8	13.9	13.2	15.5	14.85	14.35	
9	**GM**	8	14.2	13.6	13.5	12.6	13.9	13.05	
9	**OI**	8	14.9	15.5	14.9	13.9	15.2	14.4	
9	**RA**	12	23.8		22.2		23		78.2
9	**IL**	12	9.3	9.8	9.5	9.5	9.55	9.5	
9	**AM**	12	14.2	15.4	15.6	14.5	14.8	15.05	

9	**GM**	12	13.8	15	12.8	12.2	14.4	12.5	
9	**OI**	12	17.3	17.9	15	14.3	17.6	14.65	
9	**RA**	16	24		24		24		77.8
9	**IL**	16	11.5	11.6	22.6	12	11.55	11.8	
9	**AM**	16	16.9	18	14.4	15	17.45	14.7	
9	**GM**	16	16.6	17.1	16.5	17.9	16.8	17.2	
9	**OI**	16	16	15	16.2	16.3	15.5	16.25	
Age 41- 10	**RA**	0	19.6			19.7	19.65		77.3
1 c-s 10	**IL**	0	5.4	5	4	4.4	5.2	4.2	
10	**AM**	0	12.5	14.2	10.9	10.8	13.35	10.85	
10	**GM**	0	13.8	15	10.6	10.7	14.4	10.65	
10	**OI**	0	12.2	13	12.9	12.4	12.6	12.65	
10	**RA**	4	20.1		18.2		19.15		78.2
10	**IL**	4	4.7	4.6	3.9	4.8	4.65	4.35	
10	**AM**	4	11	11	11.9	11	11	11.45	
10	**GM**	4	13.1	12.9	11.7	11.8	13	11.75	
10	**OI**	4	14.8	10.8	11.7	10.9	12.8	11.3	
10	**RA**	8	23.7		23.7		23.7		77.9
10	**IL**	8	5.1	4.4	5.3	5.6	4.75	5.45	
10	**AM**	8	11.9	11.7	11.1	11.3	11.8	11.2	
10	**GM**	8	14.2	13.4	14	11.8	13.8	12.9	
10	**OI**	8	11.7	13.3	11.3	9.9	12.5	10.6	
10	**RA**	12	19		19.45		19.27		78.4
10	**IL**	12	5.86	5.7	5	5.6	5.78	5.3	
10	**AM**	12	12.3	12.8	10.5	11.3	12.55	10.9	
10	**GM**	12	15.2	16.6	13.1	10.6	15.9	11.85	
10	**OI**	12	14.9	13.3	9.8	9.8	14.1	9.8	
10	**RA**	16	23.8		23.9		23.85		78.6
10	**IL**	16	4.2	4.3	5.1	4.4	4.25	4.75	
10	**AM**	16	10.1	12.8	12.3	12.1	11.45	12.2	
10	**GM**	16	18	19.6	16.9	12.7	18.8	14.8	
10	**OI**	16	14.3	14	14.4	15.5	14.15	14.95	
Age 44- 11	**RA**	0	24.3		22.7		23.5		57.2
1 c-s 11	**IL**	0	7.9	8.1	8.6	8.9	8	8.75	
11	**AM**	0	13.1	13.3	9.5	9	13.2	9.25	
11	**GM**	0	12.7	13.1	11.9	12.2	12.9	12.05	

11	**OI**	0	13.2	14.1	10.7	11.2	13.65	10.95	
11	**RA**	4	24.3		24.3		24.3		57.2
11	**IL**	4	7.5	8.9	8.6	9.9	8.2	9.25	
11	**AM**	4	13.8	13.3	9.5	8.8	13.55	9.15	
11	**GM**	4	11.5	10.7	11.8	12.1	11.1	11.95	
11	**OI**	4	12.3	13.1	10.7	13.2	12.7	11.95	
11	**RA**	8	22.9		17.1		20		57.2
11	**IL**	8	8.2	9.5	8.4	8.2	8.85	8.3	
11	**AM**	8	16.6	13.9	11.8	12.1	15.25	11.95	
11	**GM**	8	15	14.8	12.6	11.8	14.9	12.2	
11	**OI**	8	15.7	15	11.6	12.9	15.35	12.25	
11	**RA**	12	24.2		24.2		24.2		58.4
11	**IL**	12	10.3	10.5	10.9	11.7	10.4	11.3	
11	**AM**	12	16.1	17.2	15	15.4	16.65	15.2	
11	**GM**	12	15.7	14.2	12.7	13.3	14.95	13	
11	**OI**	12	15.8	15.4	15.8	14	15.6	14.9	
11	**RA**	16	24.1		24		24.05		58.4
11	**IL**	16	10.9	9.9	9.9	11.5	10.4	10.7	
11	**AM**	16	16.5	16.7	13.6	14.1	16.6	13.85	
11	**GM**	16	16	16	14.5	14.7	16.6	13.85	
11	**OI**	16	16	14.9	15.7	14.2	15.45	14.95	
Age 43- 12	**RA**	0	20.50		20.3		20.4		48.8
1 c-s 12	**IL**	0	8.4	8.3	8.3	8.4	8.35	8.35	
12	**AM**	0	11.7	11.4	11	10.6	11.55	10.8	
12	**GM**	0	9.6	8.6	10.1	10.5	9.1	10.3	
12	**OI**	0	10.1	10.2	9.1	9.9	10.15	9.5	
12	**RA**	4	21.6		24.1		22.85		48.3
12	**IL**	4	8.7	8.4	6.9	6.8	8.55	6.85	
12	**AM**	4	13.1	11.5	9.9	10.2	12.3	10.05	
12	**GM**	4	13.1	11.8	11.3	9.9	12.45	10.6	
12	**OI**	4	12.6	12.6	11.8	11.2	12.6	11.5	
12	**RA**	8	28.9		26.9		27.9		48.2
12	**IL**	8	8.5	9.1	7.7	8.1	8.8	7.9	
12	**AM**	8	13.3	12.8	11.4	11.70	13.05	11.55	
12	**GM**	8	12.5	12.5	12.3	12	12.5	12.15	
12	**OI**	8	14.4	14.6	11.9	12.2	14.5	12.05	
12	**RA**	12	23.4		23.8		23.6		48.1
12	**IL**	12	8.8	6.9	7.6	7.4	7.85	7.5	

12	**AM**	12	13.5	12.3	10.9	11.3	12.9	11.1	
12	**GM**	12	12.3	12	11.4	10.5	12.15	10.95	
12	**OI**	12	11.4	13.7	12.4	11.1	12.55	11.75	
12	**RA**	16	23.8		23.9		23.85		47.8
12	**IL**	16	9.5	8.9	8.8	9.6	9.2	9.2	
12	**AM**	16	12.8	15.9	14	13.5	14.35	13.75	
12	**GM**	16	16.8	16.2	14	12.9	16.5	13.45	
12	**OI**	16	16	14.8	11.6	12.6	15.4	12.1	
Age 45- 13	**RA**	0	13.7		14.4		14.05		62.6
2 c-s 13	**IL**	0	4	5.5	6.8	5.6	4.75	6.2	
13	**AM**	0	12	11	8.5	9.8	11.5	9.15	
13	**GM**	0	17	14.1	14.6	14	15.55	14.3	
13	**OI**	0	9.7	11.1	8.4	9.4	10.4	8.9	
13	**RA**	4	13.2		15.3		14.25		64.7
13	**IL**	4	6.9	6	6.8	6.5	6.45	6.65	
13	**AM**	4	11.8	11.8	11.6	12.4	11.8	12	
13	**GM**	4	11.8	10.1	13.4	13.2	10.95	13.3	
13	**OI**	4	14.5	13.7	9.8	9.4	14.1	9.6	
13	**RA**	8	16.7		15		15.85		62.1
13	**IL**	8	7.1	6.2	6.3	6.4	6.65	6.35	
13	**AM**	8	11	12.8	9.9	10.1	11.9	10	
13	**GM**	8	15.3	10.7	12.5	14.6	13	13.55	
13	**OI**	8	13	14.2	9.6	10.1	13.6	9.85	
13	**RA**	12	11.8		14.9		13.35		60.4
13	**IL**	12	5.2	4.2	5.7	6.4	4.7	6.05	
13	**AM**	12	10.1	10.7	9.6	10.9	10.4	10.25	
13	**GM**	12	12.6	9.9	11.2	9.8	11.25	10.5	
13	**OI**	12	11	11.6	10.5	11.2	11.3	10.85	
13	**RA**	16	21.7		20.5		21.1		60.2
13	**IL**	16	8.7	8.7	7.8	6.8	8.7	7.3	
13	**AM**	16	13.7	12.5	12.2	12.9	13.1	12.55	
13	**GM**	16	13.3	14.5	13.6	13.7	13.9	13.65	
13	**OI**	16	13.8	14	13.4	13.6	13.9	13.5	
Age 44- 14	**RA**	0	9.1		11.1		10.1		82.1
3 c-s 14	**IL**	0	4.1	4.5	4.9	4.4	4.3	4.65	
14	**AM**	0	8.5	9.7	6.1	7.7	9.1	6.9	

14	**GM**	0	10.2	8.2	6.5	5.6	9.2	6.05	
14	**OI**	0	8.9	9.8	9.9	8.6	9.35	9.25	
14	**RA**	4	15.5		16.4		15.95		81.5
14	**IL**	4	3.6	3.8	3.2	3.2	3.7	3.2	
14	**AM**	4	7.2	9.1	6.3	7.4	8.15	6.85	
14	**GM**	4	10.2	10.5	6.4	6.9	10.35	6.65	
14	**OI**	4	8.2	7.8	6.5	8.2	8	7.35	
14	**RA**	8	16		17.7		16.85		80.5
14	**IL**	8	4.5	4.5	5.3	5.7	4.5	5.5	
14	**AM**	8	7.90	9.5	7.2	8.4	8.7	7.8	
14	**GM**	8	9.6	11.3	9.9	8.4	10.45	9.15	
14	**OI**	8	9.3	10.5	6	5.6	9.9	5.8	
14	**RA**	12	16.4		16.8		16.6		82.8
14	**IL**	12	5	4	4.6	4.2	4.5	4.4	
14	**AM**	12	10.7	9.6	9.1	9.9	10.15	9.5	
14	**GM**	12	10.7	9.6	10.4	9.5	10.15	9.95	
14	**OI**	12	8.6	8.9	7.2	9	8.75	8.1	
14	**RA**	16	21.4		22.6		22		84.7
14	**IL**	16	5.8	4.5	6.5	4.3	5.15	5.4	
14	**AM**	16	9.2	10	9.1	10.8	9.75	9.95	
14	**GM**	16	14.8	13.9	12.5	10.3	14.35	11.4	
14	**OI**	16	10.1	11	8.5	10	10.55	9.25	
Age 23- 15	**RA**	0	22.4		22.4		22.4		68.4
1 c-s 15	**IL**	0	5.2	6.4	6.8	6.9	5.8	6.85	
15	**AM**	0	13.6	13.9	11	11.2	13.75	11.1	
15	**GM**	0	10.6	11.6	10.3	10.4	11.1	10.35	
15	**OI**	0	10.7	11.6	10	11.2	11.15	10.6	
15	**RA**	4	19.3		22.1		20.7		68.5
15	**IL**	4	6.9	6.9	6.9	7.5	6.9	7.2	
15	**AM**	4	12.6	12.8	11.5	11.6	12.7	11.55	
15	**GM**	4	11	10.1	10.3	10.3	10.55	10.3	
15	**OI**	4	11.4	12.2	11.6	10.9	11.8	11.25	
15	**RA**	8	18.6		18.6		18.6		69
15	**IL**	8	8.1	6.9	7.1	7.8	7.5	7.45	
15	**AM**	8	13	13.3	11.7	12.9	13.15	12.3	
15	**GM**	8	11.2	10.9	10.9	10.9	11.05	10.9	
15	**OI**	8	11.6	11.3	11.9	11.4	11.45	11.65	
15	**RA**	12	25		24.3		24.65		69.2

15	**IL**	12	7	7	8.4	8.8	7	8.6	
15	**AM**	12	13.7	15.1	13.2	13.1	14.4	13.15	
15	**GM**	12	12.5	11.3	12.2	13.5	11.9	12.85	
15	**OI**	12	14	13.5	14.2	14.5	13.75	14.35	
15	**RA**	16	24.3		24.3		24.3		70.4
15	**IL**	16	9.3	8.6	7.7	8.8	8.95	8.25	
15	**AM**	16	13.7	13.1	12.7	12.7	13.4	12.7	
15	**GM**	16	11.6	12;5	14.1	14.1	12.05	14.1	
15	**OI**	16	12.7	12.5	12.5	12.8	12.6	12.65	
Age 27- 16	**RA**	0	16.7		16.4		16.55		94.8
2 c-s 16	**IL**	0	5.5	7.1	7	6.5	6.3	6.75	
16	**AM**	0	9.5	9.7	9.2	10.2	9.6	9.7	
16	**GM**	0	13.8	13.6	10	10.8	13.7	10.4	
16	**OI**	0	10.7	9.9	12.2	12.3	10.3	12.25	
16	**RA**	4	19.8		21.5		20.65		95
16	**IL**	4	7.7	7.6	6.4	5.9	7.65	6.15	
16	**AM**	4	9.2	7.5	9	10.9	8.35	9.95	
16	**GM**	4	12.8	10.8	10.1	10.8	11.8	10.45	
16	**OI**	4	8.7	9.5	8.7	8.4	9.1	8.55	
16	**RA**	8	22.8		22.8		22.8		95.1
16	**IL**	8	5.9	5.3	5.2	4.4	5.6	4.8	
16	**AM**	8	6.3	7.5	8.5	9.4	6.9	8.95	
16	**GM**	8	10.6	10.9	12.3	11.4	10.78	11.85	
16	**OI**	8	8.9	8.3	9.1	10.2	8.6	9.65	
16	**RA**	12	21.5		21.9		21.7		96.7
16	**IL**	12	5.5	5.1	6.6	6	5.3	6.3	
16	**AM**	12	10	9.3	8.6	12.6	9.65	10.6	
16	**GM**	12	10.1	12.3	13	11.3	11.2	12.15	
16	**OI**	12	11.5	13.1	9.6	12	12.3	10.8	
16	**RA**	16	23.8		23.9		23.85		95.9
16	**IL**	16	8.8	7.6	7	7	8.2	7	
16	**AM**	16	12.2	11.8	11.1	13.4	12	12.25	
16	**GM**	16	14.9	15.1	12.1	11.9	15	12	
16	**OI**	16	14.9	15.1	12.1	11.9	15	12	
Age 41- 17	**RA**	0	19.7		26		22.85		66.1
3 c-s 17	**IL**	0	11.6	11.2	8.1	8.4	11.4	8.25	

17	**AM**	0	10.5	13.1	9.6	9.3	11.8	9.45	
17	**GM**	0	11.5	11.9	13	12.6	11.7	12.8	
17	**OI**	0	8.3	8.7	9.7	7.2	8.5	8.45	
17	**RA**	4	18.9		21.3		20.1		66.2
17	**IL**	4	9.4	10.2	8	7.7	9.8	7.85	
17	**AM**	4	12.2	11.1	9.6	10.6	11.65	10.1	
17	**GM**	4	10.6	11.5	10.8	11.1	11.05	10.95	
17	**OI**	4	9.5	9.7	10.3	9.9	9.6	10.1	
17	**RA**	8	21.3		24.2		22.75		66.5
17	**IL**	8	11.3	10.9	8.3	8.4	11.1	8.35	
17	**AM**	8	12.1	9.6	9.4	11	10.85	10.45	
17	**GM**	8	12.1	10.7	13.2	13.3	11.4	13.25	
17	**OI**	8	11.5	10.7	8.8	11.8	11.1	10.3	
17	**RA**	12	21.7		22.6		22.15		65.7
17	**IL**	12	10.5	9.8	8.4	9.3	10.15	8.85	
17	**AM**	12	11.1	13	9.8	11.3	12.05	10.55	
17	**GM**	12	13.5	14.2	11.3	11.7	13.85	11.5	
17	**OI**	12	13.7	12.3	10.3	10.6	13	10.45	
17	**RA**	16	23.7		24		23.85		67.9
17	**IL**	16	10.6	10.3	10.2	8.8	10.45	9.5	
17	**AM**	16	12.7	14.2	11.1	12.2	13.45	11.65	
17	**GM**	16	18.6	16.6	14.2	14	17.5	14.1	
17	**OI**	16	17.2	18.9	12.2	14.6	18.05	13.4	
Age 33-18	**RA**	0	17.8		18.4		18.1		63.6
4 c-s 18	**IL**	0	7	7.1	6	6.9	7.05	6.45	
18	**AM**	0	16	18.4	11.4	11	17.2	11.2	
18	**GM**	0	14	13.1	11.8	12.8	13.55	12.3	
18	**OI**	0	14.1	12	13	13.1	13.05	13.05	
18	**RA**	4	23.8		23.9		23.85		64.7
18	**IL**	4	8.1	9.9	7.1	6.5	9	6.8	
18	**AM**	4	13.8	13	11.8	11.6	13.4	11.7	
18	**GM**	4	12.6	11.7	12.7	12.7	12.15	12.7	
18	**OI**	4	13.3	12.7	11	10.8	13	10.9	
18	**RA**	8	23.8		23.8		23.8		65.7
18	**IL**	8	9.5	8.8	7.7	6.5	9.15	7.1	
18	**AM**	8	13.9	14.4	11.1	9.7	14.15	10.4	
18	**GM**	8	14.4	12.2	13.8	14.4	13.30	14.1	
18	**OI**	8	13	13	11.4	11.8	13	11.6	

18	**RA**	12	23.7		23.9		23.8		61.7
18	**IL**	12	8.3	9.2	7.3	7.1	8.75	7.2	
18	**AM**	12	13.4	11.7	10.4	10.7	12.55	10.55	
18	**GM**	12	15.4	15	14.4	12	15.2	13.2	
18	**OI**	12	11.8	12.1	11.5	11	11.95	11.25	
18	**RA**	16	24		23.9		23.95		62
18	**IL**	16	9.5	9.1	7.9	7.9	9.3	7.9	
18	**AM**	16	14.1	13.9	11	10.9	14	10.95	
18	**GM**	16	15.9	15.5	14.9	15	15.7	14.95	
18	**OI**	16	12.9	13	13	12.7	12.95	12.85	
Age 41-19	**RA**	0	18.5		18.7		18.6		84.9
2 c-s 19	**IL**	0	6	7	7.1	8.5	6.5	7.8	
19	**AM**	0	11.4	11.5	9.5	10	11.45	9.75	
19	**GM**	0	8.7	12.3	7.9	8	10.5	7.95	
19	**OI**	0	13.6	13.3	12.8	13.3	13.45	13.05	
19	**RA**	4	12.5		15.6		14.05		83.5
19	**IL**	4	6.7	7.1	8.9	7.4	6.9	8.15	
19	**AM**	4	13.3	11.9	8.8	11.5	12.6	10.15	
19	**GM**	4	9	8.9	9.5	8.2	8.95	8.85	
19	**OI**	4	14.2	14.8	8.7	11.6	14.5	10.15	
19	**RA**	8	22		17.5		19.75		85.4
19	**IL**	8	7.4	7.1	8.3	7.8	7.25	8.05	
19	**AM**	8	9.3	12.8	8.9	9.7	11.05	9.3	
19	**GM**	8	11.8	9.6	10.3	9.5	10.7	9.9	
19	**OI**	8	12.6	13.7	8	9.6	13.15	8.8	
19	**RA**	12	12.7		19.5		16.1		84.1
19	**IL**	12	7.1	6.7	8.5	8.8	6.9	8.65	
19	**AM**	12	13.6	14.6	12.5	12.9	14.1	12.7	
19	**GM**	12	11.7	10.7	10.9	14.1	11.2	12.5	
19	**OI**	12	14.5	14.6	13.3	14.5	14.55	13.9	
19	**RA**	16	22		21.4		21.7		84.7
19	**IL**	16	7.4	7.6	8.9	8.8	7.5	8.85	
19	**AM**	16	14.9	14.7	12.9	13	14.8	12.95	
19	**GM**	16	11.8	12	12.1	13.3	11.9	12.7	
19	**OI**	16	14.8	14.9	13.9	14.6	14.85	14.25	
Age 41-20	**RA**	0	8.2		11.3		9.75		60.7
2 c-s	**IL**	0	5.5	7.3	8.8	8.4	6.4	8.6	

20									
20	**AM**	0	11.2	10.9	7.5	8.8	11.05	8.15	
20	**GM**	0	13.5	12.2	9.9	10.5	12.85	10.2	
20	**OI**	0	13.5	12.8	12.8	11.5	13.15	12.15	
20	**RA**	4	24.5		21.5		23		61.1
20	**IL**	4	9.6	9.7	9	9.8	9.65	9.4	
20	**AM**	4	13.6	13.6	9.7	9.7	13.6	9.7	
20	**GM**	4	14.2	14.5	11.7	12.8	14.35	12.25	
20	**OI**	4	13.5	13.2	9.1	10.3	13.35	9.7	
20	**RA**	8	24.4		24.2		24.3		60.6
20	**IL**	8	9.1	9.1	9.3	8.3	9.1	8.8	
20	**AM**	8	14.1	13.3	9.2	10	13.7	9.6	
20	**GM**	8	15.3	15.60	9.8	12.2	15.45	11	
20	**OI**	8	14.6	13.3	14.6	14.5	13.45	14.55	
20	**RA**	12	24.4		24.3		24.35		61.5
20	**IL**	12	9.6	10.1	10.1	10.4	9.85	10.25	
20	**AM**	12	15.4	15.1	10.9	11.1	15.25	11	
20	**GM**	12	14.5	13.1	12.3	10.2	13.8	11.25	
20	**OI**	12	13.9	12.2	10.6	10.2	13.05	10.4	
20	**RA**	16	23.9		24.1		24		61
20	**IL**	16	9	9.1	8.5	9.8	9.05	9.15	
20	**AM**	16	13.6	13.6	11.3	12.3	13.6	11.8	
20	**GM**	16	16.4	19.9	13.5	13.7	18.15	13.6	
20	**OI**	16	15.4	17.7	11.8	12.5	16.55	12.15	
Age 32-21	**RA**	0	9.9		10.6		10.25		74.5
1 c-s 21	**IL**	0	6.6	6.70	7.7	5.9	6.65	6.8	
21	**AM**	0	9.6	12.5	7.6	8.7	11.05	8.15	
21	**GM**	0	11.3	11.9	9.6	9.7	11.6	9.65	
21	**OI**	0	9.4	9.8	11.1	13.3	9.6	12.2	
21	**RA**	4	9.2		12		10.6		75.5
21	**IL**	4	7.4	6.9	6.3	6.8	7.15	6.55	
21	**AM**	4	11	11.5	8.7	9.1	11.25	8.9	
21	**GM**	4	11.9	12.6	10.2	11.1	12.25	10.65	
21	**OI**	4	9.4	10.2	8.5	9.1	9.8	8.8	
21	**RA**	8	16.4		17.30		16.85		77.4
21	**IL**	8	7	7.3	7.2	6.9	7.15	7.05	
21	**AM**	8	12.3	11.5	8.7	9.1	11.9	10.55	
21	**GM**	8	14.6	16.4	13.4	12.6	15.5	13	

21	**OI**	8	13.9	13.6	10.8	11.5	13.75	11.15	
21	**RA**	12	18.6		14.7		16.65		77.6
21	**IL**	12	7.6	5.2	7.3	6.3	6.4	6.8	
21	**AM**	12	10.8	11.6	10.6	10	11.2	10.3	
21	**GM**	12	15.6	12.8	12.5	11.2	14.2	11.75	
21	**OI**	12	12.8	12.9	10.5	11.7	12.85	11.1	
21	**RA**	16	13.6		16.6		15.1		76.9
21	**IL**	16	5.6	5.1	7	7.2	5.35	7.1	
21	**AM**	16	12.1	12.5	10.9	13.1	12.3	12	
21	**GM**	16	15.5	15.2	15.5	11.8	15.35	13.65	
21	**OI**	16	13	14.1	10.6	11.1	13.55	10.85	
Age 36- 22	**RA**	0	7.7		11.9		9.8		59.7
1 c-s 22	**IL**	0	3.4	3.7	4.7	6.7	3.55	5.7	
22	**AM**	0	10.4	9.2	7.4	8.7	9.8	8.05	
22	**GM**	0	10.1	8.9	8.4	8.4	9.5	8.4	
22	**OI**	0	10.6	10.1	9	11.5	10.35	10.25	
22	**RA**	4	20.7		18		19.35		59.8
22	**IL**	4	5.4	4.5	6.9	7.2	4.95	7.05	
22	**AM**	4	10	11.9	9.8	11.6	10.95	10.70	
22	**GM**	4	14.1	13.1	11.9	11.6	13.6	11.75	
22	**OI**	4	13.8	13.6	12.8	12.9	13.7	12.85	
22	**RA**	8	22.1		24.4		23.25		59.8
22	**IL**	8	6.1	6.4	7.8	7.6	6.25	7.7	
22	**AM**	8	14.1	16.4	12.1	11.6	15.25	11.85	
22	**GM**	8	11	12	13	14.4	11.5	13.7	
22	**OI**	8	10.7	12.2	8.2	10.8	11.45	9.5	
22	**RA**	12	18.8		21.5		20.15		59.5
22	**IL**	12	5.1	5.8	6.7	6.7	5.45	6.7	
22	**AM**	12	13.1	12.3	11.2	11.4	12.7	11.3	
22	**GM**	12	13.5	12.9	12.4	11.7	13.2	12.05	
22	**OI**	12	12.2	15.3	9.2	9.9	13.75	9.55	
22	**RA**	16	24.1		20.2		22.15		61.6
22	**IL**	16	5.5	5.1	7.5	7	5.3	7.25	
22	**AM**	16	11.8	12.8	9.5	11.4	12.3	10.45	
22	**GM**	16	17.2	16.4	15.5	16.5	16.8	16	
22	**OI**	16	14.3	14.1	12	11.7	14.2	11.85	
Age 42- 23	**RA**	0	13.4		14.1		13.75		85

1 c-s 23	**IL**	0	9.2	9.7	8.4	8.6	9.45	8.5	
23	**AM**	0	14	14.4	12	12.7	14.2	12.35	
23	**GM**	0	11	13.3	13.1	14.6	12.15	13.85	
23	**OI**	0	13.1	14.1	16.4	13.4	13.6	14.9	
23	**RA**	4	24		23.9		23.95		80.9
23	**IL**	4	8.1	9.6	7.70	8	8.85	7.85	
23	**AM**	4	15.6	13.8	12.4	12.6	14.7	12.5	
23	**GM**	4	12.9	14.2	11.4	13.5	13.55	12.45	
23	**OI**	4	13.30	11.8	11.9	12.3	12.55	12.1	
23	**RA**	8	21.7		21.8		21.75		79.9
23	**IL**	8	10.4	9.4	7.7	7.3	9.9	7.5	
23	**AM**	8	15.4	12.7	12.9	13.8	14.05	13.35	
23	**GM**	8	14	16	13.5	13.6	15	13.55	
23	**OI**	8	14.1	14.3	12.3	11.9	14.2	12.1	
23	**RA**	12	23.8		23.8		23.8		77.2
23	**IL**	12	8.3	9.1	8.4	7.9	8.7	8.15	
23	**AM**	12	13.8	11.8	10.4	11.1	12.8	10.75	
23	**GM**	12	15.1	13.5	14.7	14.4	14.3	14.55	
23	**OI**	12	13.6	13.1	11.7	12.3	13.35	12	
23	**RA**	16	23.8		23.8		23.8		77.3
23	**IL**	16	10.1	9.4	8.9	9	9.75	8.95	
23	**AM**	16	14.8	14.3	11.4	16.3	14.55	13.85	
23	**GM**	16	16.3	19.7	19.4	16.1	18	17.75	
23	**OI**	16	16.4	15.4	14.9	13.6	15.9	14.25	
Age 36-24	**RA**	0	15.1		15		15.05		99.7
2 c-s 24	**IL**	0	6.2	8.4	6.8	6.7	7.3	6.75	
24	**AM**	0	11.7	12	9.7	9.1	11.85	9.4	
24	**GM**	0	10.9	10.4	14.3	14.3	10.65	14.3	
24	**OI**	0	9.4	9.1	9.5	8.9	9.25	9.2	
24	**RA**	4	16.1		15.3		15.7	98.4	
24	**IL**	4	7.2	7.4	6.4	6.7	7.3	6.55	
24	**AM**	4	10.7	11	10.2	9.7	10.85	9.95	
24	**GM**	4	11.3	11.3	12.1	12.5	11.3	12.3	
24	**OI**	4	11.5	12.2	11.2	11.4	11.85	11.3	
24	**RA**	8	15.1		17.3		16.2		100.2
24	**IL**	8	6.9	7.2	7.3	6.7	7.05	7	
24	**AM**	8	12.5	12.2	11	11	12.35	11	

24	**GM**	8	12.4	12.8	15.2	14.8	12.6	15	
24	**OI**	8	14.2	13.3	10.7	11.9	13.75	11.3	
24	**RA**	12	18.8		21		19.9		100.9
24	**IL**	12	7.7	7.5	6.8	8	7.6	7.4	
24	**AM**	12	13.3	12.9	12.5	11.7	13.1	12.1	
24	**GM**	12	13.8	13.8	16	14.8	13.8	15.4	
24	**OI**	12	11	13.3	12.5	11.2	12.15	11.85	
24	**RA**	16	23.6		24		23.8		100.8
24	**IL**	16	11	6.8	7.3	7.4	8.9	7.35	
24	**AM**	16	15.9	13.7	11.8	12.9	14.8	12.35	
24	**GM**	16	19.3	20.7	16.1	15.4	20	15.75	
24	**OI**	16	16.6	14.5	13.9	12.7	15.4	13.3	
Age 45- 25	**RA**	0	10.7		10.6		10.65		69.9
1 c-s 25	**IL**	0	6.7	6.7	6.40	6.2	6.7	6.3	
25	**AM**	0	10.4	10.3	9	8.4	10.35	8.7	
25	**GM**	0	10.5	9.9	9.1	9.6	10.2	9.35	
25	**OI**	0	9.7	10.5	8.4	8.5	10.1	8.45	
25	**RA**	4	17.9		15.9		16.9		71.1
25	**IL**	4	6.4	5.9	6.1	6.6	6.15	6.35	
25	**AM**	4	9.70	10.3	7.4	8.6	10	8	
25	**GM**	4	8.4	9.1	8.9	9.5	8.75	9.2	
25	**OI**	4	8.2	9.5	7.3	7.6	8.85	7.45	
25	**RA**	8	13		14.5		13.75		70.4
25	**IL**	8	6.8	6.9	6.1	5.8	6.85	5.95	
25	**AM**	8	9.1	9.4	9.6	8.7	9.25	9.15	
25	**GM**	8	10.9	9	8.4	9.1	9.95	8.75	
25	**OI**	8	8.4	8	5.6	7.4	8.2	6.5	
25	**RA**	12	17		17.2		17.1		69.1
25	**IL**	12	7.7	7.8	7	6.7	7.75	6.85	
25	**AM**	12	10.7	12	9.3	9	11.35	9.15	
25	**GM**	12	10.4	10.2	8.4	10.7	10.3	9.55	
25	**OI**	12	8.6	8	8.9	7.7	8.3	8.3	
25	**RA**	16	10.3		13.5		11.9		71.3
25	**IL**	16	7.2	7.2	6.5	5.9	7.2	6.2	
25	**AM**	16	9.9	9.5	9.4	9.8	9.7	9.6	
25	**GM**	16	11.9	12	10.3	10.6	11.95	10.4	
25	**OI**	16	10.1	12.2	9.6	11.8	11.15	10.7	
Age 40-	**RA**	0	14		17.9		15.95		80

26									
1 c-s 26	**IL**	0	4.6	7.5	9	10.2	6.05	9.6	
26	**AM**	0	11.1	9.7	12.2	13.2	10.4	12.7	
26	**GM**	0	13.1	13.1	14.1	15.5	13.1	14.8	
26	**OI**	0	12.8	14.2	15.3	14.8	13.5	15.05	
26	**RA**	4	20.1		20.6		20.55		80.4
26	**IL**	4	6.4	6.4	7.9	9	6.4	8.45	
26	**AM**	4	11.4	11.5	10.9	12.7	11.45	11.8	
26	**GM**	4	12.7	13.8	13	13	13.25	13	
26	**OI**	4	11.90	12.30	11.30	12.9	12.1	12.1	
26	**RA**	8	19.7		18.9		19.3		80.6
26	**IL**	8	7.3	7.4	7.2	9.5	7.35	8.35	
26	**AM**	8	14.1	13.6	12.3	12.3	13.85	12.3	
26	**GM**	8	13.6	13.7	14.3	14.8	13.65	14.55	
26	**OI**	8	11.8	12.3	11.3	12.6	12.05	11.95	
26	**RA**	12	22.4		23.7		23.05		79.6
26	**IL**	12	7.6	7.3	8.4	8.1	7.45	8.25	
26	**AM**	12	13.6	13.6	13.3	11.8	13.6	12.55	
26	**GM**	12	14.8	13.4	14.2	14.4	14.1	14.3	
26	**OI**	12	14.9	14.5	12.8	13.6	14.7	13.2	
26	**RA**	16	23.8		23.8		23.8		79.7
26	**IL**	16	7.7	7.7	9.8	9.1	7.7	9.45	
26	**AM**	16	12.2	14.1	14.4	14.2	13.15	14.3	
26	**GM**	16	15.7	15.2	16.7	15.4	15.45	16.05	
26	**OI**	16	13.6	13.7	15.6	16.4	13.65	16	
Age 44- 27	**RA**	0	14.4		10.4		12.4		49.1
1 c-s 27	**IL**	0	7.6	9.2	7.8	7.3	8.4	7.55	
27	**AM**	0	13.5	14.9	11.3	11.7	14.2	11.50	
27	**GM**	0	14.4	14.2	12.6	12.5	14.3	12.55	
27	**OI**	0	12.9	13.9	9.1	8.5	13.4	8.8	
27	**RA**	4	14.5		21.7		18.1		49.7
27	**IL**	4	8.3	9.5	8	7.7	8.9	7.85	
27	**AM**	4	14.2	15	12.9	11.9	14.6	12.4	
27	**GM**	4	14.9	13.8	13.4	13.6	14.35	13.5	
27	**OI**	4	15.3	15.6	12.6	15	15.45	13.8	
27	**RA**	8	14.1		20.9		17.5		49.7
27	**IL**	8	7.7	7.5	6.8	5.3	7.6	6.05	

27	**AM**	8	14.6	14.2	11.6	12.6	14.4	12.1	
27	**GM**	8	14.1	16.5	11.9	12.5	15.3	12.2	
27	**OI**	8	14.5	13.2	11	12.2	13.85	11.6	
27	**RA**	12	17.8		18.3		18.05		50.4
27	**IL**	12	9.3	8.8	7.1	7.4	9.05	7.25	
27	**AM**	12	13.9	15.3	12.1	12.4	14.6	12.25	
27	**GM**	12	12.9	14.7	13	11.9	13.8	12.45	
27	**OI**	12	14.2	13.8	13	14.2	14	13.6	
27	**RA**	16	17.1		17.9		17.5		51.5
27	**IL**	16	9.9	9.4	9.3	8.7	9.65	9	
27	**AM**	16	13.8	16.2	14.8	14.2	15	14.5	
27	**GM**	16	16.4	18.4	15.8	16	17.4	15.9	
27	**OI**	16	17.1	16.7	16.4	15.2	16.9	15.8	

APPENDIX W: THESIS PROPOSAL