Lower extremity neuromuscular deficits associated with obstetric fistula

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2011

Front picture from: Muleta (2010). Thesis: Obstetric fistula – prevalence, causes, consequences and associated factors. University of Bergen

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This thesis is submitted in partial fulfilment of the requirements for the degree of Master of Philosophy in International Health at the University of Bergen.

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SUMMARY

Background: Obstetric fistula affects thousands of women every year, one of the dreadful consequences of surviving an obstructed labour. A majority of these are left untreated, abandoned by their husband and family to a life in increasing poverty and misery. Not only do these women suffer from leakage of urine and faeces, many also end up with additional tragic complications of the obstructed labour, one of them being lower extremity neuromuscular deficits. Several studies report on drop foot and walking difficulties in patients with obstetric fistula. However, less obvious neuromuscular sequel has not been focused. *Assuming that such deficits exist we aimed to describe the neuromuscular function hip down in women with obstetric fistula to uncover such deficits.*

Methods: This hospital-based case-control study was carried out at University of Gondar, Ethiopia. According to a power-calculation 101 cases of obstetric fistula and a corresponding number of controls were planned. Participants were included and a short questionnaire was used to collect background data, and the following measurements were carried out: height, weight, passive range of motion of lower extremities (PROM), manual muscle testing of lower extremities (MMT), testing of reflexes, and ankle, leg and upper arm circumference. The measurements were taken by one of two physiotherapists.

Results: During the allocated study period 51 cases and 100 controls had been included in the study. Women with obstetric fistula were significantly shorter than the controls (150.8 cm vs. 156.7 cm), had a lower weight (44.5 kg vs. 48.7 kg), were of similar BMI (19), had had a longer duration of labour (2.8 vs. 0.5 days) and a generally high rate of stillbirth. Leg pain and walking difficulties immediately following the delivery were significantly more commonly reported in the fistula group (19.6 vs. 7 % and 33.3 vs. 0 %, respectively). As many as 27 % of the fistula cases still complained of walking difficulties at the time of the present hospital admission, but it did not seem to affect activities of daily life to a great extent when compared with the control group (19 %). Time since delivery was not significantly different in the groups (median 3 years for fistula patients and 4 years for controls).

No joint contracture was found, but decreased passive range of motion on knee flexion and extension, and ankle dorsal and plantar flexion was seen. 2 cases also had their passive dorsal flexion completely lost, one of them in both ankles. A marginally increased passive range of motion on hip extension and hip abduction was also found. The fistula cases were stronger for hip extension, knee flexion and hip lateral rotation. No drop foot was found, but a tendency towards decreased strength of ankle dorsal flexion and inversion. There was no difference in testing reflexes, and only marginally smaller upper arm circumference. Controlling for observer did not seem to affect the results.

Conclusion: Women with obstetric fistula more commonly report of pain and walking difficulties in the time following the obstructed labour. With years passing by much of these problems seems to resolve but at examination at median 3 years after birth some signs of less obvious impairment and compensatory adaptation may be traced. The results, however suffer from a yet not completed recruitment of participants.

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ABBREVIATIONS

WHO:	World Health Organization
UNFPA:	United Nations Population Fund
FIGO:	International Federation of Gynaecologists and Obstetricians
CPD:	Cephalopelvic disproportion
BMI:	Body mass index
PROM:	Passive range of motion
TUG:	Time up and go
MMT:	Manual muscle testing
CI:	Confidence interval
SD:	Standard deviation
SPSS:	statistical package for the social sciences
CR:	Caesarean rate
HHD:	Handheld dynamometer
RCT:	Randomized Control Studies
KG:	Kilogram
cm:	Centimeter
AIDS:	Acquired Immune Deficiency Syndrome
HSD:	Tukey Honestly Significant Difference
REK:	Regional Committees for Medical and Health Research Ethics
ADL:	Activities of daily life

ACKNOWLEDGEMENTS

This study was conducted at the Gondar University Hospital, Amhara region, Ethiopia, in cooperation with Centre for International health, University of Bergen. First of all, I would like to thank Professor Torvid Kiserud for your willingness to become my supervisor, making it possible to start the study in the first place.

I would like to express my gratitude towards my two supervisors, Professor Torvid Kiserud and Dr.Mulu Muleta, for all their help and support during this process. Thank you Mulu for your warm welcome and contribution to making this journey a reality. I would like to thank Professor Kari Bø, for the valuable input in the planning phase of this study. I would also like to thank staff at Gondar University Hospital, especially Dr. Kibrom and Dr. Mulat for taking such good care of me and for your help on all practical matters. A special thank to my colleague Cheran for continuing my work after I left Gondar. Thank you staff at Intrahealth for your cooperation and help.

I would like to thank all staff at CIH and fellow students for two wonderful and hardworking years, especially Alexander Tungu for the time and patience you have shown to support and critically comment my work.

I would also like to thank family and friends, among them Geir Eithun for help and support throughout the whole process. A special thank to Tor-Erik for being there at all times and for following me on this journey.

I would also express my sincere gratitude to all the Ethiopian women participating in this study. Without you none of this would be possible.

Bergen, May 16, 2011

1. INTRODUCTION

1.1 Anatomy

1.1.1 Anatomy of the pelvis

The pelvis is composed of the two innominate bones and the sacrum to which the coccygus is attached. The two innominate bones and the sacrum are connected anterior at the symphysis pubis and posterior at the left and right sacroiliac joints forming a bony ring. The ring is deeper posterior forming a curved canal, making the superior border of this canal the pelvic inlet, while the inferior border is called the pelvic outlet. The space between the pelvic inlet and the pelvic outlet is called the true pelvis. Together forming a rigid joint held together by strong ligaments and musculature surrounding the pelvis. The pelvic joints are reinforced by heavy ligaments, allowing only small gliding and rotary movements, providing a stable platform for the vertebral column and to transfer weight to the lower part of the body. The female pelvis is recognized as more shallow with straighter sides, a wider angle between the pubic rami at the symphysis and a greater pelvic outlet compared with the male pelvis. The ideal female pelvis, called the gynaecoid pelvis, is shaped with a well-rounded oval inlet and outlet (figure 1). When any of the diameters of the true pelvis is less than 1 cm compared with the ideal gynaecoid pelvis, it is termed a contracted pelvis (Mantle et al 2004, Moore et al 2007).

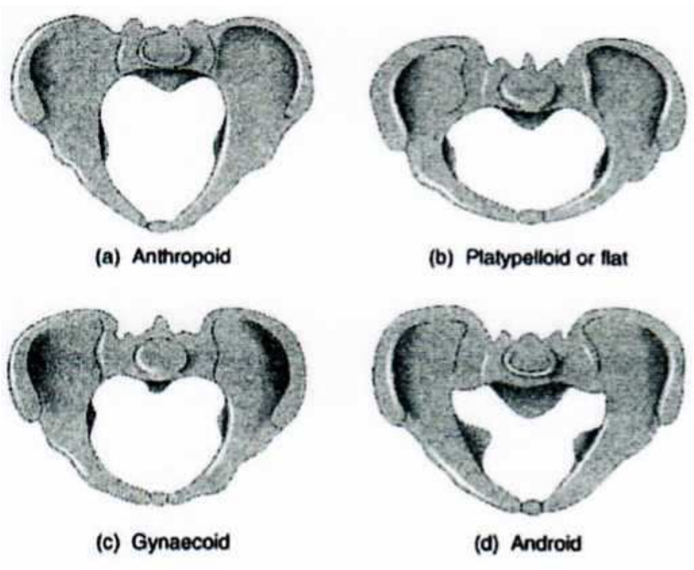

Figure 1: *4 types of pelvic inlet. (Mantle et al 2004)*

1.1.2 The musculature system

Many names are used to describe the muscles of the pelvic floor. In this study the description from Mantle et al (2004) is chosen, consisting of the levator ani, also known as the pelvic diaphragm or pubovisceralis (pubococcygeus) and iliococcygeus muscles. The anterior midline cleft of these muscles is called the urogenital hiatus, and is the location of which the urethra, vagina and rectum pass. Further, the authors divide the pubovisceralis into the pubovaginalis, puborectalis and the pubococcygeus, arranged from medial to lateral respectively. The urogenital diaphragm or the perineal membrane lies inferior to it, and the external anal sphincter posteriorly. The urogenital diaphragm consists of the compressor urethra muscle and the urethrovaginal sphincter smooth muscle anterior and is responsible for the compression of the distal urethra. Moving from internal to external we find the external genital muscles, known as the ischiocavernosus, bulbocavernosus or bulbospongiosus and the transverse perineal muscles. The most outer layer is the external genitalia and the skin. The pelvic floor muscles contribute to maintain continence for urine and faeces while allowing voiding, defecation, sexual intercourse and childbirth, in addition to the overall function to support the abdominal and the pelvic viscera.

The structure-function system responsible for keeping us continent is divided anatomically into the urethral support system and the sphincteric closure system. The urethral system consists of the anterior vagina, the endopelvic fascia, the arcus tendineus fasciae pelvis, and the levator ani muscles, while the sphincteric closure of the urethra is given by the urethral striated muscles, the urethral smooth muscle, and the vascular elements within the submucosa. It is the unique shape and function of these muscles that acts in keeping us continent. However, if the striated fibres of the levator ani are injured or the circular innervation is impaired, the muscular contraction needed to support the urethra will loose its power, hence it might never be restored (Ashton-Miller 2001, Snooks et al 1986). This is also relevant in older people (24 healthy subjects with mean age 74), as aging was found to be associated with loss of maximum voluntary isometric strength (Thelen 1996). Other muscles involved with the pelvic floor muscles are the ischiococcygeus, obturator internus and the piriformis, although none of them have direct contact with the vagina or the anal sphincter (Mantle et al 2004).

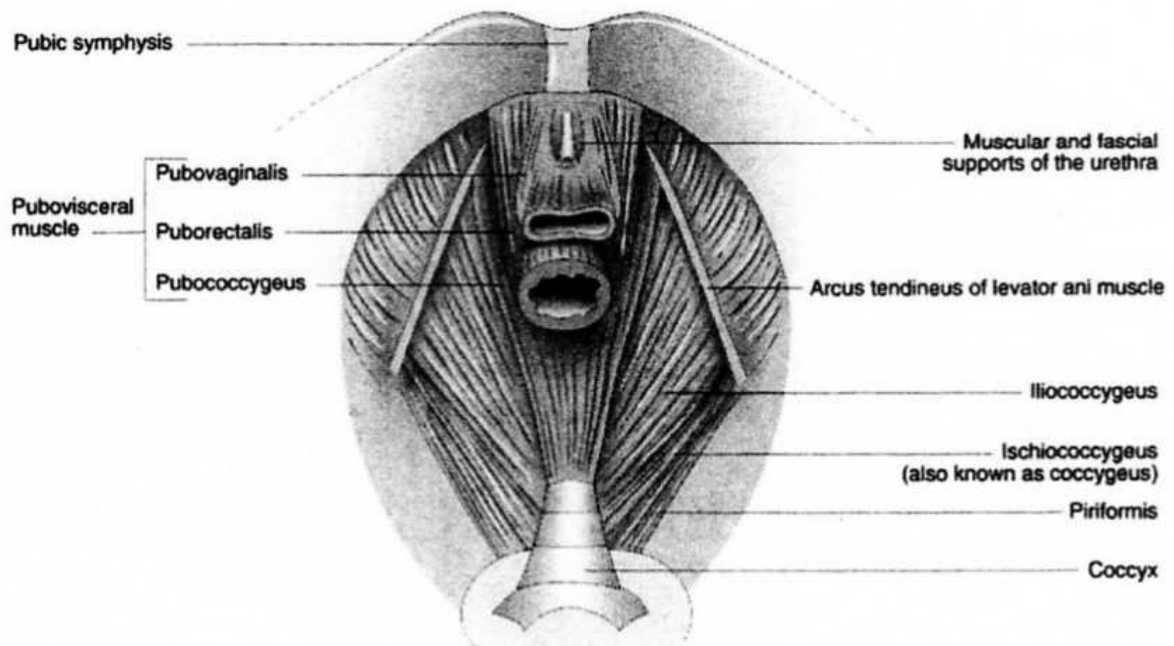

Figure 2*: Pelvic floor musculature (superior view). (Mantle et al 2004).*

1.1.3 The nervous system

The structures of the pelvis are mainly innervated by the sacral (S1-S4) and coccygeal nerve and the pelvic part of the autonomic nervous system (Moore et al 2007). The motor roots (anterior) and the sensory roots (posterior), leave the spinal cord according to their positions and joins into a single spinal nerve. Then they merge into networks of interwoven nerves, called plexuses (Standring 2008).

The lumbosacral trunk, or cord, is formed mainly by the L-5 root with a contributing branch from the L-4 root. It travels a relatively long route in close contact with the ala of the sacrum adjacent to the sacroiliac joint. The lumbosacral trunk is then cushioned throughout its course by the psoas muscle, except at its end near the pelvic brim, where it lies in close contact with bone. Further it travels inferiorly and anterior to the ala of the sacrum to link to the sacral plexus, S1-S2.

Most branches of the sacral plexus leave the pelvis through the greater sciatic foramen, the two main nerves being the sciatic nerve and the pudendal nerve. The tibial and common peroneal nerves (also called the common fibular nerve) are both branches of the sciatic nerve, and run down the posterior leg, behind the posterior knee. The common peroneal nerve, responsible for active dorsiflexion, inversion and eversion of the foot, further separates into the superficial peroneal branch and deep peroneal nerve (Butler 2000, Katirji et al 2002, Magee et al 2002, Standring 2008). The sensory sural nerve, a continuation of the tibial nerve, descends to the foot between the two gastrocnemius heads. Down the road it joins one of the communicating branches of the common peroneal nerve, changing its name to lateral sural nerve.

The anterior thigh nerves arise from the L2, 3, 4 root levels, with the femoral nerve descending through the psoas muscle, along with the inguinal ligament. The nerve is responsible for active hip flexion and active knee extension. The obturator nerve arises as a division from the lumbar plexus, L2, 3, 4, and is responsible for both motor and sensory distribution of hip adductor musculature. The lateral femoral cutaneous nerve arise from L2 and L3, crosses the iliacus muscle and pass the lateral end of the inguinal ligament, being responsible for the sensory distribution to the anterolateral thigh. A continuation of the femoral nerve is the saphenous nerve, down the leg to the medial ankle, only responsible for the sensory supply to the anteromedial knee and the medial leg (Butler 2000, Kendall et al 2005, Magee et al 2002).

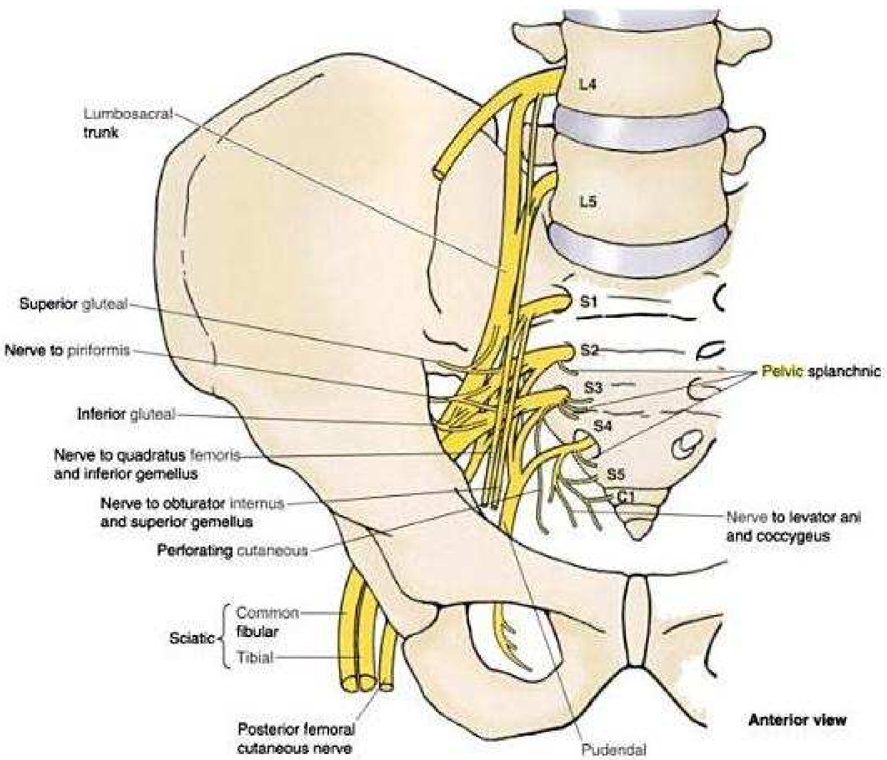

Figure 3: *The pelvic nerves. From http://anatomytopics.files.wordpress.com/2009/01/pelvic-nerves-sacral-plexus-2.jpg. [Cited 10.May 2011).*

1.2 Obstetric fistula

Obstetric fistula, as a result of obstructed, prolonged and neglected labour, manifests as a ”hole” between the bladder and the vagina (vesico-vaginal fistula) or the rectum and the vagina (recto-vaginal fistula) (Hilton 2003, Miller et al 2005, Williams 2007). In addition to the fistula in itself, a range of physical complications and morbidities are associated. Some of these injuries are caused by the fistula itself, whereas others are sequel of obstetric damage (Miller et al 2005). Further, these injuries are often labelled as local or intravaginal problems, and distant or extravaginal problems (Waaldijk et al 1994). Wall et al (2005) describes the injuries associated with the fistula as the”obstructed labour injury complex”. Foetal death, urinary and/or faecal incontinence, complex urologic injury, vaginal scarring and stenosis, secondary infertility, musculoskeletal injury, neurological conditions such as foot-drop, chronic skin irritations and amenorrhea (absence of a menstrual period), are some of the terrible complications associated with fistula. In addition, psychosocial damage due to isolation and loss of social support because of the offensive odour, divorce or separation, worsening poverty and malnutrition, affects thousands of young girls and women (Miller et al 2005, Wall et al 2005).

The vast majority of obstetric fistula that occurs in developing countries is caused by obstructed labour and obstructed trauma, vesico-vaginal and recto-vaginal fistulas being the most common injuries. Less common accidental injuries related to caesarean section, forceps delivery, other operational injuries, traditional surgical practices such as circumcision and gishiri cutting, a procedure where a traditional practitioner makes several cuts in the vagina in order to enlarge the birth canal, and complication derived from illegal abortion, may occur (Ampofo et al 1990, Hilton et al 1998, Hilton 2003, Waaldijk et al 1993, Wall et al 2004). Mathevet et al (2001) also found a 7.7 % incidence of vesico-vaginal fistulas after bladder injuries during vaginal hysterectomy. Circumcision is still practiced in various parts of North Africa, mainly Sudan and other Moslem countries, although the exact relevance to obstetric fistula is still unknown (Hilton 2003).

A study from north central Nigeria found as many as 899 cases of obstetric fistula out of 932 (96,5 %), all related to delivery and labour. Vesico-vaginal fistula was by far the most prevalent of all obstetric fistulas 764 of 899 cases (85 %), while a combination of vesico-vaginal and recto-vaginal fistula and recto-vaginal fistula alone counted for the remaining, 11 % and 4 % respectively (Wall et al 2004).

In developed countries, the main reason for obstetric fistula is surgery, due to either malignant- (30.4 %) or benign (62.7 %) conditions, caesarean section 5.9 % and obstetric injuries, only 0.9 % (Hadzi-Djokic et al 2009). This shows that with modern obstetric technologies one might decrease the number of fistula cases dramatically, as most cases of fistula in the developed world emerge as a complication of gynaecological surgery (Williams 2007).

1.2.1 Reasons for obstetric fistula development

Several studies describe “a low gynaecologic age”, “that is conception within two completed years of menarche” (Scholl et al 1989 p. 358), as a possible factor explaining why young girls in developing countries tend to develop a fistula in comparison with their female sisters in more developed countries even at the same chronological age. Higher age at menarche and young age at marriage, results in young, first-time mothers in developing countries (Miller et al 2005).

Further, to be able to understand the context around the development of obstetric fistula, one must look into the cultural, social and geographical aspects as well. Not surprisingly, obstetric fistulas are more commonly found in areas where maternal mortality is high and especially where obstructed labour contributes to the high percentage of maternal deaths. Thaddeus and Maine (1994) describes “the three stages of delay” that often result in maternal mortality; delay in the decision to seek care, delay in arrival at the health care facility and delay to receive adequate care. All this results prolonged unattended obstructed labour. Of those who reach a facility and have ended up with a fistula, 30-50% had been in labour for ≥3 days, depending on whether it was the second or later birth or the first (Muleta et al 2010). Some tragically dies. There is a higher risk of obstructed labour in young girls when the pelvis has not fully developed. Additionally they may be stunted as a result of malnutrition and infectious load during childhood and adolescence. The girls most commonly affected are often poor, illiterate with low social status, have been married early and come from remote areas of the society (Hilton 2003, Lewis et al 2006, Ramphal et al 2006, Wall et al 2005).

1.2.2 The fistula patient

A retrospective review of 932 fistula cases at a hospital in Nigeria showed that 899 (96.5%) could be linked to labour and delivery. The “typical fistula patient” was described as small and short, 44 kg and <150 cm, had been married early (15.5 years) but was now divorced or separated. The mean age at menarche was 14.5 years. She was uneducated, poor, and from a rural area and had developed her fistula as a primigravida during a labour that lasted at least 2 days and which resulted in a stillborn fetus (Ampofo et al 1990). These findings correspond with the study from Berhane et al (1999) and Muleta el al (2007). The largest study to date (Muleta et al 2010) including 15 000 fistula patients showed that the average age was higher than Muleta had reported previously and that the fraction of teenagers was small, possibly reflecting a growing awareness in the society with time. Hilton et al (1998) reported a median age of 28 years, 62.5 % were still married and of those ending up with a fistula, only 31.4 % followed their first pregnancy. Moreover, 73 % delivered at a hospital, where the duration of labour had been on an average for 2.5 days. Of those women attending the hospital for delivery, 1.96 fistula cases per 100 deliveries were estimated. Similar findings were presented by Ezegwui (2005) in a study from Eastern Nigeria. Mean age for fistula patients were 34.1 years, mean age for fistula formation was 30.1 years and the marital status 75.8%. A total of 91.9% had had an obstructed labour, and only 32.4% had a spontaneous vaginal delivery, resulting in a 78 % stillborn rate. The rest had some form of operative delivery. Mean duration of labour was 2.3 days and the majority of the women were multipara.

1.3 Epidemiology

In 2008 there was an estimated worldwide maternal mortality ratio of almost 350 000, with an uncertainty interval ranging from about 300 000-395 000 (Hogan et al 2010). In Ethiopia alone 2000 per 100 000 women die every year (Dainer 1999). The precise extent of fistula is hard to estimate due to inaccurate reporting, underreporting, and shame, which keep the women from seeking the help they need. A recent epidemiological survey in rural Ethiopia found that 0.21% of women 15-49 years of age had or had had obstetric fistula (95% CI 0.12-0.35), 0.15% were untreated, which corresponds to 26,819 women, underscoring the fact that this problem is huge and neglected (Muleta et al 2007). Hamlin et al (2002) estimated an incidence of 8700 fistula cases yearly in Ethiopia which gives 3/1000 live births, among the 2.9 million Ethiopian women giving birth every year. Although more effort has been directed through United Nations Population Fund (UNFPA), EngenderHealth, International Federation of Gynaecologists and Obstetricians (FIGO) to bring attention to the fistula problem globally, still 50-100 000 suffer from fistula every year (Lazaro 2005, Miller et al 2005). Since only a minority get surgery we can expect a prevalence of at least 500 000 in need for surgery, and the worst case, over two million (Waaldijk et al 1993). A study from UNFPA and

EngenderHealth (2010), report the fistula incidence to be especially high in nine Sub-Saharan African countries. Over 35 facilities in Benin, Chad, Malawi, Mali, Mozambique, Niger, Nigeria, Uganda and Zambia were visited during a period of six months. Nigeria, Uganda and Chad had the highest reported incidence with 1500, 1500 and 1100 respectively, maternal deaths per 100 000 live births. The percentage of skilled birth attendants was as low as 16 % in Chad and around 40 % in Nigeria and Uganda. This gives a tragic picture of the situation we are dealing with in the Sub-Saharan context, and can partly be explained by AIDS, malaria, famine, extreme poverty and political instability. Further, few fistula centres are available, there is scarcely adequate training and supplies, and the affected women have little knowledge of the existing treatment options.

1.4 The labour

”Labour is part of an ongoing and integrated physiological process starting at conception and completed some weeks after the baby is born” (Mantle et al 2004 p.53). This process normally ends between week 36 and 42 of gestation, resulting in the delivery of the fetus. It is hard to determine the exact beginning of the labour other than retrospectively, as this might be somewhat subjective, although the midwifery criteria are regular painful contractions together with cervical dilation (Mantle et al 2004).

The delivery takes place in three different stages, but it is also helpful to include a period of prelabour, recognized by a release of enzymes in the final weeks of pregnancy, allowing cervical softening prior to delivery (Fosang et al 1984).

First stage of labour

This stage encompasses both a latent (dilation of the cervix 0-3 cm) and an active phase (reaching full dilation of the cervix at 10 cm) and is recognized as the interval between the onset of labour and full cervical dilation. The latent phase is said to last 6-8 hours in primipara and 4-6 hours in multipara, followed by an active phase with dilation of 1 cm/hour, reaching full dilation of 10 cm (Arulkuraman et al 2005). This stage is established when there are regular painful contractions and at the same time effective descent of the fetus together with dilation of the cervix. Still, a difference may be seen amongst primipara and multipara women regarding the dilation of the cervix and the established labour, indicating the difficulty to assess the true onset of the delivery.

The physiologic mechanisms within the uterus involve an upward pull on the distal segment of the uterus and cervix, while simultaneously a downward pressure of the fetus is exerted.

This results in an opening of the cervix, allowing the fetus to come through. The uterine cavity becomes progressively smaller, helping further to the situation (Mantle et al 2004).

Second stage of labour

The next stage is the interval between full dilation and the expulsion of the infant, usually much shorter than stage one (conventionally within an hour). The fetus is pushed from the uterus into the vagina with help from the diaphragm and the abdominal muscles. As a consequence the pelvic floor distend, the puborectalis and pubococcygeus are separated and pushed aside and outward. The bowel is compressed and the urethra stretched as the bladder is pulled upwards above the symphysis pubis. The soft tissue of the perineum is further formed into a canal, directed anterior. The perineal soft tissue need time to stretch efficiently to allow the passage of the fetus. Although an episiotomy may release some of the stretch and pressure, there is still a risk of tearing of the soft tissue during delivery (Arulkumaran et al 2005, Decherney et al 2007, Mantle et al 2004). Not much is known regarding the tissue stretch of these muscles during labour. A study simulating vaginal birth, using the obturator internus muscle, piriformis muscle, coccygeal muscle, and sacrospinous ligaments attached to a 3D computer model, concluded that the medial portion of the pubococcygeal muscle is at greatest risk of injury during the descending foetal head in the 2nd stage of labour (Lien et al 2004). This model was based on the anatomy extracted from MR images of a healthy 34 year old, nulliparous woman. The results were also proportional with foetal head size, i.e. an increase of the foetal head size by 9 %, would increase the stretch of the medial part of the muscle with the same amount. However, this must be regarded as a model, as regions of greater and lesser stretch might be found. It is in the second stage of labour that the mother is urged to push, using her abdominal pressure, together with the force of the uterine contractions to expulse the baby. This stage normally lasts from 30 minutes to 3 hours in primipara women and 5-30 minutes in multipara women (Decherney et al 2007). A long duration of the second stage should be avoided, as this might increase the risk of injuries to the fetus and to the tissue surrounding the vagina, urethra and the rectum, including maternal pelvic floor neuropathy (Dannecker et al 2000, Lien et al 2004, Mantle et al 2004).

Third stage of labour

The last stage of labour is the interval from the infant is born to the delivery of the placenta, and is usually the shortest phase. However, the management during this stage of labour can directly influence critical maternal outcomes, such as blood loss, the need for manual removal of the placenta and vaginal bleeding after delivery, as it is during this stage the majority of deaths occur in developing countries (Arulkuraman et al 2005, Decherney et al 2007, Mantle et al 2004).

The last stage of labour, the puerperium

The process of labour also involves a period after the placental delivery, the puerperium, in which the woman's genital tract returns back to a non-pregnant state, usually a period lasting 6-8 weeks. There are several physiological factors involved in this process, placental hormone production ceases with a dramatic decline in blood levels progesterone and oestrogen, with a direct influence on maternal respiration, the cardiovascular system, digestion and metabolism (Mantle et al 2004).

1.5 Prolonged and obstructed labour

A normal labour is said to last for about 14-16 hours, whereas prolonged labour is defined as if the delivering woman is not able to achieve a safe vaginal delivery within 18 hours of its onset. Further, if it delays more than 24 hours, the risk of the mother and the child are even higher. The labour is usually prolonged in the first stage, but may be prolonged in the second stage as well. However, it would be more precise to talk about a prolonged latent phase and a prolonged active phase of labour. About 70 % of the causes of prolonged labour are due to insufficient uterine contractions. Obstructed labour is a more serious condition, requiring medical assistance, as no descent of the fetus is seen, despite of uterine contractions. The leading causes of obstructed labour are cephalopelvic disproportion (CPD), malpresentations, foetal anomalies and soft tissue lesions. When the foetal head is physically unable to go through a normal labour, there is said to be CPD, and a decision should be made whether the mother should deliver by caesarean section or to have a vaginal labour, with or without early induction (Arulkuraman et al 2005, Mantle et al 2004). Low maternal stature, primiparous pregnancy and delivery of a male fetus are thought to be associated factors to develop CPD (Ampofo et al 1990, Muleta et al 2010). Especially under age 16 the immaturity of the pelvic bones can cause obstructed labour. If the pregnancy is uneventful, anaemia is treated adequately, labour starts at term, the infant is at cephalic presentation, labour should not be at increased risk (Treffers et al 2001.) However, despite having received adequate antenatal care, CPD occur unpredicted in labour and be a source for failure to progress (Mantle et al 2004). The tragic outcome may present as foetal- or maternal death, and a vesico-vaginal fistula (Arulkuraman et al 2005).

1.5.1 Underlying mechanisms for development of obstetric fistula

The mechanism under which obstetric fistula arise during vaginal labour, is due to the baby's head being pressed against the pelvis, reducing the flow of blood to the surrounding soft tissues of the bladder, vagina and the rectum. There is an upward displacement of the bladder, leaving the anterior vaginal wall, bladder base and urethra to be compressed between the head of the baby and the posterior surface of the symphysis pubis (Hilton 2003, Lewis et al 2006). The stretch of the tissues may further impair circulation, and the combination of reduced circulation and prolonged stretch increases the risk of rupture, another mechanism to develop fistula. If the pressure is relived shortly after, there will be no risk of harm, but if the pressure continues the intervening tissues will become necrotic due to ischemia. The ischemic area will separate as a slough, leaving a hole between either the rectum and the vagina or the bladder and the vagina, usually between the third and tenth day after delivery, irrespective of the mode of delivery (Arulkuraman et al 2005, Hilton 2003). In some with a small gynaecoid or flat pelvis, the presence of peroneal palsy, an injury to the peroneal nerve, may develop as well (Arulkuraman et al 2005).

The exact location and nature of the fistula caused by obstructed labour is largely dependent on the force and duration of the compression that occurs, as well as which stage the labour has reached. Further, in order to determine the clinical details of a vesico-vaginal fistula, both size and localization is important, the relationship with urethral openings, and presence of inflammation and scar tissue around the fistula (Hadzi-Djokic 2008, Wall et al 2005). Wall et al (2005) infer from their study that "labour becomes obstructed at the pelvic brim and mid-pelvis rather than at the pelvic outlet" (p.1414). This indicates damage at a higher level in the pelvic area, which corresponds with the findings from Hilton et al (1998) where mid-vaginal, juxta-cervical (utero-vesical fistula) and large fistulas, involving the whole of the bladder base between mid-vaginal and cervical, counted for 70 % of the total fistula cases reported in their study. Muleta et al (2010) adds to these results where primiparous had more severe pelvic lesions that commonly involved the urethra and rectum, compared with multiparous.

1.6 Classification of obstetric fistula

Vesico-vaginal fistula can be subdivided into simple, complex, and complicated (Williams 2007). Sims (1998) suggested a classification system based upon the relative position of the fistula: urethro-vaginal fistula, where the fistula is confined to the urethra, fistula situated at the neck of the bladder, fistula situated at the body of the bladder and utero-vesical fistula, where the opening communicates with the body or cervix of the uterus. Waaldijk (1995) developed a surgical classification system for obstetric fistulas in order to compare surgical techniques and results, according to their anatomical/physiological location. Most of the existing classification systems are only based on the anatomical position of the fistula and not the surgical implications. Type I fistulas not involving the closing mechanism; type II fistulas involving the closing mechanism; and type III ureter and other exceptional fistulas. Type II fistulas are further divided into: (A) without (sub) total urethra involvement, and (B) with (sub) total urethra involvement; and (a) without a circumferential defect, and (b) with a circumferential defect. The result of closure becomes progressively worse from type I through type IIBb, as the surgery becomes more difficult and complicated. Further, the presence of incontinence also worsen from type I through type IIBb, because type I fistulas still has the closing mechanism intact, whereas in type II fistulas more of the closing mechanism is partly or totally lost. The system makes it possible to classify into the size of the defect, although this might not report on the damage done, the defect should rather be based on the actual tissue loss.

1.6.1 Surgical outcome

Hilton (2003) claims that it is hard to compare published results of treatment as these involve different lesions and different techniques of repair. In addition very few patients come for follow-up as they often have to travel very long distances to reach a health facility (Hilton et al 1998). Several studies report a success rate as high as 90 %, although the cure rate (closure at first operation) may vary from 60 % to 90 % (Wall et al 2004, Hilton 2003, United Nations Population Fund 2010). If need of a second or subsequent operation the cure rate drops even further, from 81.2 % to 65 %. ”Cure” was in this study defined if the patients were subjectively dry at their last assessment, and did not follow further surgery within the study period (1970-1994) (Hilton et al 1998). Further attempts are usually required due to leakage. However, a successful surgical outcome depends upon several factors, including, proper evaluation and counselling, proper time of repair, choice of approach and positioning of patient, choice of instruments and suture material (Sadiq et al 2008). The women lucky enough to have a surgery may occasionally be further impaired by vaginal scarring due to the operation (Ampofo et al 1990). Hilton (2003) reports the overall incidence of stress incontinence after fistula repair to be 26 %. Vaginal scarring, urethral loss and a small capacity bladder will increase this number.

1.7 Neurological injury in relation to labour

It is probably either by excessive compression or stretch, a mechanical damage can cause injury to the peripheral nerves during vaginal birth (Borg et al 2005). Few studies include data on the amount of pressure needed to cause the nerve injury and how long the labour must last for damage to develop (Waaldijk et al 1994), whereas it is more established at what level the obstruction must be present to cause the damage (Katirji et al 2002, Lien et al 2005).
The study by Lien et al (2005) investigated the strain in the nerves innervating the levator ani, urethra and anal sphincter during the second stage of vaginal delivery. The relevant data were imported into the previous published 3D model by the same authors (Lien et al 2004). The branches relevant to urinary and fecal incontinence were chosen for this study, including the inferior rectal nerve branch and the perineal nerve branch, which was further divided into the muscular branch innervating the striated urethra sphincter, and muscular branch innervating the external anal sphincter. The remaining part of the perineal nerve, the posterior labial branch, was also included in the investigation. The authors found a maximum average stretch of 35 % in the inferior rectal branch, followed by a 33 % stretch in the anal sphincter, 15 % stretch in the posterior labia and 13 % stretch in the urethral sphincter, all greater than what is said to be tolerated. The nerve strain also increased with foetal head- and perineal descent, and the greatest increase in stretch was seen in the inferior rectal nerve and the anal sphincter. This may be one of the explanations of the occurrence of stress urinary incontinence during pregnancy and puerperium, in addition to heredity and the presence of hormonal factors, the latter often resolving 3 months after delivery, when the woman's genital tract returns back to a non-pregnant state (Iosif 1981, Mantle et al 2004). Snooks et al (1986) found the fibre density in the anal sphincter muscle unchanged among women who underwent a caesarean section, compared to the women delivering vaginally, and among multipara, which had signs of increased damage compared to primipara. Further delivery with forceps, increased the risk of injury to the pudendal nerve, although the duration of the delivery was an associated factor for the injury as well. Further research must be conducted to establish the relationship between stretch and compression injuries, but so far, a reasonable explanation of pudendal nerve damage after vaginal delivery is a combination of direct injury to the lumbosacral nerve trunk inside the pelvis and the traction that occurs during the lengthening of the birth canal. Mantle et al (2004) supports these findings, as the pudendal nerve may be pressurized and stretched as it traverses the interior of the pelvis starting from the sciatic spine, and it is during the stretching and separation of the pelvic floor muscles, especially during forceps delivery, the risk of injury to the pudendal nerve is at its highest. Hence, we are still short of

Randomized Control Studies (RCTs) that manifest what we should implement in order to prevent nerve injury and muscle stretching (Ashton-Miller et al 2007).

Peripheral nerve injuries may also arise as a result of a hernia from an intervertebral disc, pressure of the foetal head on the lumbar sacral nerve trunk near the pelvic brim (figure 4), causing a further compression onto the peroneal nerve or a direct compression to the peroneal nerve behind the fibular head, from prolonged squatting and pushing in the second stage of labor (Katirji et al 2002, Ramphal et al 2006, Waaldijk et al 1994). The peroneal nerve might also be pinched at the head of the fibula due to the women holding their legs while they are in the squatting position (Borg et al 2005). Joint contractures may follow neuromuscular damage or prolonged bed rest after birth and may lead to muscular atrophy. Flexion contractures of the hip and knee are most present (Muleta et al 2007, Williams 2007).

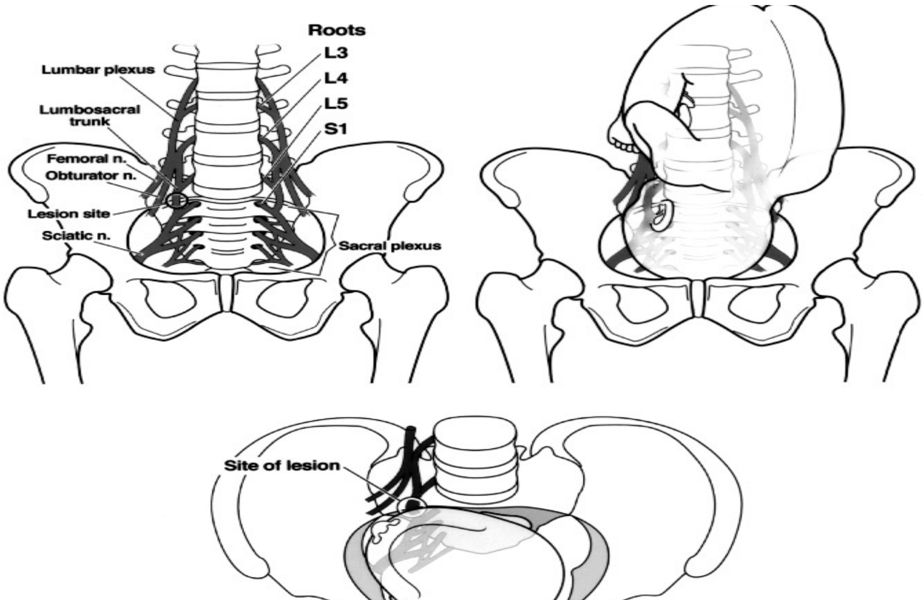

Figure 4: *Showing the pressure of the foetal head on the lumbar sacral nerve trunk near the pelvic brim. Frontal view shown upper left and right, superior view shown lower centre. From Cleveland Clinic Foundation (CCF) 2001.*

1.7.1 Signs and symptoms related to peripheral nerve injuries

The common peroneal nerve is most likely to be affected, followed by the deep peroneal nerve and the superficial peroneal nerve, with a good prognosis of healing, and is most likely due to entrapment at the head of the fibula, leading to decreased ankle dorsiflexion, eversion and inversion, and sometimes sensory loss at the dorsal foot (Aprile et al 2000, Magee 2002). An entrapment of the lateral femoral cutaneous nerve under the inguinal ligament can also arise during delivery. It is a purely sensory nerve, giving no motor loss but may give burning, pain and numbness on the anterolateral thigh. Further, damage to the femoral nerve (L2-L4) may occur as a result of prolonged pushing in extreme hip flexion. This can cause sensory alterations at the anteromedial aspect of the thigh and leg. In addition, decreased knee extension and hip flexion because of damage to the quadriceps muscle may occur. It may also limit the patellar reflex (Magee 2002, McDonald 2008). Damage to the femoral nerve can lead to significant impairment when climbing stairs, walking and going from sitting to standing (Borg-Stein 2005).

Damage to the sciatic and the obturator nerve are likely to occur, as they both cross the pelvic brim where the obstruction often occur (Wall et al 2005). The obturator nerve (L2-L4) might, but seldom, manifest with decreased sensation at the medial thigh, together with motor loss of the hip adductor musculature. No reflex change will be observed. The sciatic nerve (L4-L5, S1) can give sensory loss at the entire foot and weakness of ankle dorsiflexion and inversion, and sometimes ankle plantarflexion and knee flexion, in addition to diminished Achilles reflex (Magee 2002). Knee extension, dorsalflexion (tibialis anterior and extensor hallucis longus) and plantar flexion (gastrocnemius) are the movements and muscles of greatest diagnostic value (Standring 2008).

Ankle oedema can lead to compression of the tibial nerve as it pass behind the medial malleolus of the ankle, leading to paraesthesia of the sole of the foot and the plantar surface of the toes. This is often seen during pregnancy, but can also be relevant postpartum due to impaired circulation, neuromuscular injury and inactivity (Mantle et al 2004).

Early detection and treatment of obstetric fistula is rare, due to delays in seeking and receiving adequate help. They may have had the fistula for months or years, and is suffering from anaemia and malnutrition, in addition to the fistula itself. Physiotherapy is crucial in treatment of neurological injuries and contractures of the legs, and should be initiated as soon as possible since delay in surgical treatment can take up to three months in obstetric cases, due to slouching of the vaginal tissue (Miller et al 2005, Thaddeus and Maine1994, Hilton 2003). Physiotherapy is also important in training of pelvic floor muscles pre operative and in case of residual incontinence after the fistula closure. The role of pelvic floor exercises pre and post operatively has not been evaluated in the long term due to lack of follow up, but should be implemented in both the pre- and postoperative treatment programs (Williams 2007).

1.7.2 Nerve injuries reported in previous studies

Several reports have been carried out to manifest the true extent of neuromuscular injuries in relation to obstetric fistula, but few have kept this as the main focus of their study. Foot-drop was reported to be almost 20 % at the Addis Ababa hospital in Ethiopia (Arrowsmith et al 1996). Williams (2007) report a 30 % incidence of either unilateral or bilateral foot-drop from the same hospital. Muleta et al (2008) reported no foot drop or contractures in their study, but amenorrhea, leg pain and difficulty walking were mentioned. However, no physical examination was carried out, which might result in an inability to detect less obvious neuromuscular injuries that may occur. A study from the Addis Ababa Fistula hospital in Ethiopia reported 1.5 % gait impairment in primipara (95 % confidence interval (CI) 1.47-1.53) versus 0.8 % in multipara (95 % CI 0.6-1.0), where the primipara underwent a significantly longer labour, had a higher rate of stillbirth and a more extensive fistula formation. Both groups were equally short of stature 152.4 and 153.1 cm, for primipara and multipara, respectively, an equally low weight 46 and 47 kg, and an equally low BMI 19.8 and 19.9 kg/m^2. Age at marriage was also similar. The difference compared with the general population was seen for height, the fistula group being of shorter stature, 152.7 versus 156.5 cm. Neuromuscular damage was noted if there was an obvious uni- or bilateral drop-foot or if more serious impairment of walking ability was noted at admission (Muleta et al 2010). Ezegwui (2005) found associated morbidities such as perineal skin irritation (41.9 %), cervical damage and amenorrhea (21.6 %), while there was no sign of foot-drop. Increased parity, shorter duration of labour and higher caesarean was given as a possible explanation of these findings.

Waaldijk et al (1994) aimed to assess the presence of peroneal nerve damage in 947 patients with vesico-vaginal fistula. For the first half of the patients hospital records were reviewed for the presence of any obvious foot drop, which turned out to be 5.3% and a higher (12.6%) if she had sought the hospital within two years of the delivery. The second half of patients was identified as they came for treatment and was asked of any history of foot-drop or leg weakness lasting at least one month after delivery. Those still complaining of weakness at time of examination were examined for muscle weakness and foot drop. These patients had both signs and history of peroneal paralysis in 64.9%, but only 26.5% had direct signs of

peroneal paralysis at the time of presentation. Also this group had more peroneal problems if time from birth was less than two years. These results indicate that patients suffering from lower leg weakness have a good chance of recovering within the first two years after the injury, but these claims need validation (Waaldijk et al 1994, Ramphal et al 2006). Still, 13 % had persistent signs of nerve disruption with permanent loss of motor function. Patients with both vesico-vaginal and recto-vaginal fistula had more signs of peroneal nerve damage, indicating greater damage to the pelvic nerves. Unilateral nerve injury, right-sided, were also shown to occur the most frequent. This highlights the importance of early recognition in order to reduce long-term complications such as foot drop and general leg weakness, as well as the need to thoroughly examine these patients for less obvious neurological injuries that can arise during child birth. The author did not examine any sensory loss (Waaldijk et al 1994).
Wall et al (2005) states that no studies report on using electromyography to evaluate the precise neurophysiologic abnormality in fistula patients.

1.7.3 Neurological injuries in women without obstetric fistula

Over the past years more studies have been carried out in order to establish a relationship between childbirth and peripheral nerve lesions during- and after pregnancy in healthy women. A study by Katirji et al (2002), using neurological and electrodiagnostic evaluation at L5 level, report of a weak ankle dorsiflexion and toe extension whereas milder weakness was found on eversion and inversion of the ankle. Less obvious was weakness related to hip extension, knee flexion and hip abduction, which also recovered rapidly. Plantar flexion and the Achilles reflex were normal. All the women had obstructed labour and underwent a caesarean section. 6 patients were short of stature, and one delivered a relatively large baby. However, 7 cases may not be a sufficient number for a valid conclusion. The authors believe the main reason for these injuries and the rapid recovery (3-5 month) were due to segmental demyelination of the nerves supplying the muscular- and sensory fibres of the under-extremities, rather than axonal damage, although the results suggest some disruption in the most distal areas. This means, if the myelin-cover of a nerve is damaged, this will lead to slower or even full stop of nerve transmission.

1.8 Purpose of the study

Obstetric fistula occurs mainly in less developed countries, as a result of prolonged and obstructed labour. Peroneal nerve damage, with foot drop, is well documented in relation to obstructed labour and obstetric fistula, but a more detailed neuromuscular assessment to uncover less obvious nerve injuries are missing. In the present study we therefore focused on a functional neuromuscular assessment of the lower extremities in women with obstetric fistula.

1.9 Hypothesis:

Neuromuscular deficits of the lower extremities beyond that of foot-drop are present in women with obstetric fistula.

1.10 Objectives:

1.10.1 General objective:

- To identify the neuromuscular deficits of the lower extremities in patients with verified obstetric fistula

1.10.2 Specific objectives

- To assess passive range of motion, sensitivity, reflexes and strength of the under-extremities of fistula patients
- To assess basic mobility and walking pattern in women with obstetric fistula
- To compare the extent of neuromuscular damage in women with obstetric fistula with a control group.

2. METHODOLOGY

2.1 Study design

A case-control study to assess neuromuscular deficits in women with obstetric fistula and to compare the extent of these deficits with women attending the hospital for other (benign) conditions.

To be able to answer the objectives of this study the following procedures were performed:

- Questionnaire
- Height
- Weight
- Upper arm, leg and ankle circumference
- Manual muscle testing of lower extremities (MMT)
- Passive range of motion of lower extremities (PROM)
- Patellar, achilles and babinski reflex
- Time up and go (TUG)
- Sensibility

2.2 Procedure and time frame

The study was conducted at Gondar University Hospital, Gondar, Amhara region, Ethiopia. The cases were recruited from the gynaecological ward, where they were admitted. The control group was planned to be recruited among women attending the out patient department of the hospital. As these women turned out to be very few, recruitment included all wards and out patient departments in the hospital area. In addition fistula cases were recruited from three different preoperative waiting areas, Dangla, Adet and Woreta, in the same region. (Figure 5)

Figure 5*: Map of regions and zones in Ethiopia, showing Amhara region in green.*
From www. http://commons.wikimedia.org/wiki/File:Ethiopia_zone_region.jpg. [Cited 10.April 2011]

2.3 Inclusion and exclusion criteria

Inclusion criteria for the study group:

- Reproductive age (15-49 years).
- Delivery that caused the fistula >3 months and <7 years
- Cases who delivered <3 months and >7 years, and were <15 years and >49 years, required matched controls +-5 years.

Inclusion criteria for controls:

- Reproductive age (15-49 years).
- Last delivery >3 months and <7 years
- Coming from a rural area

- Controls were included to match specifically cases that had a delivery (<3 months and >7 years) and were (<15 years and >49 years) +-5 years.

Exclusion criteria for the study group:

- None (those <15 and >49 years of age were included, but needed specifically matched controls)

Exclusion criteria for the control group:

- Obstetric fistula
- Central neurological injuries (acquired and congenital involving the brain or spinal cord) following injury or organic disease.
- After trauma:
  - Fracture of lower extremities
  - Severe injury to musculature, tendon, ligament of lower extremities
- After surgery of lower extremities
- Prolonged and obstructed labour
- Malignancy

2.4 Planning and establishing the study

The physical examination was carried out by me with assistance of one local health educated person. The assistant was involved in translation of the questionnaire and translation of instructions (from English to Amharic) needed for the examination, after a short brief prior to each examination. The assistant was also involved in stabilization of extremities when needed. One additional physiotherapist was involved in the study, to continue the examination after I left. He was not involved in the study from the start, but received and followed the examination procedure. The results from his pilot (n=5) were calculated for intra-tester reliability (appendix 11). Each examination took approximately 60 minutes, in addition to 5 minutes preparation and 20-30 minutes after work.

Planning of the study involved selection of different tools and methods, in addition to a pilot study carried out during the preparation of the field work. The pilot was performed in a relevant age group (7 healthy females aged 28-52 years), with all tests and measurements done with 2 days in between, by the same examiner (Jakobsen 2009, Jakobsen et al 2009). All anthropometrical measurements and passive range of motion were recorded and used to check for intra-tester reliability. Anthropometrical measurements are shown in appendix 11. Height was practiced in the pilot using KaWe height measurement tool (to be placed on the wall), but due to practical reasons this was not used in the study. Therefore training of height was done during the study by measuring the first 10 participants height twice with a non-stretch tape measure and recording the highest measure (appendix 11). In addition, weight scale consistency was performed prior to and during the fieldwork, and compared against another weight scale. When testing for intra-tester reliability on passive range of motion, each measurement was done 3 times on each practice session. A slight increase in passive range of motion was seen as a normal response to the stretching of the soft tissue and not as an error in the measurement (Clarkson 2000).

Based upon the training and available information, a standardised examination protocol was made and will be presented in the following section.

2.5 Physical examination

2.5.1 Questionnaire

Attached in appendix 7.

2.5.2 Anthropometric measurements

Height was measured, for practical reasons, using a non-stretch tape measure. The participants were asked to stand up straight, remove heavy clothes and shoes. A correct position was obtained when both heels were flat on the ground and against the wall, the knees were extended, and the calf, buttock, shoulder and the back of the head, were toughing the wall (figure 6). The participants were asked to make a small nodding movement of the head and keep the position while being measured. The measurement was performed by setting a mark on the wall in a 90 degrees angle to the highest point on the head. The measurement was recorded to the nearest 0.1 cm (Berkley et al 2005, Geeta et al 2009).

Figure 6. *Showing height measurement with correct position and without heavy clothing. Used with permission.*

Weight: to measure weight, a digital weight scale *Salter streamline electronic scale 9040*, was used. The participants were asked to remove heavy clothing and shoes. They were told to stand up straight with no support, with the arms hanging freely and look straight forward. The weight was measured twice, recording the highest score.
The weight scale was placed on an even surface. The measurement was recorded to the nearest 0.1 cm (Berkley et al 2005, Geeta et al 2009).

Figure 7. *Weight measurement with correct position and without heavy clothing. Used with permission.*

Upper arm circumference: to measure upper arm circumference, a non-stretch tape measure was used. The participant was sitting on the examination table, with no clothes covering the part to be measured. The starting point for the measurement was just below the axilla, in a horizontal direction around the upper arm. The tape measure was not tightened but registered where the tape measurement ends met. Both arms were measured. The measurement was recorded to the nearest 0.1 cm (Berkley et al 2005, Geeta et al 2009).

Figure 8. *Measurement of upper arm circumference. Correct position. Used with permission.*

Leg circumference: To measure leg circumference a non-stretch tape measure was used. The participant was sitting on the examination table, with both legs hanging freely and both knees flexed, with no clothes covering the part to be measured. The most distal point of the patella was marked with a pen. A new mark was put 15 cm distal to the distal point at the patella. This was the point of measurement. The tape measure was not tightened but registered where the tape measurement ends met. Both legs were measured. The measurement was recorded to the nearest 0.1 cm (Berkley et al 2005, Geeta et al 2009).

Figure 9. *Measurment of leg circumference. Correct position. Used with permission.*

Ankle circumference: To measure ankle circumference a non-stretch tape measure was used. The participant was sitting on the examination table, with both legs hanging freely and both knees flexed, with no clothes covering the part to be measured. The medial and lateral malleoli was localised and the circumference was measured just proximal to these landmarks. The tape measure was not tightened but registered where the tape measurement ends met. Both legs were measured. The measurement was recorded to the nearest 0.1 cm (Berkley et al 2005, Geeta et al 2009).

Figure 10*. Showing ankle circumference. Correct position. Used with permission.*

2.5.3 Manual muscle testing (MMT)

To test muscle strength, Kendall's 5-point scale was used. The scale ranges from 0-5 and is interpreted as: "grade 0: no contraction felt or seen in the muscle, grade 1: tendon becomes prominent or feeble contraction felt in the muscle with no visible movement, grade 2: movement through complete range of motion for the muscle being tested in gravity related position, grade 3: holds test position in the antigravity position (no pressure added), grade 4: holds test position against moderate pressure in the antigravity position, grade 5: holds test position against strong pressure in the antigravity position" (Kendall et al 2005 p.23).

In the present study, MMT was performed including 12 different positions involving the hip, knee and ankle. The participants were asked to remove heavy clothing. Position of the participant, stabilization, point of force of resistance and instructions were standardised for each muscle group and modified from Kendall et al 2005. See appendix 6 with descriptions and pictures of test positions.

2.5.4 Passive range of motion (PROM)

Passive range of motion was measured using a big universal goniometer with one degree precision and an arm length of 30 cm (figure 11). Two measurements were done and the highest value recorded to the closest 1 degree (Jakobsen 2009). 8 joints around the hip, knee and ankle were measured. Hyperextension of the knee and hip was measured, and registered as a negative degree. The starting position for each measurement was is in the anatomical position (Norkin et al 2009). The participants were asked to remove heavy clothing and shoes and were provided underwear if needed. Position of participant, stabilization of proximal joints and goniometer alignment were standardised for all measurements and modified from Jakobsen et al 2010a, Jakobsen 2010b, Hvidovre Hospital 2009a, Hvidovre Hospital 2009b, Norkin et al 2009 (appendix 6).

Figure 11*: A universal goniometer. From http://www.vaktrommet.no/index.php?nr=90&case=4&id=355&idkategori=121&kat_name=Goniometer&prod_name=Prestige medical (USA) goniometer&startrow= [Cited 10.May 2011].*

2.5.5 Reflex testing

Testing of the muscle-stretch reflex was done for Achilles and patella (Reese 1999). Babinski was included as an additional test as well. All reflexes were noticed as visible or absent, irrespective of the degree of activity, and the method standardised (Butler 2000, Kendall et al 2005, Magee 2002).

Achilles reflex was tested with the participant in the prone position with a firm pillow under the ankle or the foot supported against the examiners thigh, adding a small pressure in the direction of dorsalflexion. The leg to be tested should be as relaxed as possible. Alternatively tested in the supine position. A tap was given directly to the Achilles tendon with a reflex hammer. The procedure was repeated about 5 times if no contraction (plantar flexion) was observed. If plantarflexion of the ankle was observed (irrespective of any grade) this was recorded as visible. The participants were asked to close their eyes or look in another direction. Both legs were tested.

Patellar reflex was tested with the participant sitting with knees flexed and the legs hanging freely. Alternatively in the supine position with supported knees in the flexed position. The patellar tendon was localised just distal to the patella and a tap was given directly with a reflex hammer. The procedure was repeated 5 times if no contraction (knee extension) was observed. If knee extension was observed (irrespectively of any grade) this was recorded as visible. The participants were asked to close their eyes or look in another direction. Both legs were tested.

Babiniski reflex was tested with the participants in the supine position. The edge of the reflex hammer was used to facilitate the reflex by stroking the sole of the foot. A non-pathological reaction was registered as negative when curling of the toes was observed. If extension of the toes were seen this was recorded as a positive test. Both feet were tested once or more than once if necessary.

2.5.6 Time up and go (TUG)

Walking was assessed using Time Up and Go (Podsiadlo et al 1991), by instructing the participants to rise from a chair (with a seat height of approximately 46 cm), walk three meters, turn, walk back to the chair and sit down again. The test was performed 3 times, where time was recorded the 2nd and 3rd time and the average of these was calculated. The participants were told to use their walking aid, if any, and their regular shoes, and were told to remove heavy clothing before starting the test. In addition to time, surface, heel height and if they had a walking aid was noted. A test procedure was standardised according to Botolfsen et al (2010), Hvidovre Hospital (2002), Kristensen et al (2009), Sletvold (1996). (Appendix 9).

2.5.7 Sensibility

Sensibility was assessed using a sensation roller. The participant was prevented from watching the test, while a light stimulus was given on both legs following the dermatomes, starting at the proximal thigh, moving downwards to the toes. An area of reference on the participants skin was used. The participant was asked if she felt a difference from left to right leg. A standardized dermatome map was used as registration and all sensory deficits were recorded directly. (Appendix 8).

2.5.8 Additional information from hospital records

- What kind of fistula?
- Repaired fistula? Yes/No
- Residual incontinence problems after repair? Yes/No

2.6 Statistics

Power calculation: a total of 101 cases were calculated based on the assumption that incidence of neuromuscular deficits in obstetric fistula patients is 10 %, incidence in controls is 1 %, with the power of 80 % and 95 % CI. Ratio of cases per control is 1. Power calculation is shown below.

N=((z1+z2)^2 x 2p(1-p)/(p1-p2)/(p1-p2)^2)) x (c + 1)/(2c)
N=((1.96+0.84)^2 x 2 0.055 (1-0.055)/ (0.10-0.01)^2)) x (0.10-0.01)^2=100.61
N=100.6 ~101 cases

The graphical and statistical analysis was performed in SPSS (Statistical Package for the Social Sciences) version 16.0. The statistical methods used were independent sample t-test for normally distributed continuous variables, Mann-Whitney U test for not normally distributed continuous data and Chi-square test for independence was used for categorical variables. Two-way between groups ANOVA was used to further assess the relationship between the variables. P-values were 2-tailed and considered statistically significant if < 0.05. A difference was also considered significant if the 95 % CI of the mean did not overlap in the two dataset or did not include the null in the single dataset.

2.6.1 Descriptive statistics

To dataset were made, one for cases and one for controls. Descriptive statistics for categorical values were made using frequencies. The total number of participants (frequencies) and the number of participants and percentages in the different subgroups were looked at separately. For continuous variables, descriptive statistics were used. Mean, median, minimum, maximum and standard deviation (SD) were obtained. 5 % trimmed mean was compared against the original mean, to ensure that extreme scores did not have a strong influence on the mean. 95 % CI of the mean were obtained and considered statistically significant if the intervals in the two groups did not overlap. Further, the descriptive analysis was visually analyzed to check if the continuous data were normally distributed, using histogram and normal Q-Q plot. Kolmogorov-Smirnov statistics was used for the same purpose and considered normally distributed if the result from this statistics was non-significant (>0.05). To test for outliers, box plot was used, and the extreme numbers were recognized by their ID.

In the present study, none of the outliers affected the 5 % trimmed mean, and all data were included in further analyses.

2.6.2 Independent sample t-test

To be able to compare the two groups in relation to the mean score of passive range of motion, independent sample t-test was used, if the distribution of the scores were normal. T-tests were also performed on circumference measurements and characteristics of the fistula cases. Time since labour was not normally distributed, and therefore Mann-Whitney U test was used.

2.6.3 Chi-square test for independence

To compare the groups related to strength, pain and reflexes Chi-square test for independence was used. Chi-square test was also used for primi- and multipara fistula cases. The test makes it possible to compare the frequencies or proportions of scores that fall in the different groups. The test will be presented as a cross tabulation, with strength scores classified to the categories in each variable. In order to meet the assumptions that at least 80 % of the cells should have expected frequencies of 5 or more, the strength scores, ranging from 0-5, were merged into "full strength", representing grade 5, and "less than full strength", representing all scores below grade 5. Self-reported walking difficulties were also analysed using the same statistics. Observer variation was used as control (layer factor) variable. Strength of the association is presented as phi (0.1=small effect, 0.3=medium effect, 0.5=large effect).

2.6.4 Two-way between groups ANOVA

A two-way between groups ANOVA was performed to test if time since labor had an impact on passive hip extension and passive knee extension, most often associated with decreased mobility. Further, post hoc test with Tukey Honestly Significant Difference (HSD) test was performed to see where the mean difference between the two groups was significant. Observer was analysed as a factor to control for differences in measurement performance.

2.7 Ethical clearance

This study was approved by the Regional Committees for Medical and Health Research Ethics (REK-Vest) (appendix 1) and Ethical review board of University of Gondar, Ethiopia (appendix 2). As it turned out, we had to sample cases outside the hospital area through an organization called Intrahealth, and obtain ethical clearance for that as well (appendix 3).

All participants either signed or used fingerprint before voluntary participation in this study (Appendix 4 and 5).

Since we wanted to know the situation of the fistula participants both prior to and after the examination it was hard to give the participants anonymity, but anonymity was implemented for the data set once the data collection was completed and for future analysis and publication of results by substituting names with identification numbers. The names and corresponding identification numbers were stored separately, on an external hard disk (locked), while only the identification numbers were used during the analysis (Research methods knowledge base 2006). The Norwegian regulation requires that the key file to be destroyed within 5 years of the study completion.

3. RESULTS

In this section group characteristics and results of measurements will be presented. However, although skin sensory test was part of the protocol, it was not included in the analyses. During the initial part of the study it turned out that language and cultural differences were major obstacles towards completion within time frames and the skin test was abandoned.
Another test, Time up and go (TUG), was carried out in 7 participants only, and not sufficient for statistical analysis. The reason was that the tests were carried out in various examination rooms, most of them with insufficient space for carrying out this particular test.
Another important change was the fact that the control group could not be recruited from women attending the gynaecology unit as planned. They were too few. The decision was made to recruit participants from other departments of the hospital, which may not be ideal.

3.1 Group characteristics

151 participants were included in the study, 51 cases and 100 controls. Delays in hospital development schedule and time constrains of the MPhil-project were causes for the lacking numbers. Group characteristics are presented with mean, median, SD, minimum, maximum and 95 % CI of the mean for fistula cases in table 1 and controls in table 2.

Table 1: Group characteristics for fistula cases presented with mean, median, SD, minimum, maximum, 95 % CI. N=51

	Mean	**Median**	**SD**	**Min**	**Max**	**95 % CI**
Age (years)	30	27	11.56	15	63	26.79, 33.3
Duration of labour (days)	3	3	1.803	0.1	8	2.28, 3.30*
Weight (kg)†	44.5	43.6	7.29	30.7	64.8	42.4, 46.5*
Height (cm)	150.8	149.5	7.58	132.5	172	148.6, 152.9*
BMI (kg/m^2)†	19	19	2.4	13	25	18.3, 19.69

† N=50

** Significantly different compared with controls*

Table 2: Group characteristics for control group presented with mean, median, SD, minimum, maximum, 95 % CI. N=100

	Mean	Median	SD	Min	Max	95 % CI
Age (years)	32	30	8.08	20	65	30.11, 33.31
Duration of labour (days)	0.5	0.23	0.831	0.1	5	0.348, 0.686*
Weight (kg)	48.7	48.1	8.22	29.8	72.5	47.1, 50.3*
Height (cm)	156.7	156	5.58	140.7	173	155.6, 157.8*
BMI (kg/m^2)	19.31	19	3.26	12	31	18.7, 19.9

** Significantly different compared with controls*

As seen from table 1 and 2, mean age for the women with fistula was 30 years, and for controls 32 years, ranging from 15-63 years and 20-65 years, respectively. Time since labour was not normally distributed and therefore analysed using Man Whitney U to show no difference between the groups (p 0.396). However, the groups were different in mean days of labour, weight and height, but not BMI (Table 1-2).

Table 3: Group characteristics presented for fistula cases and controls for community, place of delivery, mode of delivery, sex of neonate and neonatal outcome using Chi-square test for independent observations presented with frequency, percentage (%) and p-values. Dataset is complete.

	Fistula cases n=51	Control group n=100	P-value
Community			0.643
Rural	50 (98)	95 (95)	
Urban	1 (2)	5 (5)	
Place of delivery			0.001
Hospital	31 (60.8)	30 (30)	
Home	20 (39.2)	70 (70)	
Mode of delivery			0.001
Vaginal	38 (74.5)	95 (95)	
Abdominal	13 (25.5)	5 (5)	
Parity			0.000
Primipara (1)	25 (49)	19 (19)	
Multipara (>1)	26 (51)	81 (81)	

Sex of neonate			0.000
Male	24 (47.1)	53 (53)	
Female	10 (19.6)	46 (46)	
Unknown	17 (33.3)	1 (1)	
Neonatal outcome			0.000
Live birth†	11 (22)	97 (97)	
Stillbirth	39 (78)	3 (3)	

† 2 fistula cases reported early neonatal death; death of a live-born baby within the first seven days of life

Table 3 shows differences between the two groups on place of delivery, mode of delivery, sex of neonate and neonatal outcome. There is still a difference between case and control group if the unknown neonates fall into the male group p= 0.003, but is no different if it falls into the female group p=0.604.

3.1.1 Primi- and multipara fistula cases

Current age for primipara was different from multipara as expected, 24 years versus 35 years, respectively (95 % CI -16.7,-5.2). Age at injuring delivery was also different where primipara were 19 years, versus multipara who were 28 years (95 % CI -12.3,-5.6). The majority of fistulas were vesico-vaginal fistula 86 %, recto-vaginal fistula 6 % and urethro-vaginal fistula 8 %. Of these 12 were examined after fistula surgery, with a mean 12.8 months since the operation, ranging from 1-60 months (5 years). Totally 33 % of the 33 cases from which we have data, complained of residual incontinence of some kind, the same as for the cases we examined post operatively.

Table 4 Mode of delivery and sex of neonate for primi- and multipara fistula cases presented with Chi-square test for independence showing proportion, percentage (%) and p-values. Data is complete

	Primipara n=25	**Multipara n=26**	**P-value**
Mode of delivery			*1.0*
Vaginal	19 (76)	19 (73.1)	
Abdominal	6 (24)	7 (26.9)	

Sex of neonate			*0.025*
Male	16 (64)	8 (30.8)	
Female	5 (20)	5 (19.2)	
Unknown	4 (16)	13 (50)	

Table 4 shows that there was a difference between primipara delivering a male neonate versus the multipara. There was still a difference if the unknown neonates were distributed to the female group p= 0.036, but not if distributed to the male group p=1.0.

3.2 Hypothesis.

Neuromuscular deficits of the lower extremities beyond that of foot-drop are present in women with obstetric fistula.

Table 5. Pain in the legs after birth for cases and controls using Chi-square test for independent data. Presented with frequency and percentage (%). Non-overlapping 95% CI of the means indicate a significant difference. Dataset is complete.

	Fistula cases n=51	**95 %CI**	**Control group n=100**	**95 %CI**
Pain legs				
Yes	10 (19.6)	8.6, 30.6	7 (7)	2, 12
No	41 (80.4)	69.4, 91.4	93 (93)	88, 98

Results of the question whether there was pain in the legs in the period after the index birth are presented in Table 5.

Table 6. Ankle, leg and upper arm circumference measurements presented for fistula cases and controls analysed using Chi-square test for independent groups and presented with mean, SD and 95% CI of the difference. Dataset was complete.

	Fistula cases n=51	Control group n=100	95 %CI
Arm circumference			
Left	25 (2.7)	25.9 (3.6)	-1.9,0.1
Right	25.1 (2.8)	26.3 (3.6)	-2.3,-0.01*
Leg circumference			
Left	27.3 (2.8)	28.3 (3.1)	-2,0.0
Right	27.6 (2.8)	28.5 (2.9)	-1.8,0.1
Ankle circumference			
Left	20.3 (2.5)	19.7 (1.5)	-0.1, 1.3
Right	20.5 (2.5)	19.7 (1.5)	-0.03, 1.5

*Significant

Right upper arm circumference was marginally larger in the control group (Table 6).

Table 7. Self-reported walking difficulties and difficulties with daily activities (ADL) for fistula cases and control group before and after childbirth and at present. Chi-square test for independent observations was used to test differences and the results are presented with frequency, percentage (%) and p-value. Dataset was complete.

	Fistula cases n=51	Control group n=100	P-value
Difficulties walking			
Past	0 (0)	4 (4)	0.362
After delivery	17 (33.3)	0 (0)	0.000
Present	14 (27.5)†	20 (20)††	0.406
Difficulties with ADL*			
Past	1 (2)	3 (3)	1.0
Present	10 (19.6)	22 (22)	0.897

† 4 participants reported that difficulties walking had healed spontaneously

†† Of the 20 controls none were related to the childbirth. 4 of these were past difficulties.

**Difficulties of daily activities involved cooking, cleaning, working, taking care of the family etc, and were registered as yes if the problems were related to walking difficulties.*

Table 7 shows that 1/3 of the fistula cases had difficulties walking after the delivery. 4 fistula cases said that their problems had healed spontaneously, whereas 13 still had problems with walking. In the control group, 16 had developed their problems in resent time and were not related to the delivery, but due to gynaecological and obstetric problems (n=11) and mild weakness of unknown causes (n=9). A fistula case reported the same, which was due to leg pain. Gynaecological and obstetric problems were also the cause for the 4 controls that complained of walking difficulties before the delivery. There was no difference concerning difficulties in ADL between the groups.

Table 8. Passive range of motion presented for fistula cases and control group using independent sample t-test. N, mean of degrees of angle joint excursion and 95 % CI of the difference between cases and controls are shown. Each individual is presented with left and right joint, therefore numbers are 102 in 51 fistula cases and 200 in 100 controls. Mean and median of degrees, SD, minimum, maximum and 95 % CI of the difference are presented in appendix 10.

	N	**Fistula cases**	N	**Control group**	**95 % CI**
Hip					
Medial rotation	102	41.87	200	41.74	-1.5, 1.8
Lateral rotation	102	37.28	197	36.18	-.42, 2.46
Flexion	102	112.20	198	113.17	-3.3, 1.4
Extension #	94	-14.94	137	-12.88	-3.5, -.5*
Abduction	99	29.12	186	23.96	2.8, 7.5*
Adduction	102	23.55	190	24.34	-2.0, .44
Knee					
Flexion	102	147.06	198	153.76	-9.6, -3.8*
Extension #	102	-4.43	198	-7.19	1.5, 4.0*
Ankle					
Dorsalflexion	102	21.70	198	26.35	-6.4, -2.8*
Plantarflexion	102	49.05	198	54.31	-7.4, -3.0*

Hyperextension

* Significant

The results show a difference with increased passive hip extension and hip abduction, and decreased passive knee flexion, knee extension, ankle dorsal flexion and ankle plantar flexion (table 8).

Two-way-between groups ANOVA was performed to see if time since labour was determinant for passive range of motion. Passive knee extension and passive hip extension were set as dependant continuous variables, controlled for observer. Time since labour influenced neither passive hip extension nor passive knee extension (not presented in table).

Table 9. Manual muscle testing presented for fistula cases and control group using Chi-square test for independence with Yates Continuity Correlation. N, frequency, percentage (%) and p-values are shown. Each individual is presented with left and right together, therefore numbers are 102 in 51 fistula cases and 200 in 100 controls. Grades (Grd) were 0-5, 5 signifying full strength and <5 signifying all scores less than full strength.

	Fistula cases			**Control group**			**P-value**
	N	Grd 5	Grd <5	N	Grd 5	Grd <5	
Hip							
Medial rotation	102	40 (39.2)	62 (60.8)	198	66 (33.3)	132 (66.7)	.378
Lateral rotation	102	35 (34.3)	67 (65.7)	198	43 (21.7)	155 (78.3)	.027*
Flexion	102	37 (36.3)	65 (63.7)	200	68 (34)	132 (66)	.791
Extension	84	17 (20.2)	67 (79.8)	113	5 (4.4)	108 (95.6)	.01*
Abduction	102	29 (28.4)	73 (71.6)	198	47 (23.7)	151 (76.3)	.456
Adduction	100	16 (16)	84 (84)	195	31 (15.9)	164 (84.1)	1.0
Knee							
Flexion	102	26 (25.5)	76 (74.5)	196	29 (14.8)	167 (85.2)	.036*
Extension	102	59 (57.8)	43 (42.2)	200	116 (58)	84 (42)	1.0
Ankle							
Dorsalflexion	101	76 (76)	24 (24)	198	167 (84.3)	31 (15.7)	.111
Inversion	100	56 (56)	44 (44)	198	122 (61.6)	76 (38.4)	.419
Eversion	100	63 (63)	37 (37)	198	126 (63.6)	72 (36.4)	1.0
Rising on tip toe	102	42 (82.4)	9 (17.6)	182	80 (87.9)	11 (12.1)	.508

* Significant

There is a difference in strength of hip extension, p=0.001, phi 0.248. Observer variation moderated this finding, p=1.0, phi=0.793. A difference was also found in strength lateral rotation, p=0.027, phi 0.136. Observer variation moderated this finding as well p=0.869, phi 0.741. Knee flexion was also different, p=0.036, phi=0.131. Knee flexion was tested in two different positions: with gravity and against gravity. The same percentage of controls were tested in either position and graded equally, whereas only 8 fistula cases were tested with gravity, 1 of these graded full strength. The same percentage of fistula cases and controls were tested with gravity. The results from this test still came out non different, and could most likely be due to the low power. Observer variation moderated the difference further, p=1.0, phi=0.852. There is a tendency of weaker ankle dorsal flexion and inversion. Ankle measurements were most precise and did not have a big impact on the p-value listed in table 9.

There is no difference between cases and controls concerning reflexes (table 10).

Table 10. Reflexes presented for fistula cases and control group using Chi-square test for independent observations to test differences. Frequency, percentage (%) and p-values are shown.

	Fistula cases n=51	**Control group n=100**	**P-value**
Patella (visible response)			
Left	50 (98)	95 (95)	0.643
Right	48 (94.1)	95 (95)	1.0
Achilles (visible response) †			
Left	48 (94.1)	83 (83.8)	0.125
Right	49 (96.1)	85 (85.9)	0.101
*Babinski (negative) ††**			
Left	51 (100)	96 (99)	1.0
Right	50 (98)	95 (97.9)	1.0

† Achilles left/right n=99
†† Babinski left/right n=97
* Negative=non pathologic

4. DISCUSSION

In this chapter we will present the main findings of the study and relate these to existing literature. We will then discuss details of the results and methods, indicate some recommendations for the future and a conclusion.

4.1 Main findings

Self-reported pain and walking difficulties are common (1/3) in the period following the index childbirth in women with obstetric fistula. At the time of admission for fistula repair (median 3 years) these problems seem largely to have cured spontaneously. Although we did not find drop foot at this stage, 2 women had no passive dorsal ankle flexion and some marginal differences in musculoskeletal performance compared with the control group may indicate adaptive adjustments following the injury of childbirth. The study suggests that some degree of neuromuscular injuries to the lower limb function may exist after the disastrous childbirth but that healing and adaptation improves the condition in the following years leaving the majority with mild or no sequel but with a slightly different pattern of function.

4.2 Significance of the results

Our hypothesis was based on the assumption that neuromuscular deficits of the lower extremities beyond that of foot-drop are present in women with obstetric fistula. Why we were not able to show this in greater clarity may be due to several reasons, one being that such birth related neuromuscular injuries tend to cure spontaneously with time. Existing studies supports this (Katirji et al 2002, Waaldijk et al 1994). A damaged neuron may not have been severed, and the possibility for neuronal recovery is maintained for the following months and years, earliest for the proximal portions of the limb and latest for the ankle and foot function. The fact that we found a tendency of decreased strength in ankle dorsal flexion and inversion could be due to that. In the same vein is the information given by some of the women; their walking ability had recovered. Walking difficulties interfered with ADL equally between the groups but constituted 1/5 of the participants. This could be interpreted that the walking problems were minor since it was not different from the controls. However, it could equally well be the opposite. Patients searching help in the hospital are expected to have problems affecting their daily life. One could therefore say that daily activity in fistula patients was affected at the same level as patients otherwise attending the hospital.

This brings us to another possible reason why neuromuscular problems did not stand out, the composition of the control group. This group was recruited from various wards of the hospital and clearly not the average of the background population. Pain and reduced physical capacity reflected in the tests performed by a physiotherapist would be expected to be present in patients of a hospital (even when the conditions most obviously associated with physical impairments were excluded). Thus the results may very well be biased towards underestimating the disability of women with obstetric fistula.

On the other hand side, there is also a possibility of recall bias as the study group tends to remember more details in relation to the delivery that caused the fistula than those having had a favourable outcome. Another aspect is the limitation in recall, as some cases had their delivery 34 years back, but this would most likely be of little influence.

Our study included a number of tests. The higher the number of questions put forward, the more likely it is that some of them will come out with significant results purely by chance. In this study we used 95% CI or p-value of 0.05, which means a 5 % likelihood of a significant result produced by chance. One possible example would be that we found the study group to be stronger in lateral rotation, hip extension and knee flexion, but with a low effect, possibly by chance, as we were examining several other parameters as well. It appeared that when adding observer variation as a control factor these differences became non-significant. We believe, however, that the latter result may have another explanation. Since we only were controlling for observer variation in the fistula group (one of the observers had not examined members of the control group), makes the statistics somewhat difficult to interpret. Judged from previous repeatability studies we would not expect this much of a variation, and suggest that the non-significant results could be due to decreased power in the subgroup instead of an observer bias (Cuthberth et al 2007, Frese et al 1986, Jain et al 2006).

Knee flexion was also tested in two different positions, with gravity and against gravity. Adding gravity related positions as a factor in the analysis decreased the power in the subgroups, a reasonable explanation of a non-significant finding. By examining muscle groups instead of individual muscles we might think that well functioning muscles would compensate for the loss of others, and leave us with an inability to detect the detailed change in functional profile. However, muscles contributing to knee extension, ankle dorsal flexion and ankle plantar flexion, comes with the greatest diagnostic value (Standring 2008). Ankle dorsal flexion and inversion were also the tests with least variation among testers. Since more fistula cases reported of pain, it would be relevant to suspect that pain could play a significant part in testing of the ankle, interfering with the ability to produce enough force when tested (Cuthbert et al 2007, Rider et al 2010).

We found increased passive hip extension together with passive hip abduction in the study group. The minimum values in hip extension were almost similar in both groups, and the mean difference small, indicating that this would probably be of little clinical relevance. Although the fistula cases had greater passive hip abduction, we could not exclude the possibility that the low values seen in the groups could be due to other factors. A valid suggestion for less abduction in the control group would be cultural aspects. There is a high threshold for a decent woman to spread her legs in the Ethiopian society in general, and this would also be reflected in the situation when being admitted to the hospital for some infirmary other than obstetric or gynaecological and being asked to spread her legs for an examination not related to her disease. The influence of age on passive range of motion is known, but since age was one of the matching criteria in this study, the age related effect was cancelled out (Jevsevar et al 1993, Ostrosky et al 1994, Roach et al 1991). Further, we found less mobility in knee flexion and extension and ankle dorsal and plantar flexion. It is plausible that restricted mobility would follow neuromuscular injuries and be further augmented if the women were not able to move around (Williams 2007). However, we were not able to demonstrate any of this. In the present study the women were able to access the hospital by themselves, representing a relatively healthy group, with that a possible selection bias of having left the most severe cases at home.

Since the changes we describe are rather subtle, there is a risk of not detecting them because of lack of power (we managed to recruit only half of the planned group) and the nature of the background population (patients in the hospital expected to have diseases that might interfere with neuromuscular performance). Never the less, two cases had complete loss of passive dorsal flexion in their ankles, one of them both ankles affected, which would be unusual in the general background population used to physically demanding labour and walking as their main mean of transportation. Controlling for observer in the analysis of passive hip- and knee extension did not alter the results, which was in line with previous studies showing high inter-observer agreement (Brosseau 2000, Elveru et al 1988, Jacobsen et al 2009, Rothstein et al 1983, Watkins et al 1991).

We also found that the fistula patients had a marginally smaller upper arm circumference on the right side (1 cm) (table 6). The statistics is barely significant, hardly of any functional importance, could be significant due to chance, but could also reflect the fact that the fistula patient are smaller than the control group, or a shift in use of her body after the trauma of childbirth. Height and weight came out highly significant as was expected from previous studies in the same population (Muleta el al 2010).

Reflex and skin sensory testing was added to strength the study by giving some information on neural function. Since only a few cases had limitations in ankle dorsal flexion and inversion, most often associated with a diminished Achilles reflex, we would not expect this to come out as a significant finding (Magee 2002, Rico et al 1982). However, it is important to remember that muscle strength and tendon response do not necessary correlate, a normal reflex does not exclude a neurological finding and that a negative response could be due to technique or clinical experience. Unfortunately, we were not able to assess sensory function, due to time constrains and the practical difficulty concerning language and conveying knowledgeable instruction in a limited time. This kind of information could have underscored the role of neural damage in the group (Butler 2000, Reese 1999).

4.3 Results in relation to previous literature

Injury to the common peroneal nerve with drop foot is well known and documented (Arrowsmith et al 1996, Waaldijk et al 1994, Williams 2007). Walking difficulties following fistula formation have also been described earlier (Muleta et al 2008, Muleta et al 2010, Waaldijk et al 1994). It is also known that a longer duration of labour, being young at age and being primipara, being short of height, having a low weight and having a still birth, are characteristics of women with obstetric fistula (Ampofo et al 1990, Berhane et al 1999, Ezegwui 2005, Hilton et al 1998, Muleta el al 2007). Mean age for primipara who developed a fistula was 19.4 years, which is lower than that found by Ezegwui (2005) and Hilton et al (1998), but higher than that reported by Ampofo et al (1990). This suggests a recent rise in first time mothers between 25 and 49 in Ethiopia, and could be a step in the right direction towards reducing the percentage of young first time mothers. However, 17 % of women

between age 15 and 19 still carry their first child (Central Statistical Agency [Ethiopia] and ORC Macro 2006).
In addition, this study shows that a reasonable explanation of an equally low BMI could be that the two groups were equally nutritioned, leaving height to be the primary factor for the development of neuromuscular injuries (Muleta et al 2010). Unlike previous studies have shown, this study will not be able to see a clear relation between delivery of a male versus a female neonate for either case or control, or primipara and multipara fistula cases, due to the huge group of unknown neonates and the variation in statistics (Muleta et al 2010). One possible explanation could be that male neonates tend to predispose for obstructed labour, whereas on the other hand side, it may be biased towards the female neonates, as more male deliveries will be appreciated and remembered. This means that there might be a higher proportion of female neonates in the stillborn group as well. Further, a relatively high hospital rate could be due to the women starting their labour at home, visiting the health institution after several days in labour, when the injury already have occurred (Central Statistical Agency [Ethiopia] and ORC Macro 2006). This means that the injury most likely had occurred irrespective of the mode of the delivery (Hilton 2003).

The highest proportion of the fistulas was vesico-vaginal fistula, the same as reported by Wall et al (2004) and Muleta et al (2010). Residual incontinence was 33.3 %, the same as for the cases we examined post operatively, which corresponds to that of previous published literature on residual incontinence after fistula repair (Browning 2006, Carey et al 2001). It must be taken into consideration that the age distribution in this study group is higher than that of Carey at al (2001), whereas the study by Browning (2006) showed that the women left with stress incontinence were both younger and of lower parity.

4.4 Choice of methods

The methodology is based on a functional assessment in order to detect limitations in joint movement and strength. The methods are easy to administer, cheap, non-invasive, and thought to be an appropriate measurement for this setting. Therefore, it also comes with some limitations in the accuracy of the measurements. We acknowledge that the suggested sensory test was not viable in the present setting of restrained resources and time, and that the test Time up and go (TUG) could not be realised in the premises of the hospital.

Recruitment of participants were done from the hospital area and due to the time factor this was the most convenient sampling procedure, as we were able to access most cases in a short time. To maximize the number of cases, we also included both pre- and postoperative fistula patients, and therefore an additional risk of injuries occurring from the operation rather than the delivery. The recruiting controls from the hospital are most probable not a representative group of the general population, hence making it harder to identify true deficits in the study population.

Anthropometry is a relatively quick, simple, and cheap way of measuring nutritional status. Weight and height measurements are relatively easy to administer, while circumference is a more extensive way, and therefore comes with more potentially errors and require also more training (Ulijaszek et al 1999). The results from Geeta et al (2009) show high intrarater- and interrater reliability for weight, height and waist circumference, in that order. Training and standardisation of measurements were done prior to the study, results were acceptable, and should therefore minimize measurement errors to some extent. Since height and weight were clearly different between the groups, this is also the measurements with the highest reliability.

Manual muscle testing (MMT) is a common way for physiotherapists to examine patients with different neurological and muscular impairments. It is an easy, non-invasive and efficient method to detect gross disturbances in human beings. In addition it is cost effective and easy to administer. Various results exists concerning the reliability of MMT, but higher reliability is reported on testing muscle groups, versus individual muscles, training and following a standardized protocol (Cuthberth et al 2007, Frese et al 1986, Jain et al 2006).

A limitation of MMT is the intervals between the different grades that are not well established, and relies to some extent on a subjective measurement (Domholdt 2000). This scale corresponds to the 10-point scale produced by the same author in 1993, when it was originally validated (Kendall 1993). The 10-point scale is presented with its advantages when processing the statistical analysis, compared to the 5-point scale, but the 10-point scale relies on a great amount of subjectivity when performing the different gradients of the manual resistance applied (Jain et al 2006). Therefore, the 5-point scale is chosen, and will not implement minus or pluses for the same purpose. MMT below grade 4 show good correlation with handheld dynamometer (HHD). However above grade 4 the MMT looses some of its ability to discriminate between gradients of strength, while HHD retains their sensitivity. In the present study the different categories of strength were merged into ”full strength” indicating grade 5 on the scale, and less than ”full strength”, indicating grade 4 and lower on the scale. This was done in order to make the statistics easier, as very few participants fell into scores 3 and 2. Despite MMT being less sensitive to detect differences above grade 4, the results from the present study give a good estimate of the more functional limitations we are interested in.

Passive range of motion is a way to measure joint mobility, and the use of a universal goniometer is by far the most common device, as it is practical, easy and offers to a minimal extent discomfort for the patients (Clarkson 2000). In addition, it requires only minimal training. Passive range of motion (ROM) will give us information about the real limitation, because it doesn’t depend on the ability to independently move the joint, as in active range of motion (Jakobsen 2009). Goniometer measurements show moderate to high intra- and inter-tester reliability for hip, knee and ankle, ICC 0.70- >ICC 0.90, with the lowest ICC for knee extension and plantarflexion of the ankle. (Brosseau 2000, Elveru et al 1988, Jacobsen et al 2009, Rothstein et al 1983, Watkins et al 1991). By adding observer variation as an extra factor in the analysis did not influence the results, meaning differences in testers would not play a significant part.

Reflex testing is a simple procedure and gives the clinician a valuable estimate of the situation, and should be used as a supplement to other neurological observations. Few recent studies are published regarding the reliability of reflex testing, but a considerable variability in inter-observer and intra-observer has been shown. To obtain a reliable result as possible, training of the examiner and position of the patient is crucial, although alternating test positions can be a useful method to elicit reflex responses (Butler 2000, Reese 1999). Further, by strictly recording visible response vs. non-visible response, we made the assessment more crude but minimized measurement errors (Butler 2000, Kendall et al 2005, Magee 2002).

4.5 Future recommendations

A longitudinal study of those fistula patients searching help at an early stage after injury would permit insight in the dynamics of neuromuscular injury and extent of spontaneous cure with time, which would be important in planning and supporting treatment and reintegration into normal life. A study including a control group recruited from a background population that more truly matches the fistula patient would enable a more differential profiling of the neuromuscular condition of fistula patients.

4.6 Conclusion

In spite of an incomplete recruitment to the study, it has indicated that pain and walking disabilities is a very common problem in the early phase of the disease and that there seams to be a considerable natural cure rate with time. There are indications, however, that the profile of the musculoskeletal function is slightly shifted according to compensatory mechanisms and adaptation. We believe that the data will give a more detailed picture when the recruitment eventually is completed, and if the study is reiterated with a more appropriate control group matching the background of the fistula patient.

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6. Appendix

Appendix 1.

Ethical clearance REK, Norway

UNIVERSITY OF BERGEN
Regional Committee for Medical and Health Research Ethics, Western-Norway

To whom it may concern

Your ref	Our ref	Date
	2010/503	20.04.10

Confirmation;

We hereby confirm that the project "Neuromuscular damage in women with obstetric fistula." by project leader Torvid Kiserud, Centre for International Health, University of Bergen, is reviewed and recommended/approved by the Regional Committee for Medical and Health Research Ethics, Western-Norway.

Best regards

Øyvind Straume
Higher Executive Officer

This letter is approved for electronic dispatch without signature.

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Org no. 874 789 542

Regional komité for medisinsk forskningsetikk, Vest-Norge
Telefon 55 97 84 97 / 98 / 99

Besøksadresse
Haukeland
Universitetssykehus

Appendix 2.

Ethical clearance Gonder University, Ethiopia

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University of Gondar
Research & Community Service
Process

Ref.No RCS/05/540/2010
Date 21/09/2010

To: Dr. Mulu Muleta
CMHS

Subject: **Ethical Clearance**

Your research project proposal titled ***"Neuromuscular Damage in Women with Obstetric Fistula."*** has been reviewed by the Institutional Ethical Review Board of University of Gondar for its ethical soundness, and it is found to be ethically acceptable.

Thus, the Research and Community Service Core Process Office has awarded this ethical clearance for the above stated study to be carried out by, **Dr. Mulu Muleta** as a principal investigator and **Professor Torvid Kiserud** as Co-investigator as of September 20,2010 for one year.

The investigators are expected to submit their research progress report to the Research and Community Service core Process Office of the University of Gondar. I would like to remind you that you need to have annual review of the project.

With best regards

Shitaye Alemu (Dr)
Chairperson, Institutional Ethical Review Board

የፖ.ሣቁ	ቴሌግራም ጤ.ኮ		ስልክ
P.O. Box 196	Cable A.A.U. PH.	Telephone PBX	058111 01 74
ጎንደር ኢትዮጵያ	Fax - 251-058-114 1240	President office	058 114 1231
Gondar, Ethiopia	058 114 1233	V/P/for A/ & Research	058 114 1236
	058 114 1235	Research & Community Service	058 231 1130
URL Addres:- www.uog.edu.et		Email rcs@uog.edu.et	

መልስ ሲጽፉልን የእኛን ቁጥር ይጥቀሱ
In Replying please Quote our Ref. No

Appendix 3.

Ethical clearance Intrahealth

010 04:57 FAX GONDAR CMHS

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Gondar University Hospital
Gondar, Ethiopia

Ref Gyn [illegible] /2002

September 24/2010

To IHI-E
Bahir Dar

Subject: Patient access for research on neurological problems on fistula patients as a result of obstructed labor.

Student Merete Kolberg has got ethical clearance to conduct her research on fistula patients in our hospital department of Gynecology and obstetrics. But due to limited number of cases she could not complete the research, so if your kind office can help her to access your fistula patients for possible additional cases so that she can complete her research.

With best regards

Dr. Birhanu Sendek
Head Department of OBGYN
University of Gondar CMHS

To all Fistula PRU Mentor!
Please Cooperate them
28/09/.10

ፖ.ሣ.ቁ.
P.O.Box 196
ጎንደር ኢትዮጵያ
Gondar, Ethiopia

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Dean's office 11 02 43
Hospital Director 11 06 94
Directro General Hos. Ser.110331

መልስ ሲጽፉ የእኛን አድራሻ ይጥቀሱ::
In Replying, Please Quote our Ref. No

Attention to
- Annex

Appendix 4.

Consent form cases

Participant's information
Good Morning/ Afternoon!

My name is-------------------------. I am working for Gondar University Hospital. Gondar University Hospital has recently started treating patients who have been through difficult labour and suffering from gait abnormalities and failed to control urine and or feces. This injury to the bladder and or rectum as a result of difficult labour is referred to as obstetric fistula.

Obstetric fistula is a distressing injury resulting from lack of proper delivery service during difficult labor. Most women give birth in one day, but few other women will have long labor which some times take even a week. This is either because the baby is big or the mother's pelvis is narrow to allow the baby to pass through. This mismatch results in failure of advancement of the labour (obstructed labour), during which time the bladder and or rectal tissue is squashed between fetal head and mothers bony pelvis. This results in cease of blood supply to the tissues compressed, which eventually falls off leaving a defect (a hole) to the affected organ which is often the bladder and sometimes is the rectum. The injury is sometimes extensive and the surrounding soft tissues, smooth and skeletal muscles and nerve tissues so squashed are disturbed affecting the gait of the women. Babies are also suffocated during such difficult births and often born dead.

If the encountered defect is to the bladder, failure to control the urine is a symptom and if the rectum is involved faecal incontinence may occur. If both are affected, one might be incontinent to both urine and feces.

Continuous leakage of urine/feces might irritate the skin resulting in skin rashes. This lesion might get worse among women confined to bed. Confinement to bed might also worsen the status of muscles/nerves and joints (i.e. weakness of unused muscles and contractures of unused joints).

Provided women are taken to nearby hospital on time during difficult labour, they could have been rescued and had healthy baby. However, this is a problem through out poor countries where hospitals are far from where people live and transportation to a hospital is a problem.

This injury is not a curse, evil spirit or sign of failure in giving birth. It is treatable and can also be prevented from occurring.

Although the mentioned information is known to us, the type and extent of nerve and muscle injury to women with fistula is unknown.
Measuring the type and extent of the problem, (compared to women without obstetric fistula) will help us to plan for appropriate health interventions. To strengthen the Gonder fistula care center and integrate neuromuscular care service to fistula care and to expand the service to other regions, we have to know the extent and type of the problem among women with fistula. This is why we are inviting you to participate in this study.

If you agree to take part in this study, I will ask you certain questions and make some nerve and muscle function tests important for our study. The examinations are done privately and you might be asked to undress but not the underwear. If you have no underwear a onetime use paper underwear will be provided to you. There is no painful procedure far from mild knocking below the patella to check for certain reflexes. Your participation is voluntary. You can refuse to participate at any point or selectively refuse to answer certain questions you don't want to. Refusal to participate in the study involves no loss of benefit. If you have injury to your bladder, rectum and have some walking difficulties/or nerve/muscle damage, Gondar fistula center provides you a treatment for free. None of this benefit will be lost by your refusal to participate in the study.
If you have any question or something you don't understand, please ask me and I will explain.

Consent

I am told that the purpose of the study is to identify the neuromuscular pelvic injuries from obstructed labor. The information has been read to me. I have been given opportunity to ask questions and I am satisfied with the clarification. I consent voluntarily to participate in the study and I have the right to withdraw from the study at any time without in any way affecting any benefit of medical care at Gondar fistula center.

Name of participant________________________

Signature of participant_______________________

Date______________________________________

Name of interviewer/examiner__________________________________

Appendix 5.

Consent form controls

Participant's information

Good Morning/ Afternoon!

My name is-------------------------. I am working for Gondar University Hospital. Gondar University Hospital has recently started treating patients who have been through difficult labour and suffering from gait abnormalities and failed to control urine and or feces. This injury to the bladder and or rectum as a result of difficult labour is referred to as obstetric fistula.

Obstetric fistula is a distressing injury resulting from lack of proper delivery service during difficult labor. Most women give birth in one day, but few other women will have long labor which some times take even a week. This is either because the baby is big or the mother's pelvis is narrow to allow the baby to pass through. This mismatch results in failure of advancement of the labour (obstructed labour), during which time the bladder and or rectal tissue is squashed between fetal head and mothers bony pelvis. This results in cease of blood supply to the tissues compressed, which eventually falls off leaving a defect (a hole) to the affected organ which is often the bladder and sometimes is the rectum. The injury is sometimes extensive and the surrounding soft tissues, smooth and skeletal muscles and nerve tissues so squashed are disturbed affecting the gait of the women. Babies are also suffocated during such difficult births and often born dead.

If the encountered defect is to the bladder, failure to control the urine is a symptom and if the rectum is involved faecal incontinence may occur. If both are affected, one might be incontinent to both urine and feces.

Continuous leakage of urine/feces might irritate the skin resulting in skin rashes. This lesion might get worse among women confined to bed. Confinement to bed might also worsen the status of muscles/nerves and joints (i.e. weakness of unused muscles and contractures of unused joints).

Provided women are taken to nearby hospital on time during difficult labour, they could have been rescued and had healthy baby. However, this is a problem through out poor countries where hospitals are far from where people live and transportation to a hospital is a problem.

This injury is not a curse, evil spirit or sign of failure in giving birth. It is treatable and can also be prevented from occurring.

Although the mentioned information is known to us, the type and extent of nerve and muscle injury to women with fistula is unknown.
Measuring the type and extent of the problem, (compared to women without obstetric fistula) will help us to plan for appropriate health interventions. To strengthen the Gonder fistula care center and integrate neuromuscular care service to fistula care and to expand the service to other regions, we have to know the extent and type of the problem among women with fistula. We are inviting you to participate in this study to be able to compare women without fistula to woman suffering from this condition.

If you agree to take part in this study, I will ask you certain questions and make some nerve and muscle function tests important for our study. The examinations are done privately and you might be asked to undress but not the underwear. If you have no underwear a onetime use paper underwear will be provided to you. There is no painful procedure far from mild knocking below the patella to check for certain reflexes. Your participation is voluntary. You can refuse to participate at any point or selectively refuse to answer certain questions you don’t want to. Refusal to participate in the study involves no loss of benefit. If you have injury to your bladder, rectum and have some walking difficulties/or nerve/muscle damage, Gondar fistula center provides you a treatment for free. None of this benefit will be lost by your refusal to participate in the study.
If you have any question or something you don’t understand, please ask me and I will explain.

Consent

I am told that the purpose of the study is to identify the neuromuscular pelvic injuries from obstructed labor. The information has been read to me. I have been given opportunity to ask questions and I am satisfied with the clarification. I consent voluntarily to participate in the study and I have the right to withdraw from the study at any time without in any way affecting any benefit of medical care at Gondar fistula center.

Name of participant________________________

Signature of participant_______________________

Date______________________________________

Name of interviewer/examiner___________________________________

Appendix 6.

Clinical examination procedure, correct order of measurements

All measurements will be taken on both legs and registered in accordance with the test procedures described. Other positions than listed is reported. In case of limitations of movement the manual muscle, testing can be done in the neutral position, but this should be noted. The test person is asked to remove heavy clothing and shoes for all examinations, and is allowed using flexible and light clothing during the examination.
Pain will be noted. Participants will be provided with onetime use underwear.

Standing:

Height:
The participant is standing against a wall, wearing no shoes. The examiner makes sure the correct position with both heels against the wall, extended knees, calf, buttock and shoulder toughing the wall and the back of the head against the wall. The participant is asked to make a small nodding movement of the head and keep the position while measuring the height with a non-stretch tape measure in a 90 degrees angle at the top of the head to the wall. The measurement is recorded to the nearest 0.1 cm.

Rising on tiptoe:
Nerve innervation: Gastrocnemius: Tibial, S1, S2 (Standring S, 2008)
The participant is standing on both feet, slightly resting the palms of the hands in the examiners hands. The participant is asked to rise on tiptoe and repeat it 10 times. The test is performed with extended knees and the body kept in a straight, upright position. Resistance is the persons body weight. If the participant is able to repeat the test 10 times this indicates grade 5.
If the participant is able to perform 10 times, but needs extra support it indicates grade 4.
5-10 times indicates grade 4
0-5 times indicates grade 3
0 times indicates grade 2

Figure 12. Strength ankle plantar flexion. Showing correct position and stabilisation. Used with permission.

Weight:
The participant is asked to remove heavy clothing and shoes. The weight will be measured twice, using the highest weight, on a digital weigth scale. The weight scale is on an even surface, time of day will be noted. The measurement is recorded to the nearest 0.1 cm. The weight scale will be checked for consistency twice a week.

Sitting:

Test position for passive medial and lateral rotation, strenght medial and lateral rotation, knee extention and hip flexion. The participant is sitting with one leg fixated manually or with a strap over the distal end of the femur. The leg is in 90 degrees flexion, 0 degrees abduction and 0 degrees adduction. The participant is sitting upright. The other leg is abducted, not to interfere with the movement of the test leg. The distal end of the patella and the tibial crest will be marked with a line.
Passive medial and lateral rotation, strenght medial and lateral rotation and strenght knee extention is performed at one leg before changing. Strenght hip flexion is done last with no fixation.

Hip:
Passive medial rotation
Test procedure: The measuring arm of the goniometer is positioned to the patients leg using the tibial crest as reference, the center of the goniometer is at the distal patella. The other goniometer arm is hanging freely downwards with a weight attached to it. The distal femur is stabilized with the examiners left hand, while the right hand is at the distal leg, moving it laterally. End of movement is when resistance is felt or tilting of the pelvis or lateral flexion of the trunk is seen. The joint is measured twice, registering the highest value to the closest 1degree, reading at the black numbers at the top right of 180 degrees.
Pain is noted.

Figure 13.Passive hip medial rotation. Showing correct position of goniometer in full passive medial rotation without fixation and attached weight. Used with permission.

Passive lateral rotation

Test procedure: The measuring arm of the goniometer is positioned at the leg using the tibial crest as reference, the center of the goniometer is at the distal patella. The other goniometer arm is hanging freely poining down with a weight attached to it. The distal femur is stabilized with the examiners right hand, while the left hand is at the distal tibia moving it medially. End of movement is when resistance is felt or tilting of the pelvis or lateral flexion of the trunk is seen. The joint is measured twice, registering the highest value to the closest 1degree, reading the black numbers at the top left of 180 degrees.
Pain is noted.

Figure 14. Passive hip lateral rotation. Showing correct position of goniometer in full passive lateral rotation without fixation and attached weight.Used with permission.

<u>Strenght hip medial rotation</u>
Nerve innervation: Tensor fascia latae, gluteus minimus and medius (anterior fibres), iliacus: Femoral nerve (L2), Superior Gluteal nerve (L4,L5) (Standring S, 2008)
Test position: Sitting with one knee over the edge of the table and holdning on to the table. The hip is kept in full medial rotation. The examiner gives counterpressure medially at the lower end of the thigh, while simultaneously applies pressure lateral at the leg above the ankle in an attempt to push the hip into lateral rotation. The participant is instructed to push the leg outward. If the test position is held against max resistance this indicates grade 5.
Holding the test position against moderate resistance indicates grade 4.
Holding the test position with no resistance indicates grade 3.
Not being able to hold the test position indicates grade 2.
Tendon becomes prominent or feeble contraction felt in the muscle with no visible movement indicates grade 1.
No contraction felt or seen in the muscle indicates grade 0.
If pain prevents the participant to contract this is noted.

Figure 15. strenght hip medial rotation. Showing correct position of resistance and stabilisation. Used with permission.

<u>Strenght hip lateral rotation</u>
Nerve innervation: Piriformis, Quadratus femoris, Obturator internus, gemellus superior/inferior: Lumbosacral plexus, L5, S1. Obturator externus: Obturator, L3, L4. Sartorius: Femoral nerve L2, L3. (Standring S, 2008)
Test position: Sitting with one knee over the edge of the table and holdning on to the table. The hip is kept in full lateral rotation. The examiner gives counterpressure laterally at the lower end of the thigh, while simultaneously applying pressure medial at the leg above the ankle in an attempt to push the hip into medial rotation. The test person is instructed to push the leg inward. If the test position is held against max resistance this indicates grade 5.
Holding the test position against moderate resistance indicates grade 4.
Holding the test position with no resistance indicates grade 3.
Not being able to hold the test position indicates grade 2.
Tendon becomes prominent or feeble contraction felt in the muscle with no visible movement indicates grade 1.
No contraction felt or seen in the muscle indicates grade 0.
If pain prevents the participant to contract this is noted.

Figure 16. strenght hip lateral rotation. Showing correct position of resistance and stabilisation. Used with permission.

<u>Strenght knee extention:</u>
Nerve innervation: Quadriceps: femoral, L2, L3, L4 (Standring S, 2008)

Test position: Sitting with one knee over the edge of the table and holdning on to the table. The examiner holds the thigh down just proximal to the knee. Resistance is given to the leg just above the ankel in the direction of flexion. The test person tries to extend the knee.
If the test person is able to extend the knee with resistance, the test is performed with almost full extention and max resistance is given at the end of motion, this indicates grade 5.
Holding the test position against moderate resistance indicates grade 4.
Holding the test position with no resistance indicates grade 3.
Not being able to hold the test position indicates grade 2.
Tendon becomes prominent or feeble contraction felt in the muscle with no visible movement indicates grade 1.
No contraction felt or seen in the muscle indicates grade 0.
If pain prevents the participant to contract this is noted.

Figure 17. strenght knee extention. Showing correct position of resistance and fixation. Used with permission

Strength hip flexion

Nerve innervation: Iliopsoas: Lumbar, L1, L2, L3. Iliacus, pectineus, rectus femoris, sartorius: Femoral nerve L2, L3, L4. Adductor longus: obturator nerve L2, L3, L4. (Standring S, 2008)
Test position: Sitting with knees over the edge of the table and holdning on to the table. (no fixation strap) (alternative position is supine) Pressure is given at the thigh, just proximal to the knee in the direction of extention. The participant tries to flex the hip by lifting the thigh a few inches from the table. If the fully flexed hip can be held against max resistance this indicates grade 5.
Holding the test position against moderate resistance indicates grade 4.
Holding the test position with no resistance indicates grade 3.
Not being able to hold the test position indicates grade 2.
Tendon becomes prominent or feeble contraction felt in the muscle with no visible movement indicates grade 1.
No contraction felt or seen in the muscle indicates grade 0.
If pain prevents the participant to contract this is noted.

Picture 18 strenght hip flexion. Showing correct position of resistance and stabilisation. Used with permission.

Reflex:

Patellar: Femoral nerve L2-L4 (Magee 2002)

The participant is sitting with knees flexed and and the legs swinging freely. The patellar tendon is localised just distal to the patella and a tap is given directly with a reflex hammer. (alternative position supine with slightly flexed knees). The procedure is repeated about 5 times if no contraction (knee extention) is observed. If knee extention is observed (irrespectively of any grade) this is indicated as ”normal”. The participant will be asked to close her eyes or look in another direction.

Circumference measurement:

Upper arm:

The participant is sitting upright, and is asked to remove clothes covering the upper arm. The examiner uses a nonstretch tape measure just below the axilla, in a horizontal direction around the arm. The examiner should not tighten the tape measure but register the point where the tape measurement ends meet. The measurement is recorded to the nearest 0.1 cm.

Leg:

The participant is sitting with the knees flexed, and asked to remove clothes covering the knee and leg. The most distal point of the patella is marked with a pen. 15 cm below is measured with a non stretch tape measure and marked with a pen. The circumference of the calf is measured at this distal point. The examiner should not tighten the tape measure but register the point where the tape measurement ends meet. The measurement is recorded to the nearest 0.1 cm.

Ankle:

The participant is sitting with knees flexed, and is asked to remove clothes covering the ankle. The examiner localises the medial and lateral malleoli and measures the circumference just proximal to these marks. The examiner should not tighten the tape measure but register the point where the tape measurement ends meet. The measurement is recorded to the nearest 0.1 cm.

Supine:
The most prominent part of the trocanter major, lateral epicondyle of the femur, head of fibula and lateral malleoli is marked using a pen. Trocanter major is first marked with both legs straight and again localised when the hip is flexed, showing a distal gliding of the trocanter major, this is the point of reference for hip flexion.

Hip:
Passive flexion
Test position: the participant is placed in the supine position, with knees extended and both hips in 0 degrees of abduction, adduction and rotation.
A fixation belt is used to stabilize the pelvis to the table and is placed just below the sias. Stabilize the pelvis with one hand and leave the other leg flat on the table to provide additional stability. Flex the hip, with knee flexion, while keeping the hip in neutral adduction, abduction and rotation. When testing the left hip, the right hand is under the patients lumbar spine/pelvis, feeling the movement of the pelvis, and the left hand performs the movement of the hip. When testing the right hip, the left hand is under the patients lumbar spine/pelvis, feeling the movement of the pelvis, and the right hand performs the movement of the hip. The end of ROM occurs when resistance is felt and posterior tilting of the pelvis is felt under the lumbar spine as it attemps to flatten. This position is held by the assistant/participant.
The examiner places the goniometer with the center at the greater trochanter, with the proximal (unnumerated) arm with the lateral midline of the pelvis and the distal arm (numerated) with the lateral midline of the femur using the lateral epicondyle of the knee as the reference point. The joint is measured twice, registering the highest value to the closest 1degree, reading the black numbers at the bottom left or right of 90 degrees.
Pain is noted.

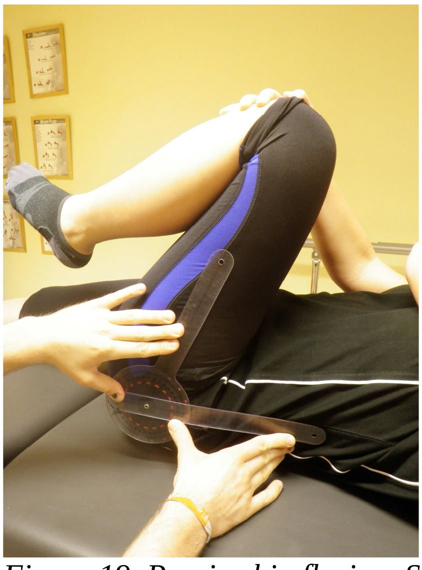


Figure 19. Passive hip flexion. Showing correct position of goniometer without fixation for better visualization in the end movement. Used with permission.

Left abduction, right adduction. The participant is asked to slide towards her right side of the examination table. Right abduction, left adduction. The participant is asked to slide towards her left side of the examination table.

Passive abduction:
Test position: The knees extended and the hips in 0 degrees of abduction, adduction and rotation. A fixation belt is used to stabilize the pelvis to the table and is placed just below the sias. The participant will hold the center of the goniometer over the SIAS of the test leg, in an 90 degrees angle to the hip joint, the unnumerated goniometer arm pointing horizontally towards the SIAS on the opposite leg. The distal arm (numerated) is placed with the midline of the patella as the reference point, not the femur. Abduct the hip by sliding the hip laterally, with no additional movements of the hip. The end of movement is when resistance is felt or lateral tilting of the pelvis, pelvic rotation or lateral flexion of the trunk is seen. This position is held by the examiner while simontaneously doing the measurement. The joint is measured twice, registering the highest value to the closest 1degree, reading the red numbers at the bottom left of 0 degrees, indicating starting position as 0 degrees.
Pain is noted.

Figure 20. passive hip abduction. Showing correct position of goniometer and fixation in the end movement. Used with permission.

Passive adduction
Test position: The knees extended and the hips in 0 degrees of abduction, adduction and rotation. A fixation belt is used to stabilize the pelvis to the table and is placed just below the sias. The participant will hold the center of the goniometer over the SIAS of the test leg, in an 90 degrees angle to the hip joint, the unnumerated goniometer arm pointing horizontally towards the SIAS on the opposite leg. The distal arm (numerated) is placed with the midline of the patella as the reference point, not the femur. Abduct the contralateral leg to allow enough space to complete the movement, but make sure the goniometer arm points horizontally. Adduct the hip by sliding it medially towards the contralateral leg. One hand is at the knee to move the extremity into adduction and to maintain the hip in neutral flexion and rotation. The end of movement is when resistance is felt or lateral tilting of the pelvis, pelvic rotation or lateral flexion of the trunk is seen. This position is held by the examiner while simultaneously doing the measurement. The joint is measured twice, registering the highest value to the closest 1degree, reading the red numbers at the bottom left/right of 0 degrees, indicating starting position as 0 degrees..
Pain is noted.

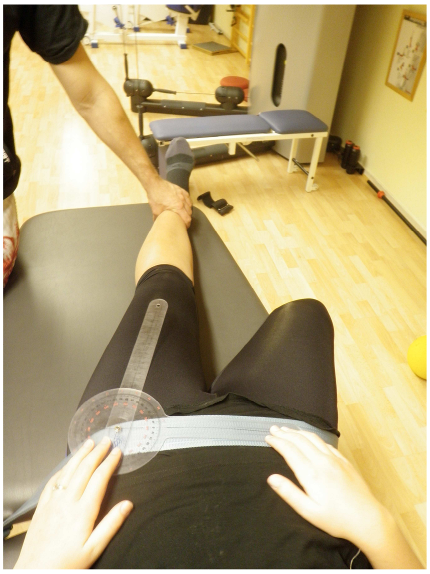


Figure 21. passive hip adduction. Showing correct position of goniometer and fixation in the end movement. Used with permission.

Knee:

Knee flexion and extention is performed at one leg at the time.

Passive flexion

Test position: The participant is supine with hips in 0 degrees abduction, adduction and rotation and knee extended. The most prominent parts of the throchanter major, caput fibula, lateral epicondyle and lateral malleol is palpated. The participant moves the heel as close to the buttocks as possible. The examiner performs the last part of the movement. End of movement is when resistance is felt or when further knee flexion is not possible, or an attempt to movement of the hip is seen. The assistant will support this position. The goniometer is placed with the center over the lateral epicondyle of the femur, with the numerated proximal arm in midline with the femur using the greater trochanter as reference. The distal arm (unnumerated) is at the midline of the fibula, using the lateral malleol and head of fibula as reference. The joint is measured twice, registering the highest value to the closest 1degree, reading the black numbers at the top left of 180 degrees.

Pain is noted.

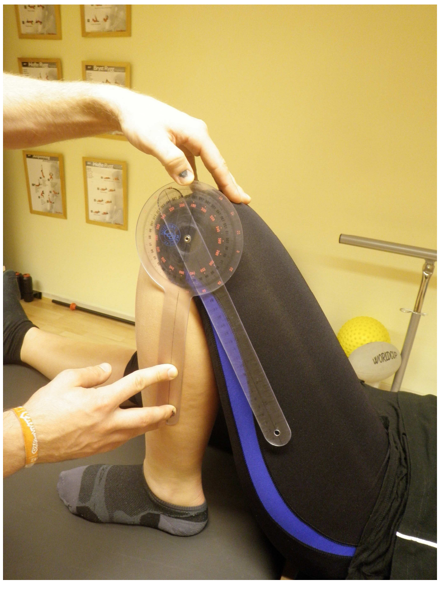


Figure 22.passive knee flexion. Showing correct position of goniometer in the end movement. Used with permission.

Passive extention

Test position: The participant is supine with hips in 0 degrees abduction, adduction and rotation. The knee is extended using a firm roll under the ankle, allowing space under the knee. A fixation belt is used to stabilize the femur to the table and is placed at the mid thigh. The most prominent parts of the throchanter major, caput fibula, lateral epicondyle and lateral malleol is palpated and marked. The knee joint is pushed into full extention with the hands of the examiner just below and above the patella. The assistant will support this position. End of movement is when resistance is felt or the patient says stop. The goniometer is placed with the center over the lateral epicondyle of the femur, with the numerated proximal arm in midline with the femur using the greater trochanter as reference. The distal arm (unnumerated) is at the midline of the fibula, using the lateral malleol and head of fibula as reference. The joint is measured twice, registering the highest value to the closest 1degree, reading the black numbers at the distal arm of the goniometer right (extention deficit) or left (hyperextention) of 0 degrees, indicating 0 degrees as the starting position.
Pain is noted.

Figure 23. Passive knee extention. Showing correct position of goniometer in the end movement. Used with permission.

Ankle:

Test position: Supine with the hips in 0 degrees external rotation and adduction. A fixation strap is just proximal to the knee to prevent knee flexion A firm roll under the test knee providing at least 30 degrees of flexion. The foot to be tested is hanging freely over the edge of the table. The ankle joint is in neutral position in relation to inversion and eversion. The caput fibula is marked. Dorsalflexion and plantar flexion is done at one leg at the time. When testing the right foot, the right hand is around the leg and the left hand around the foot. When testing the left foot, the left hand is around the leg and the right hand around the foot.

Passive dorsalflexion

Test procedure: the center of the goniometer is over the lateral malleol of the ankle. The unnumerated proximal arm following the midline of the crus and towards the head of fibula. The distal arm (numerated) in a 90 degrees angle to the proximal arm. The participant dorsiflexes the ankle as much as possible, and the examiner guides the movement to secure correct alignment. The end of the movement is done by the examiner, using one hand around the lower leg and the other hand giving a manual pressure under the foot. No pressure is put

on the lateral edge of the ankle or the toes. End of movement is when resistance is felt or the participant says stop. For stabilization one hand is around the lower leg and the goniometers proximal arm, while the other arm holds the foot and the distal arm of the goniometer, parallell to the 5th metartars. When full dorsiflexion is obtained, the position is held and measurement is taken. The joint is measured twice, registering the highest value to the closest 1degree.
The starting position for measuring dorsiflexion is when the goniometer is at 90 degrees, this is recorded as 0 degrees, reading the red numbers to the top right of 0 degrees. Pain is noted.

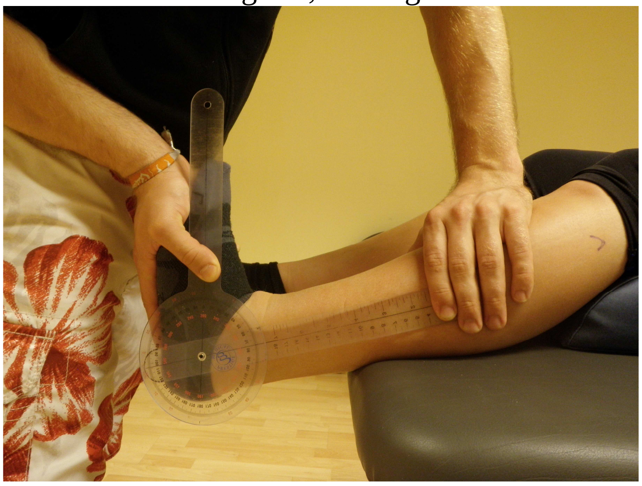


Figure 24. Passive ankle dorsal flexion. Showing correct position of goniometer in the end movement. Used with permission.

<u>Passive plantarflexion</u>

Test procedure: the center of the goniometer is over the lateral malleol of the ankle. The unnumerated proximal arm following the midline of the crus and towards the head of fibula. The distal arm (numerated) in a 90 degrees angle to the proximal arm. The participant plantarflexes the ankle as much as possible, and the examiner guides the movement to secure correct alignment. The end of the movement is done by the examiner, using one hand around the crus and the other hand giving a manual pressure over the foot. No pressure is put on the lateral edge of the ankle or the toes. End of movement is when resistance is felt or patient says stop. For stabilization one hand is around the lower leg and the goniometers proximal arm, while the other arm holds the foot and the distal arm of the goniometer, parallell to the 5th metatars. When full plantarflexion is obtained, the position is held and measurement is taken. The joint is measured twice, registering the highest value to the closest 1degree.
The starting position for measuring dorsiflexion is when the goniometer is at 90 degrees, this is recorded as 0 degrees, reading the red numbers to the top left of 0 degrees.
Pain is noted.

Figure 25. Passive ankle plantar flexion. Showing correct position of goniometer in the end movement. Used with permission.

<u>Strenght ankle dorsalflexion</u>
Nerve innervation: Extensor digitorum longus, extensor hallucis longus, peroneal tertius, Tibialis Anterior: deep peroneal nerve, L4, L5, S1. (Standring 2008)
Test position: Participant is supine with knee flexed in 30 degrees. The participant is asked to dorsiflex the ankle. (toes towards the nose). The examiner stands at the distal end and gives resistance to the foot with the right hand, while stabilising the leg above the knee. Resistance is given in the direction of plantar flexion. If the dorsiflexed position is held against maximal resistance this indicates grade 5.
Holding the test position against moderate resistance indicates grade 4.
Holding the test position with no resistance indicates grade 3.
Not being able to hold the test position indicates grade 2.
Tendon becomes prominent or feeble contraction felt in the muscle with no visible movement indicates grade 1.
No contraction felt or seen in the muscle indicates grade 0.
If pain prevents the participant to contract this is noted.

Figure 26. Strenght ankle dorsal flexion. Showing correct position of resistance and stabilisation. Used with permission.

<u>Strenght ankle inversion:</u>
Nerve innervation: Tibialis anterior: Deep peroneal, L4, L5. Tibialis posterior: tibial nerve: L4, L5. (Standring 2008)

Test position: Particiant is supine with knee flexed in 30 degrees. The participant is asked make an inverted position and is told to move the ankle in, towards the other leg. The examiner is at the lateral end of the leg to be examined, giving resistance with the left hand on the medial side. Resistance is given in the direction of evertion, while simontaneously stabilixing the leg above the knee. If the inverted position is held against maximal resistance this indicates grade 5.
Holding the test position against moderate resistance indicates grade 4.
Holding the test position with no resistance indicates grade 3.
Not being able to hold the test position indicates grade 2.
Tendon becomes prominent or feeble contraction felt in the muscle with no visible movement indicates grade 1.
No contraction felt or seen in the muscle indicates grade 0.
If pain prevents the participant to contract this is noted.

Figure 27. Strenght ankle inversion. Showing correct position of resistance and stabilisation. Used with permission

Strenght ankle eversion

Nerve innervation: Peroneus tertius: deep peroneal nerve L5, S1. Peroneus longus and brevis: Superficial nerve peroneal L5, S1. (Standring 2008)
Test position: Test participant is supine with knee flexed in 30 degrees. The participant is asked to make an everted position and is told to move the ankle out, away from the other leg. The examiner is at the medial side of the leg to be examined, with one hand on the lateral side giving resistance and the other hand stabilising the leg above the knee. Resistance is given in the direction of inversion. If the everted position is held against maximal resistance this indicates grade 5.
Holding the test position against moderate resistance indicates grade 4.
Holding the test position with no resistance indicates grade 3.
Not being able to hold the test position indicates grade 2.
Tendon becomes prominent or feeble contraction felt in the muscle with no visible movement indicates grade 1.
No contraction felt or seen in the muscle indicates grade 0.
If pain prevents the participant to contract this is noted.

Figure 28.Strenght ankle eversion. Showing correct position of resistance and stabilisation. Used with permission

Babinski:
The edge of the reflex hammer is used to fascilitate the reflex by stroking the patients sole of the foot. A normal reaction is noted when curling of the toes is observed, meaning no central nerve damage. If extension of the toes is seen this is reported. Both feet are testet once and the reflex should be visible by the examiner. The reflex can be tested more than once if necessary.

Sensibility:
Sensibility was assessed using a sensation roller. The participant was prevented from watching the test, while a light stimuli was given on both legs following the dermatomes. The participant was asked if she felt a difference from left to right leg. A standardized dermatome map was used to set the marks directly and is attached in appendix 7.

Side lying, patient needs to turn from one side to the other:
Hip:
Strenght hip abduction
Nerve innervation: Gluteus medius, minimus, tensor fascia latae: Superior gluteal, L4, L5, S1. Piriformis: lumbosacral plexus: L5, S1, S2. (Standring 2008)
Test position: sidelying with underneath leg flexed at the hip and knee and the pelvis rotated slightly anteriorly to place the glut med in an antigravity position. Alternative position supine. The examiner is standing at the back of the participant with one hand stabilizing the pelvis and the other hand giving resistance. The leg is held in abduction, slight extension and slight internal rotation to decrease the influence of the hip flexors. The knee is in extension. Resistance is given near the ankle in the direction of adduction and slight flexion, not against the rotation component. If the test position is held against max resistance this indicates grade 5.
Holding the test position against moderate resistance indicates grade 4.
Holding the test position with no resistance indicates grade 3.
Not being able to hold the test position indicates grade 2.
Tendon becomes prominent or feeble contraction felt in the muscle with no visible movement indicates grade 1.
No contraction felt or seen in the muscle indicates grade 0.
If pain prevents the participant to contract this is noted.

Figure 29. Strenght hip abduction. Left side showing correct position of resistance and stabilisation. Right side showing alternative position with correct position of resistance and stabilisation. Used with permission.

<u>Strenght hip adduction</u>
Nerve innervation: Pectineus: Femoral L2, L3. Add.Magnus: Obturator, tibial nerve L2, L3. Gracilis, add brevis and add.longus: Obturator, L2, L3, L4. (Standring 2008).
Test position: side lying on the side to be tested with the body, lumbar spine and lower extremities in as straight line. The patient flexes the upper leg, so that the lower leg can adduct freely. The test person holds on to the table in front. Resistance is applied at the medial aspect just proximal to the knee in the direction of abduction (downward pressure). If the adducted position is held against max resistance this indicates grade 5.
Holding the test position against moderate resistance indicates grade 4.
Holding the test position with no resistance indicates grade 3.
Not being able to hold the test position indicates grade 2.
Tendon becomes prominent or feeble contraction felt in the muscle with no visible movement indicates grade 1.
No contraction felt or seen in the muscle indicates grade 0.
If pain prevents the participant to contract this is noted.

Figure 30. Strenght hip adduction. Left side showing correct position of resistance and stabilisation. Right side showing alternative position with correct position of resistance and stabilisation. Used with permission.

Prone:
Hip:
Passive hip extension
Test position:
Both knees extended and the hip to be testet is in 0 degrees of abduction, adduction and rotation. A pillow can be used under the abdomen for support, but no pillow under the head. A fixation belt around the participant buttocks is used to stabilize the pelvis to the table. Stabilize the pelvis with one hand to avoid anterior tilt, the contralateral leg should be flat on the table. The patient extends the hip to be tested by raising the leg with extended knee. The end of movement is performed by the examiner and stopped when an attempt to pelvic anterior tilting is seen. The assistant will keep the position when full range of motion is obtained. The goniometer is placed with the center at the greater trochanter, with the proximal arm with the lateral midline of the pelvis and the distal arm with the lateral midline of the femur using the lateral condyle of the femur as the reference point.
Pain in noted.

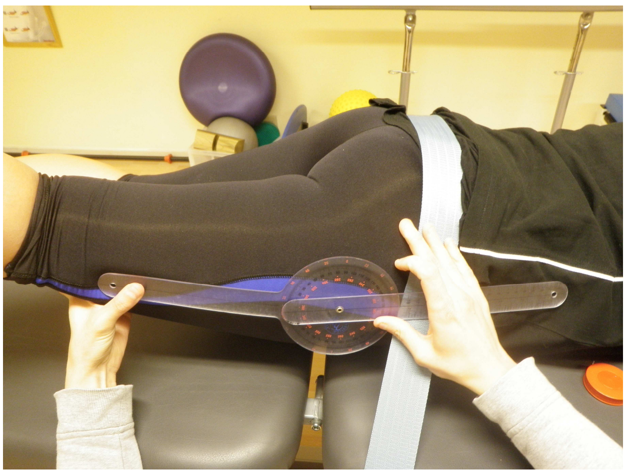


Figure 31. Passive hip extention. Showing correct position of goniometer and fixation.Used with permission.

Strenght hip extention
Gluteus maximus:
Nerve innervation: Gluteus maximus: Inferior gluteal, L5, S1, S2. Adductor magnus: obturator and tibial nerve: L2, L3, L4. Hamstrings Tibial nerve: L5, S1, S2. (Standring 2008).
Test position: the test person is prone with the knee flexed 90 degrees or more. (alternative position is trunk prone on the table) A fixation belt around the participant buttocks is used to stabilize the pelvis to the table. The examiner stabilizes the pelvis with one hand while the other hand is placed just proximal to the posterior knee. Resistance is given in the direction of flexion. If the participant keeps the extended position with the knee flexed against max resistance it indicates grade 5.
Holding the test position against moderate resistance indicates grade 4.
Holding the test position with no resistance indicates grade 3.
Not being able to hold the test position indicates grade 2.
Tendon becomes prominent or feeble contraction felt in the muscle with no visible movement indicates grade 1.
No contraction felt or seen in the muscle indicates grade 0.
If pain prevents the participant to contract this is noted.

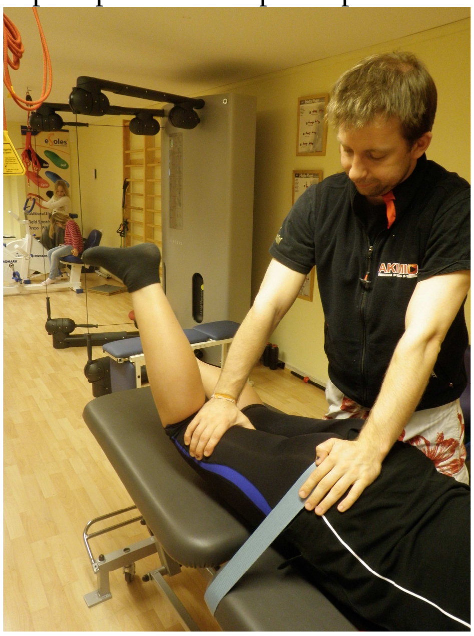


Figure 32. Strenght hip extention. Showing correct position of resistance and stabilisation. Used with permission.

Knee:
Strenght knee flexion
Nerve innervations: Hamstrings: tibial nerve and (common peroneal nerve innervating biceps femoris): L5, S1, S2. (Standring 2008)
Test position: Test participant prone with knee flexed between 50 and 70 degrees (alternative position is supine with hip and knee flexed) A fixation belt around the participant buttocks is used to stabilize the pelvis to the table. The examiner stabilizes the pelvis with one hand while the other hand is placed just proximal to the posterior ankle. Resistance is applied in the direction of knee extention. If the participant keeps the flexed position it indicates grade 5.
Holding the test position against moderate resistance indicates grade 4.

Holding the test position with no resistance indicates grade 3.
Not being able to hold the test position indicates grade 2.
Tendon becomes prominent or feeble contraction felt in the muscle with no visible movement indicates grade 1.
No contraction felt or seen in the muscle indicates grade 0.
If pain prevents the participant to contract this is noted.

Figure 33. Strength knee flexion. Left side showing correct position of resistance and stabilisation. Right side showing alternative test position with correct position of resistance withouth fixation. Used with permission.

Reflex:
Akilles: sciatic nerve: L4-L5. (Magee 2002)
Prone with a firm pillow under the participants ankle, resting. Apply a little pressure with the examiners thigh against the dorsum of the foot. (alternative position supine) Slight dorsiflexion of the ankle is allowed. A tap is given directly at the akilles tendon. The procedure is repeated about 5 times if no contraction (plantar flexion) is observed. The participant will be asked to close the eyes or look in another direction.

<u>Appendix 7</u>

Examination protocol

Date:

Name:

Number:

Examiner:

<u>Patient history:</u>

- Name?
- Age?
- Duration of labour that caused the fistula? (days/hours) (cases)
- Duration of the last labour? (hours) (controls)
- Time since that labour? (months/years)
- Which delivery caused the fistula? (cases)
- Which delivery was the last delivery? (controls)
- Does she have difficulties with daily activities before pregnancy? (what kind) No/yes*
- Does she have difficulties with daily activities present? (what kind) No/yes*
- Does she have difficulties walking before pregnancy? No/yes
- Does she have difficulties walking after the delivery? No/yes
- Does she have difficulties walking present? No/yes
- Community? rural/urban
- Place of delivery? home/hospital
- Mode of delivery? vaginal/abdominal
- Sex of neonate? female/male
- Live birth? No/yes
- If live birth, did the neonate die within the first week after birth? No/yes
- Did you have pain in the legs after the delivery? Yes/no

NB. Cases: delivery that caused the fistula
Controls: last pregnancy

From hospital records:

- Vesico-vaginal or recto-vaginal fistula or both?
- Successfully repaired fistula?

➢ Residual incontinence problems after successful repair?

<u>Result clinical examination:</u>

Standing:

Height			
Rising on tip toe	Strengt		
Weight	1st test	2nd test	

Comments:____

____

Sitting:

<u>Hip:</u> Passive medial rotation	Left leg1st test	2nd test	Right leg 1st test	2nd test
Passive lateral rotation	Left leg1st test	2nd test	Right leg 1st test	2nd test
Strenght hip medial rotation	Left leg			Right leg
Strenght hip lateral rotation	Left leg			Right leg
Strenght knee extention:	Left leg			Right leg
Strength hip flexion	Left leg			Right leg
Reflex: Patellar:	Left			Right
<u>Circumference measurement</u>: Upper arm:	Left			Right
Leg	Left			Right
Ankle	Left			Right

Comments:____

____

Supine:

<u>Hip:</u> Passive flexion	Left leg1st test	2nd test	Right leg 1st test	2nd test
Passive abduction	Left leg1st test	2nd test	Right leg 1st test	2nd test
Passive adduction	Left leg1st test	2nd test	Right leg 1st test	2nd test
<u>Knee:</u> Passive flexion	Left leg1st test	2nd test	Right leg 1st test	2nd test
Passive extention	Left leg1st test	2nd test	Right leg 1st test	2nd test
<u>Ankle:</u> Passive dorsalflexion	Left leg1st test	2nd test	Right leg 1st test	2nd test
Passive plantarflexion	Left leg1st test	2nd test	Right leg 1st test	2nd test

Strenght dorsiflexion	Left			Right
Strength inversion	Left			Right
Strenght eversion	Left			Right
Babinski	Left			Right

Comments____

____

Side-lying

Hip: Strenght hip abduction	Left			Right
Strenght hip adduction	Left			Right

Comments____

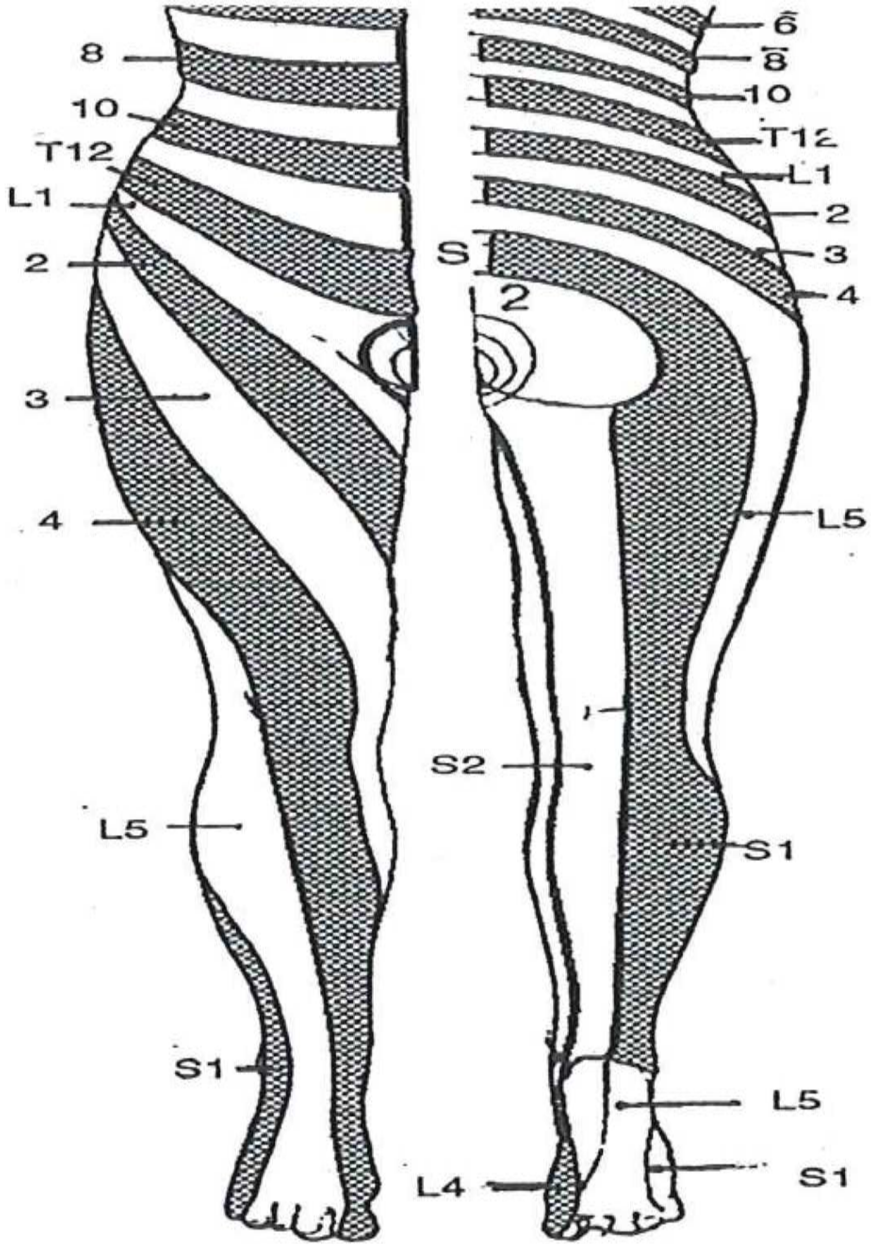
____

Prone:

Hip: Passive extention	Left leg1st test	2nd test	Right leg 1st test	2nd test
Gluteus maximus:	Left			Right
hamstrings	Left			Right
Reflex akilles:	Left			Right

Appendix 8

Map of dermatomes



Slightly modified from Keegan, JJ, Garrett, FD. Anat. Rec. 102:411, 1948; and Haymaker, W, Woodhall, B. Peripheral Nerve Injuries. 2d ed. Philadelphia. Saunders. 1953

Appendix 9.

Timed up and go procedure

Timed up and go
Name:____
Number:____

Description of test
Timed Up & Go (TUG) test measures the time (in seconds), it takes one person to stand up from an ordinary chair with armrests (seat height approx. 46 cm), walk 3 meters, turn, walk back to the chair and sit down again.

Preparation
The participant is wearing her usual footwear and but uses a standardized walking aid provided by the examiner. The participant is sitting with the back against the chair, the arms are resting on the armrests and walking aid within reach in front of the patient. There will not be given any physical support, but verbal instructions can be given.

Instruction
At the command: "Ready –Go" the test person stands up and goes quickly, but in a comfortable and safe pace to a clearly marked line on the floor 3 meters away, walk past the line, turns, go back to the chair and sit down again. The test is performed 3 times. First one tryout test is performed where the examiner guides the patient and the patient uses the standardized walking aid, then two times when time is measured and the average is calculated based on the last two measurements. Instruction on the two measurements is "ready-go". A rest of two minutes between each test is performed.

Time taking
For the time taking use a stopwatch. Start the stopwatch at "go" (even if the participant waits to stand up) and stop when the person sits down on the chair. The arms do not have to rest on the armrests.

Equipment
An armchair is used, seat height approx. 46 cm, a stop watch. It is used a walking length, with a clearly marked line 3 meters from the first chair leg. It is recommended to use a walking length with enough space on both sides, so the participant can choose whether to turn left or right. The length should therefore not be placed next to a wall. Walking aid will be standardized for all patients in need of this assistance.

Result
Comments____
____
____

Date:____________

Time measured in seconds with one decimal:
First measure: ________________Second measure:______________Average:_______________

Walking aid:________________________

Shoes:___________________Height of heel:__________________

Surface:_______________________________

Appendix 10.

Passive range of motion for cases with n, mean, median, SD, min, max, 95 % CI.

Fistula cases	n	**Mean**	**Median**	**SD**	**Min**	**Max**	**95 % CI**
Hip							
Medial rotation left	51	41.98	41	6.8	25	58	40,43.9
Medial rotation right	51	41.76	41	7.4	27	63	39.6,43.8
Lateral rotation left	51	36.8	38	6.5	20	48	35,38.6
Lateral rotation right	51	37.7	40	6.2	24	50	35.9,37.8
Flexion left	51	110.2	111.0	8.7	86	129	107.7,112.7
Flexion right	51	114.1	115.0	8.3	90	131	111.8,116.5
Extention left #	47	-14.7	-14	6	-27	-4	-16.5,-12.9
Extention right#	47	-15.3	-14	6.2	-29	-5	-16.9,-13.3
Abduction left	49	29.2	28.0	10	11	43	26.4,32.1
Abduction right	50	28.9	28.5	10	10	44	26,31.8
Adduction left	51	23.2	24	4.3	14	31	22,24.4
Adduction right	51	23.8	25	5.3	7	33	22.3,25.3
Knee							
Flexion left	51	146.4	153	14	110	164	142.5,150.3
Flexion right	51	147.5	154	14.2	118	165	143.6,151.6
Extention left#	51	-4.2	-4	4.3	-20	2	-5-5,-3
Extention right#	51	-4.5	-4	5.4	-16	4	-6.1,-3
Ankle							
Dorsalflexion left	51	22.3	20	8.5	0	42	19.9,24.7
Dorsalflexion right	51	21	18	8.4	-3	40	18.7,23.4
Plantarflexion left	51	48.8	50	9.8	30	72	46,51.6
Plantarflexion right	51	49.2	50	9.3	25	79	46.5,51.8

Hyperextension

Passive range of motion for controls with n, mean, median, SD, min, max, 95 % CI.

Control group	n	**Mean**	**Median**	**SD**	**Min**	**Max**	**95 % CI**
Hip							
Medial rotation left	100	41.29	40	6.9	25	64	39.9,42.6
Medial rotation right	100	42.19	42	6.7	28	70	40.8,43.5
Lateral rotation left	98	36.2	35	6	20	51	34.9,37.4
Lateral rotation right	99	36.1	35	6.6	22	55	34.8,37.4
Flexion left	99	112.3	115	11.3	66	136	111.1,114.6
Flexion right	99	113.9	114	9.5	90	136	112,115.8
Extention left #	70	-11.9	-12	4.5	-23	-3	-13,-10.8
Extention right#	67	-13.8	-13	5.1	-29	-3	-15,-12.9
Abduction left	92	23.9	24	8.6	6	50	22.2,25.7
Abduction right	94	28.9	28.5	8.8	10	44	26,31.8
Adduction left	96	23.8	24	4.9	10	35	22.8,24.8
Adduction right	94	24.8	24	5.5	12	38	23.6,25.9
Knee							
Flexion left	99	153.5	154	7.1	104	165	152,155
Flexion right	99	153.9	155	4.8	136	163	152.9,154.9
Extention left#	99	-7.4	-7	5.6	-20	6	-8.5,-6.3
Extention right#	99	-6.9	-7	5	-20	5	-7.9,-5.9
Ankle							
Dorsalflexion left	99	26.9	27	6.9	10	45	25.5,28.3
Dorsalflexion right	99	25.8	25	6.8	10	38	24.4,27
Plantarflexion left	99	54.6	54	8	40	76	53,56.2
Plantarflexion right	99	54	55	7.9	31	75	52.4,55.6

Hyperextension

Appendix 11

Merete

Intratester reliability for anthropometrical measurements "Technical error of measurement" TEM

The calculations are made from the participants in the pilot, n=7. The measurements are done with 2 days in between.

Test	Prosent TEM	Acceptable TEM for anthropometry
Upper arm circumference	1.39 %	0-5 % acceptable
Leg circumference	1.17 %	0-5 % acceptable
Ankle circumference	2.12 %	0-5 % acceptable

Intratester reliability for anthropometrical measurements "Technical error of measurement" TEM

Calculations for height are made from 10 participants in the study, weight are measured on my-self, prior to and during the study.

Test	Prosent TEM	Acceptable TEM for anthropometry
Height	0.05 %	<1.5 %
Weight	0 %	<1.5 %

Bruhan

Intratester reliability for anthropometrical measurements "Technical error of measurement" TEM

The calculations are made from 5 participants. The measurements are done with 2 days in between.

Test	Prosent TEM	Acceptable TEM for anthropometry
Upper arm circumference	0 %	0-5 % acceptable
Leg circumference	0 %	0-5 % acceptable
Ankle circumference	0 %	0-5 % acceptable

Test	Prosent TEM	Acceptable TEM for anthropometry
Height	0 %	<1.5 %
Weight	0.014 %	<1.5 %