Section for Physiotherapy Science, The Department of Public Health and Primary Health Care, University of Bergen

Instruction on Weight Bearing As Tolerated or Partial Weight Bearing after total hip replacement with the direct lateral approach; a comparison of change in velocity and symmetry in gait over time.

MSc Thesis for the Advanced Master of Science (MSc) Program in Physiotherapy

Willemijn Vervaat
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Forord

Mens jeg studerte Fysioterapivitenskap fikk jeg mulighet til å delta i prosjektet til stipendiat Caroline Hodt-Billington. Vi samlet inn gangparametere av hofteprotesepasienter ved bruk av en GAITRite® gangmatte. Det viste seg at post operative belastnings regimer varierte mellom forsøks personer. Jeg er som ortopedisk fysioterapeut interessert i hvorfor disse regimene varierer, og hvordan ulike belastningsregimer påvirker gange. Denne interesse, kombinert med de dataene jeg hadde tilgjengelig ble grunnlaget for problemstillingen til denne oppgaven. Det tok noen år fra starten av datainnsamlingen (september 2005) til masteroppgaven min var ferdig (mai 2009). Men en fordel med dette var at jeg kunne bruke data fra tre forskjellige tidspunkter for å evaluere gange.

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Contents

Abbreviations

THR	total hip replacement
OA	osteoarthritis
NWB	non weight bearing
PWB	partial weight bearing
TTWB	toe touch weight bearing
TDWB	touch down weight bearing
WBAT	weight bearing as tolerated
FWB	full weight bearing
Single Support SI	single support symmetry index
Abs. Single Support SI	absolute single support symmetry index
Step Length SI	step length symmetry index
Abs. Step Length SI	absolute step length symmetry index
SQRT	square root
Lg10	base 10 logarithm
1/	inverse

Tables and Figures

Instruction on Weight Bearing As Tolerated or Partial Weight Bearing after total hip replacement with the direct lateral approach. A comparison of change of velocity and symmetry in gait over time. A master thesis.

Willemijn Vervaat, 2009, willemijnvervaat@hotmail.com

Section for physiotherapy science, Department of public health and primary health care, University of Bergen.

ABSTRACT:

Background: Regaining velocity and symmetry in walking is an important part of rehabilitation after total hip replacement. Post operative weight bearing instructions after use of the direct lateral approach vary between hospitals.

Objectives: Obtain knowledge about whether total hip replacement patients operated with the lateral surgical approach that are instructed with partial weight bearing will show a different change over time of velocity and symmetry in walking compared to a group of subjects that is instructed with weight bearing as tolerated.

Design: a longitudinal, quasi experimental design with two non-equivalent comparison groups and 3 data collections; pre-operatively, 3 and 6 months post-operatively.

Methods: 12 subjects instructed with partial weight bearing and 17 subjects instructed with weight bearing as tolerated were included. Spatiotemporal gait parameters were measured with a GAITRite portable walkway system. Direction of assymetry was described. Symmetry indexes of step length and single support time at a standard speed of 0,9 m/s were computed. Change over time of velocity and symmetry indexes in step length and single support time were compared between the two weight bearing groups.

Results: No between group differences were observed in gait symmetry. A repeated measures analysis of variance did not show significant differences between groups for any of the outcome measures. More research is needed to tell whether larger sample size or other outcome measures would give significant differences.

Keywords: *total hip replacement, lateral approach, weight bearing, step length symmetry, single support symmetry, gait velocity*

Instruction on Weight Bearing As Tolerated or Partial Weight Bearing after total hip replacement with the direct lateral approach. A comparison of change of velocity and symmetry in gait over time. En master oppgave.

Willemijn Vervaat, 2009, willemijnvervaat@hotmail.com

SEKSJON for fysioterapivitenskap, Institutt for samfunnsmedisinske fag, Universitetet i Bergen

SAMMENDRAG:

Bakgrunn: Gjenvinning av ganghastighet og symmetri i gange er en viktig del av opptreningen etter operasjon med totalprotese i hoften. Postoperative belastningsinstruksjoner etter bruk av lateral operasjonstilgang varierer mellom sykehusene.

Mål: Å erverve kunnskap om forskjell i forandring over tid i ganghastighet og symmetri i gange hos pasienter som er operert med en totalprotese i hofte med lateral tilgang, og som er instruert med delvis belastning eller belastning til smertegrense.

Design: En longitudinal, kvasi-eksperimentel design med to non-equivalente sammenligningsgrupper og 3 data innsamlinger; pre-operativt, 3 og 6 måneder post-operativt.

Metode: 12 personer instruert med delvis belastning og 17 personer instruert med belastning til smertegrense ble inkludert. Spatiotemporale gangparametere ble målt med en GAITRite gangmatte. Retning av assymmetri ble beskrevet. Symmetri-indekser av steg lengde og enkel standfasetid ved en standard hastighet av 0,9 m/s ble beregnet. Forandring over tid av hastighet og symmetri-indekser av steg lengde og enkel standfasetid ble sammenlignet mellom de 2 gruppene.

Resultater: Ingen forskjell mellom gruppene ble påvist symmetri i gange. ANOVA for repeterte målinger viste ingen signifikante forskjeller mellom gruppene for resultatmålene. Det trengs videre forskning for å finne svar på om et større utvalg eller andre resultatmål kan gi signifikante forskjeller.

Nøkkelord*: Total protese i hofte, lateral tilgang, vektbæring, steg lengdesymmetri, enkel standfasesymmetri, ganghastighet.*

1. Introduction

Total hip replacement (THR) is a successful treatment in reducing pain, and improving function and quality of life in osteoarthritis patients (1). In Norway in 2007, there were 6 643 THR operations and 1 043 reoperations (2). Several surgical approaches are used in THR. After use of the direct lateral surgical approach, an approach used in about two third of the THR operations in Norway in 2007 (2), post operative weight bearing protocols vary within and between Norwegian hospitals. THR patients operated with the direct lateral approach in Norway are either instructed with weight bearing as tolerated (WBAT) (3-5)or with partial weight bearing (PWB) (6-8).

Early post operative weight bearing instructions influence choice of exercises, type of gait training, and use of crutches. When restricted weight bearing is prescribed, exercises aimed at symmetrical limb loading will be postponed until weight bearing is allowed. Early weight-bearing can be expected to promote functional recovery (9).Walking ability is one of the most common and useful outcome measures used with THR patients and ability to ambulate is considered pre-requisite for discharge from most orthopedic clinics (10). It is of interest for the individual patient and his or her rehabilitation program to know if lateral approach THR patients that are instructed with PWB, for a period of time, show a different change over time in recovery of gait compared to patients instructed with WBAT.

A practical and reliable method for analyzing temporal and spatial gait parameters is the GAITRite portable walking system (11-15).

As weight bearing protocols are varying it is interesting to see what evidence exists in the research literature for the choice of weight bearing instructions after THR with the direct lateral approach.

2. Theoretical background

2.1 Total hip replacement

THR surgery refers to the replacement of the acetabulum and femoral head in the hip joint with prosthetic implantation of a cup, head and stem (16). Osteoarthritis of the hip is the most common indication for THR surgery (5 154 of 6 643 patients operated with primary THR in Norway in 2007 had idiopathic osteoarthritis of the hip) (2), and it is the most common disorder of the hip (17). The term osteoarthritis and degenerative joint disease are used synonymously in the English literature. As the condition lacks inflammation typically denoted by the *–itis* suffix, some prefer to use the suffix *-osis* yielding the term osteoarthrosis (18) or coxarthrosis. Because the term osteoarthritis (OA) is most common in English literature, this term will be used in this thesis. Altman et al (19) have developed descriptive criteria for The American college of rheumatology, that distinguish OA from other rheumatic disorders of the joint. Bilateral involvement of hip OA is reported in about one third of patients diagnosed with hip OA (20). Grotle et al (21) found that the prevalence of hip OA in Norway in 2004 was 5.5 percent. OA is a disorder of the entire joint involving cartilage, bone synovium and capsule. There is an increase in the vascularity and activity of subchondral bone (17). Generalized susceptibility is reflected by the age association, positive family history, diabetes, and hypertension(17). Local biomechanical factors include associations with abnormalities in joint shape, Legg- Calvé-Perthes disease, and slipped capital epiphysis. Obesity has not proven to be associated with hip OA, as it is with knee OA (17). In Osteoporosis it is uncommon to observe OA (22) [p 38]. OA may be classified as primary, or idiopathic, and secondary types, with the secondary types being the result of some other primary disorder. Though Armfield and Towers (18) state that there is considerable disagreement regarding this classification. Secondary OA of the hip can for example result from childhood sepsis, slipped capital epiphysis, or rheumatoid arthritis(23). The prevalence of OA increases with age. OA is more common in women than in men (24). Radiographic signs of OA are joint space narrowing, osteophytes, sclerosis and bony attrition (22). Radiographic signs of OA are not strongly correlated with clinical symptoms. Jørring (25) concluded that only half of the patients who exhibit radiological evidence of osteoarthritis of the hip actually need treatment. He reports that one fifth of the patients with radiographic OA were free of pain, and one-quarter had never sought medical advice because of their hip disease (25).

Indications for THR other then OA of the hip are rheumatoid arthritis, fractura colli femoris, hip dysplasia, Perthes/epifysiolyse and Bechterew. Alternative operations for some suited patients are osteotomies and hip resurfacing. Total hip resurfacing can be an alternative for THR for patients who are categorically at increased risk for failure of a THR with favourable proximal femoral anatomy and a sufficient socket. This generally includes patients less than 60 years of age in good health with OA (26). Total hip resurfacing is more physiologic and conservative than THR (26).

Historically, patients 60 to 75 years old were considered the most suitable candidates for THR, but since the 1990s this age range has expanded (27). THR surgery is indicated if there is pain at night, and if pain with movement and weight bearing is so severe that the patient has problems with working or carrying out activities of daily living. Pain in the presence of a destructive process in the hip joint as evidenced radiographically is the primary indication for surgery. Before any major reconstruction of the hip is recommended, advice on conservative or non operative measures should be given (27), such as weight reduction, exercise, assistive devices, analgesics and non-steroidal anti-inflammatory drugs (28).

Hip prosthesises are made up of a femoral and an acetabular component. Components of various materials designs are available. Selection of type of component is based on the patient's need, the patient's anticipated longevity and level of activity, the bone quality and dimensions, the ready availability of implants and proper instrumentation, and the experience of the surgeon (27).

The primary function of the femoral component is the replacement of the femoral head and neck after resection of the arthritic and necrotic segment. All total hip systems in current use achieve fixation of the femoral prosthesis with a metal stem that is inserted into the medullary canal. Femoral components are of three general types: cemented, cementless with porous surface for bone ingrowth, and cementless press-fit varieties (27). Acetabular components can be broadly categorized as cemented or cementless (27). A combination of either a cementless acetabulum and a cemented femur component or a cementless acetabulum component combined with a cementless femur component is called a hybrid THR.

The surgical approaches for THR differ chiefly in whether the patient is operated on in the lateral or supine position, and whether the hip is dislocated anteriorly or posteriorly. The choice of surgical approach for THR is largely a matter of personal preference and training of the surgeon (27). In Norway in 2007, 66,3 percent of all primary THR operations patients were operated with a lateral approach, while 25,7 percent were operated with a posterolateral approach (2).

The anterolateral approach:

Watson – Jones developed the anterolateral approach to expose the head of the femur and the entire length of the femoral neck and upper shaft of the femur. It dissects between the gluteus medius muscle and tensor fascia muscle, both of which are innervated by the superior gluteal nerve (29).

The direct lateral approach:

The direct lateral approach to the hip provides access to the hip joint through the anterior hip capsule directly through the anterior portion of the abductors. The direct lateral approach was popularized by Hardinge in 1984 (29). The skin incision for the direct lateral approach is centralized over the greater trochanter and runs parallel to the anterior border of the femoral shaft. The proximal incision extends posterior, ending at a point even with the anterior superior iliac spine. The deep incision into the fascia lata is made directly over the greater trochanter, and the margins are retracted in an anterior and posterior direction. With the hip in extension, the fibers of the gluteus medius muscle are divided a short distance proximally. The dissection is carried distally into the vastus lateralis, and the entire muscle and tendinous attachment is elevated off of the trochanter sharply (29). There are modifications of the direct lateral approach in the manner of extent of the dissection of the soft tissue structures. An approach called standard lateral approach differs from the direct lateral approach in use of a trochanteric osteotomy (29).

The posterior approach and posterolateral approaches:

The approach described by Moore is considered to be the classic posterior approach to the hip. The Moore incision extends from the posterior superior iliac spine to the posterior border of the trochanter and then extends distally along the axis of the femoral shaft. Posterior incisions split the fibers of the gluteus maximus muscle. There are several modified posterior approaches (29).

The posterolateral approach developed from a combination of the posterior approach described by Langenbeck and an approach described by Kocher. The approach is modified by several orthopedic surgeons. The posterolateral approaches all approach the hip cephalad to the gluteus maximus muscle, rather than splitting the fibers (29). The short rotators (Piriformis muscle, Superior gemellus muscle, Obturator Internus muscle and Interior Gemellus muscle) are released during surgery (29).

Minimal invasive surgery: minimally invasive approaches have been described for all the standard procedures. Minimally invasive hip surgery is a group of procedures which aim to limit soft tissue dissection in the insertion of a hip replacement (30).

Controversy remains regarding the superiority of the posterior or modified direct lateral approach in THR. One issue is the incidence of dislocation, where generally, the rate of dislocation has been reported to be lower following the direct lateral approach (31) Another controversy is that of a reduced incidence of limping following posterior approach compared to approaches that disrupt the abductor musculature, such as the direct lateral approach (31). Jolles and Bogoch (Jolles and Bogoch, 2006) conclude in their Cochrane review on the posterior versus lateral surgical approach for THR in adults with OA that, the posterior approach may improve range of motion more than the lateral approach,and the posterior and lateral approaches may improve function about the same. The chance of dislocating the hip after surgery and the chance of having difficulty walking may be about the same with either the posterior or lateral approach. The posterior approach may cause less nerve damage than the lateral approach, but there is not enough evidence to be certain about wether the posterior or the lateral approach to THR surgery is better in people with OA of the hip (16). Whatling et al (1) conclude that patients operated with the posterior approach exhibited greater characteristics of non-pathological gait and displayed a greater range of functional ability as compared with the patients operated with the lateral approach.

The ultimate goal of rehabilitation after THR is to maximize functional performance and improve the individual's ability to perform daily activities (32). Common physical impairments that must be overcome include pain, limited range of motion at the hip, and muscular weakness (32). Successful treatment after THR depends on the efforts of the interdisciplinary team. An early post-operative goal is preventing bed rest hazards e.g., thrombophlebitis, pulmonary embolism, decubitus ulcers, and pneumonia (23). Rehabilitation programs include education to reduce the risk of dislocation of the endoprosthesis during mobility and self – care activities (32). Functional tasks encompass activities such as transfers, gait training on level and uneven surfaces, stair climbing, and lower extremity dressing (32). In gait training it is particular importance to restore proper gait rythm, speed and fluidity of motion (33). Over the long term, failure to correct loading imbalances could be a factor in the development of OA at joints of the unaffected limb for unilateral THR patients (34). Limping to improve function or limit pain at one joint may alter loading at other joints and lead to generative changes. Over the long term, a gait pattern that loads limbs asymmetrically predisposes weight-bearing joints to altered loading patterns that could affect the normal, healthy cycle of cartilage degradation and synthesis (34).

Rehabilitation occurs in a variety of settings and intensities postoperatively. These include postoperative rehabilitation in the acute hospital setting, comprehensive inpatient rehabilitation, rehabilitation at a skilled nursing facility and home or outpatient rehabilitation (32).

There is a wide variation in the type of exercise that is initiated in the postoperative phase (32). Strickland et al state that rehabilitation procedures in the United States of America appear to be largely based on local conventions (35). This seems to agree with some parts of Norwegian rehabilitation after THR. In Norway there is, besides variation in weight bearing protocols, variation in active abduction restrictions after use of the direct lateral approach, variation in if patients routinely get physical therapy after hospital discharge, and if patients travel home or to a rehabilitation centre after hospital discharge (3, 5, 7, 8, 36). Relatively new in Norway is the Fast Track program in the direct postoperative hospital phase. In the Fast Track program treatment is standardized. Patients are trained and informed in groups. The aim of Fast Track program is improvement in quality, and increasing the efficiency of the treatment of total hip and knee replacement patients (37).

2.2 Weight bearing instructions after a total hip replacement surgery

The amount of weight bearing allowed on the operated limb depends on the means of fixation of the components (cemented/cementless), the presence of structural bone grafts, stress risers in the femur, trochanteric osteotomy (27), and the use of the direct lateral approach. Decision on amount of weight bearing must be individualized according to the implant and experience of the surgeon (27). The use of structural bone grafts is not standard in primary THR, and only used in special cases (38). Trochanteric osteotomy was only used in about one percent of primary THR with the direct lateral approach in Norway in 2007 (2). And therefore those two reasons for instructing PWB will not be further discussed.
With a cementless THR the initial fixation is press-fit, and maximal implant fixation is unlikely to be achieved until some tissue ongrowth or ingrowth into the implant has been established. Stability is usually adequate by six weeks. For these reasons some surgeons advocate toe-touch weight bearing for the first six weeks, while many orthopedic surgeons believe that initial stability of THR achieved with cement fixation is adequate to allow immediate full weight bearing with a cane or a walker (23). No adverse effects of immediate weight bearing with a cementless THR were found in recent studies on weight bearing after cementless THR (39-43).

Weakness, or even an avulsion of the abductor muscle, is a potential risk when THR is performed using a anterolateral (44) or direct lateral approach. It may result from injury to the nerve supply, but it is most often due to disruption of the tendinous attachments of the abductors (29). When using the direct lateral approach the gluteus medius muscle is incised and loosened from its origin, and an avulsion of the re-attached gluteus medius muscle leads to limp (44). Abductor avulsion after primary THR with the lateral approach is an uncommon event (45, 46). Lubbeke et al (45) found in their study that 0,7 percent of THR patients operated with the lateral approach were operated upon for repair of abductor avulsion on average og 19 months after primary THR. While there are many reports on early weight bearing after THR with a cementless implant, no literature was found on effect of weight bearing on abductor avulsion or abductor repair. Recent papers on WBAT after Achilles tendon repair and quadriceps and patellar tendon repairs shows good functional results and no adverse affects (47-49). But in those studies weight bearing was combined with the use of an ankle-foot orthosis or knee brace locked in extension, and it is unknown if this information can be generalised to the load on a repaired gluteus medius muscle.

The assumption that WBAT will increase the risk of abductor avulsion is the reason why some orthopedic surgeons instruct their patients with PWB after THR when using the direct lateral approach (7, 8). Others instruct their patients with WBAT combined with the use of crutches, assuming that the use of crutches alone will protect the gluteus medius muscle enough (3, 5, 6). The length of the PWB period is varying from six weeks (8) to three months (7).

English terminology for weight bearing is as follows:

Non-weight bearing (NWB) – No weight can be placed on the operated leg. Assistive device is required (crutches or walker)(50).

Toe touch (TTWB) or touchdown weight bearing (TDWB) –The foot of the involved lower extremity is allowed to rest on the floor to assist in balancing, weight bearing with no more than 10% of body weight is allowed and it is sometimes described as walking on eggshells (32). Assistive device is required (crutches or walker)(50).

Partial weight bearing (PWB) – Clinically PWB means 30 percent to 50 percent of body weight (32). A specific weight limit may be provided by the surgeon such as 20 kg. A scale is often useful to instruct the patient in maintaining the restriction. Assistive device is required – (crutches or walker) (51).

Weight bearing as tolerated (WBAT) or to pain limit - The patient is allowed to determine the amount of weight she feels comfortable in applying to the involved lower extremity. This may vary from very light to full weight. Assistive devices may or may not be required depending on the medical condition of the lower extremity. An assistive device may be used initially and then discarded as the patient improves. Assistive device options are crutches, a walker or a cane (52).

Full weight bearing (FWB) - the patient is allowed to put full weight through the involved lower extremity. An assistive device is not used to decrease weight bearing but may be used for balance (52) or for decreasing the demand placed on the abductor muscles (53).

Ambulation with PWB or WBAT is a sensimotor skill that physical therapists teach. A method used by physical therapists to teach weight bearing is using a combination of verbal instruction and a bathroom scale. The patient stands with the operated extremity on the bathroom scale and with the other extremity on a board in the same height as the bathroom scale, allowing the patient to observe and control weight distribution between the extremities and recall that weight during walking. An objective method for correcting weight bearing are relative newly developed pressure sensitive insoles (54, 55), but they are rarely used in clinical settings.

2.3 The function of the gluteus medius muscle in walking

In understanding why some surgeons instruct PWB after using the direct lateral approach it is interesting to know the function of the gluteus medius muscle in standing and walking.

Wasielewski (56) is referring to Soderburg and Dostal, who found that the gluteus medius muscle has anterior, middle, and posterior parts that contract asynchronously during movement of the hip. The gluteus minimus and medius muscles function together to abduct the femur during the stance phase of gait to counter the effects of the adduction moment created by the patient’s weight (56).

Johnston (53) is referring Tackson, Krebs and Harris, who found that during gait between heel strike and early midstance, abductor muscle activity increases together with ground reaction forces and peak pressures. Muscle contraction, passive soft tissue stretch and articular reaction forces contribute to the joint reaction forces. It is not possible to directly calculate the contribution of each of these components (53). A simplified example of reducing demands on the abductor muscles and therefore joint reaction force by using a walking stick is if a 70 kg subject holds the stick 50 cm from the weight bearing hip and pushes with a force of 10 kg, then the walking stick has reduced the joint reaction force from 210 Kg to 100 Kg. (57). The moment produced from both the walking stick and abductor muscle together produce a moment equal and opposite to that produced by the effective body weight (53). Even when a relatively small load is applied to the walking stick, the contribution it makes to the moment opposing body weight is large enough to lead to significantly decreased demand placed on the abductor muscles (53). Neumann measured surface electromyographic activity from the hip abductor muscles from THR patients using a walking stick in the contra lateral hand, compared with THR patients walking without a stick. Hip abductor electromyographic activity when using a walking stick was 31.1 percent less then when not using a walking stick and 42.3 percent less when pushing with near-maximal effort on the walking stick. Neumann concludes that holding the cane contra lateral to the prosthetic hip appears to be an effective method of reducing demands on the hip abductor muscles (58).

Alterations in joint anatomy, for example due to THR surgery, can dramatically affect the force acting across the joint and the stress developed within the articular surfaces, and the moment generating capacity of abductors and other muscle around the hip joint (53).

It would be interesting to know if patients that are instructed with WBAT after a THR with the direct lateral approach have more abductor problems than patients instructed with PWB. No literature was found on this topic. Material from patient journals from different hospitals practicing different weight bearing protocols would be excellent for a retrospective study. Accomplishment of reduced weight bearing is not without consequences. Many activities of daily living can be influenced. Sooner or later many patients complain of secondary symptoms of the upper extremities, often in terms of numbness and pain (55). Weight bearing restrictions after THR surgery prescribed by the surgeon directly impact the level of functional independence attained by discharge (32). Therefore it should be questioned if the instruction of PWB after use of the direct lateral approach in THR really is necessary for the repair of the gluteus medius muscle, and further research is needed to answer this question.

2.4 Spatial and Temporal Gait parameters and Gait analysis

Walking is the most essential modality of human locomotion, and thus disturbances of gait have a significant impact on quality of life (33). Physiological gait is an extremely energy efficient form of locomotion, which means that any disturbance of its normal mechanisms is accompanied by increased energy costs and decreased muscle efficiency (33). The forces that operate while walking are generated by muscle actions that accelerate or retard the movement of various body segements, grafity, and momentum (33). In particular, measurements of gait function are relavant to assess outcome. Because gait is highly important in everyday life, gait function is closely linked to overall functioning (59)

To describe and analyse gait, defenitions of parts of the gait cycle have been made. **The gait cycle** is the time interval or sequence of motions occurring between two consecutive initial contacts of the same foot (60). The time it takes for this to occur is called the gait cycle duration, or stride time (61). It’s usual to start the cycle with the initial contact, often called heel contact in normal gait, of one foot, so that the end of the cycle occurs with the next contact of the same foot, which will be the initial contact of the next cycle (61).

A gait cycle can be divided into smaller temporal and spatial parts. **The stance phase** of gait occurs when the foot is on the ground and bearing weight. This phase consists of five sub phases; the initial contact, the load response, the midstance, the terminal stance and preswing (60). **The swing phase** of gait occurs when the foot is not bearing weight and is moving forward. It consists of three sub phases: initial swing, midswing and terminal swing(60). **Double support** or **double-leg stance** refers to those phases of the gait cycle in which parts of both feet are on the ground. When walking at normal speed, the two phases of double support are the initial contact of the stance phase and the terminal stance and preswing phase (60). Double support increases the more slowly one walks; it becomes shorter as walking speed increases and disappears in running (60). The initial double support of one limb is the same as the terminal double support of the opposite limb. The part of stance phase between the double support phases, when only one foot is on the ground, is called **single limb support** (61). Single limb support equals swing phase of the other leg.

Step length is the distance from the heel of the trailing limb to the heel of the leading one. When one of each limb has occurred, the person has taken a stride, or performed one gait cycle (61). It should not be assumed that the side with the longer step length is healthier. Step length differences are useful only as a measure of symmetry. The step length ratio of the shorter to the longer step length is useful for tracking a patient's progress through their rehabilitation (61). **Step width** is the distance between the two feet. Balance problems or tight hip abductors can cause a wider step width (60).

The number of steps per minute is called **cadence**. Cadence is related to the length of the lower-limb, longer legs have a slower cadence. Since women are, on average, a little shorter than men, they tend to have a slightly higher cadence (61). **Walking speed** has been shown to correlate well with function. Sometimes walking speed alone can be misleading, since it is a product of cadence and stride length (61).

Nearly all temporal and spatial gait parameters are speed dependent. They change in amount when speed changes. Only step length as a percentage of stride length, has been given a normal value; in normal gait step length is 50 percent of stride length. This is because this percentage is independent of speed (62).

The temporal gait determinants that can be used to characterize normal gait are as follows: Isometry, when the steps made with both limbs have the same length; Isotony, when the movements of the upper and lower limbs while walking are properly coordinated; isochronicity, when the duration of weight bearing on both lower limbs is equivalent (33).

The term gait analysis can mean many things to different people, from a brief observation to sophisticated computerized measurements (61). A full gait analysis includes testing the strength of foot pressure on the ground, three-dimensional video recording of the motion of the patient's anthropometric points and electromyographic tests of activity of the muscles that are involved in walking. Because of high cost, inaccessibility of the research apparatus inolved and the discomfort of the patient must endure to go through all these tests, this type of gait analysis is seldom done in clinical practice (33). Simplified analysis using spatiotemporal parameters can also be valuable and a portable device may be advantageous for this (63). The temporal-spatial parameters of gait are important functional measures. The main applications for them are: Screening, as a performance measure, monitoring the efficacy of therapy, normalization of other gait measurements (61). Also temporal-spatial parameters of gait are rarely measured in routine clinical practice (61).

In the normal condition the degree of both temporal and spatial asymmetry is only slight. When the degree of asymmetry increases the walking pattern becomes noticeably abnormal and the patient is regarded as walking with a limp (62). Symmetry indices provide simple overall outcome measures (61). In literature different formulas for symmetry indexes are reported. Some researchers report that they calculated the ratio between the difference of the left and right limbs parameter, and the mean left-right limb value for the same parameter (64) as a symmetry index. Others use the ratio between the left and right limb parameter (65, 66) or the ratio of mean percentage of the gait parameter of the affected, and the unaffected leg (67). Robinson (64) gives an arbitrary range of 10 percent from perfect symmetry as indication on what amount of asymmetry can be considered as normal. Balasubramanian (66) indicates that symmetry indexes between 0.9 and 1.1 are considered as normal.

2.5 Temperospatial gait parameters in osteoarthritis of the hip and after total hip replacement:

Patients with OA of the hip show abnormal gait patterns and walk in a manner that is both asymmetric and consistently different from the gait of normal subjects (68). Abnormal patterns can be caused by pain, stiffness of the hip and weakness of muscles around the hip. Combinations of different factors will cause the patients individual gait pattern.

In **antalgic**, pain avoiding, gait is stance duration often decreased on the painful side, and the contralateral stance duration will be prolonged to compensate (61). The swing phase of the uninvolved leg is also decreased (60)**.** In **arthrogenic** or stiff hip gait, the step lengths are different for the two legs. When the stiff limb is bearing the weight, the step length is usually smaller(60). **Trendelenburg** gait is seen in patients with abductor dysfunction, weakness, denervation, or transaction (69). The pelvis is tilting down on the opposite site during stance phase. As a compensation for the pelvis tilting patients are noted to move their trunk and head over the affected hip just prior to the stance phase of gait to prevent falling to the unaffected side (69) this is called Duchenne gait. **Circumduction** is a pattern suggestive of limb- length inequality, particularly if there is also joint stiffness. In this pattern, the limb is rotated away from and then toward the body through the gait cycle to permit clearance of the long leg from the ground (69).

In literature on temperospatial gait parameters of THR patients with unilateral hip OA, gait parameters of the affected side are compared with normal values as reported in literature, with previous collected data on the same patient, or with the unaffected side of the same patient. A problem with comparing with normal values as reported in literature, is that differences in temperospatial parameters can be cuased by differences in gait speed. This can also be a problem when comparing with a control group, or with previous parameters from the same subject, when data are not controlled for gait speed. Not all research reports explain if or how they controlled for gait speed.

Cichy et al (33) report that the pre-operative step length is significant shorter in both lower limbs in patients with OA of the hip when compared to the age-matched norms for healthy adults reported in the literature. One month after THR, the mean length of step was slightly increased in both limbs compared to preoperatively but still less than normal (33). Ten years post-operatively THR patients showed reduced step length on both sides compared to a normal control group (70). Step length was increased significantly in comparison with preoperative values by six months after surgery and then remained stable after that on both sides (71). Though all the results in this paragraph may be explained by different walking speeds. Preoperative subjects may for example walk slower than normal and therefore have a shorter step length.

Variation in if the affected or unaffected limb has the longer step length preoperatively is reported in literature; Wall (62) reports that pre-operatively the step length of the affected side is longer than the step length of the unaffected side. While others report that the step length of the unaffected side is longer than the step length of the affected side (33, 72). And some report that there were no differences in step length between both sides (71). This same variation in reported results is seen for the step length after THR. Some report that after THR, the mean step length of the healthy limb was longer one month after THR (33), while others report no difference in step length between the operated side and the non operated side at one, three, six or twelve months postoperatively (71). Wall found that six months after THR the step lengths for both sides are more equal and by twelve months normal (62). Ten years post operatively no significant differences were found between the operated limb compared to the non-operated limb for step length (70).

Long et al (73) found that single limb stance time on the involved limb averaged 83 percent of normal pre-operatively, though it is unclear what they consider as normal. Long et al found that after THR, the single limb stance time on the involved limb averaged 92 percent of normal by one year and 96 percent of normal by two years post operatively (73). This can correspond to other results that report that the support time for the normal leg has near normal values by six months with a little change in the ensuing six months (62). Again, it is unclear what is considered as normal for the results above. Wall (62) found that the stance phase time of the unaffected leg is preoperatively longer than the stance phase of the affected leg. Six months after THR the support time for both sides are more equal and by twelve months normal (62). Stance phase symmetry ratio improved after three months postoperatively (67).Ten years post operatively no significant differences were found between the operated limb compared to the non-operated limb for stance duration (70). Talis et al (74) found that in normal and fast walking at a mean time of 19 months after THR the swing phase duration of the non operated leg was shorter than that of the operated leg, which means that the stance phase duration of the operated leg was shorter.

Ten years post-operatively THR patients showed reduced stride length compared to a normal control group (70). Stride length was increased significantly in comparison with preoperative values by six months after surgery and then remained stable after that on both sides (71).

Long et al (73) showed that gait velocity of hip OA patients averaged 80 percent of normal preoperatively, and that Cadence was 95 percent of normal before surgery. Velocity was increased significantly in comparison with preoperative values by six months after surgery and then remained stable after that on both sides (71). The increase in velocity occurs mainly during the first six months after THR. By six months, and even more noticeble at twelve months postoperatively, males show a marked improvement in velocity, while females showed little change from six to twelve months (62). Velocity of THR patients reached that of normal persons by twelve month after surgery (71), and had returned to 100 percent by two years (73). Though others report that ten years post-operatively THR patients showed reduced velocity, compared to a normal control group (70).

Before surgery there was no statistically significant asymmetry between the affected and healthy lower limbs in respect to maximum foot-ground pressure, but one month after surgery, there was less weight bearing in the operated limb, leading to assymetry (33). THR patients still walked with the lower limbs loaded unequally two or more months after surgery and from four or more months after surgery the asymmetries were not as large but still apparent (34). Six months after surgery, THR patients still had a more asymmetrical loading than able-bodied subjects (75).

Wall (62) concludes also that improvement in gait symmetry, both temporal and spatial; occur mainly in the first six months following THR.

2.6 Previous research on weight bearing instructions and gait in total hip replacement patients.

A part of the literature on effect of instruction of WBAT and PWB after THR is concentrated on the risk of prosthesis loosening in early weight bearing after use of a cementless implant (39, 40, 42, 43) this is already discussed earlier in this thesis in the paragraph about weight bearing instructions.

During hospital stay the subjects instructed with WBAT performed transfers earlier (42). Subjects instructed with WBAT had a shorter hospital stay (42, 76), and at hospital discharge the subjects instructed with WBAT had a significantly greater walking distance (42).

Three months postoperatively, the subjects instructed with WBAT still had a significantly greater walking distance than subjects instructed with PWB (42), they walked faster than the subjects instructed with PWB and they had a walking pattern different from the subjects instructed with PWB (9). The way the walking patterns were differing is not reported in the article. Further had subjects instructed with WBAT at three months postoperatively more hip extension, external rotation, gluteus medius strength and gluteus maximus strength (42), they used crutches for a shorter time and had a better Harris hip score (42). No group differences in load during walking and muscle strength in abduction were found three months postoperatively (77).

Six months after THR there were no differences in gait velocity and the walking pattern of subjects instructed with WBAT was not different from those instructed with PWB (9). No between group differences were reported in hip extension, pain (9), load during walking and muscle strength in abduction.

Neither was there a group difference in load during walking and abduction muscle strength at twelve months after THR (77). After twelve and 24 months were there no between group differences in Harris hip score (39).

3. Objectives and approach to the problem

3.1 Objectives

The aim of this study is to explore data to obtain knowledge about if THR patients operated with the direct lateral surgical approach that are instructed with PWB on their operated leg, will show a different change over time of symmetry in walking and velocity compared to a group of subjects that is instructed with WBAT. This information can be important in choice of rehabilitation program for each individual patient. Possibly patients instructed with PWB need extra exercise when they are allowed to bear full weight again.

3.2 Approach to the problem

Some research literature was found on differences in velocity between PWB and WBAT subjects, but no research literature was found on weight bearing instructions and temperospatial gait parameters. When a subject is walking with PWB for several weeks, muscles in the operated leg will be used in a different way than in normal walking. Some muscles may be used less, while other muscles may be used more. As the instruction of PWB does also affect the type of exercises that can be used, it can be assumed that the instruction of PWB will influence walking and symmetry in walking in a different way than WBAT. PWB and walking with crutches in 3 months could influence step length and single support time. Subjects with OA of the hip so severe that THR is indicated often walk asymmetric at the time they are operated. It can be assumed that walking with WBAT generally will give a faster regaining of symmetric gait and velocity.

3.3 Research question

'Does change over time in velocity and asymmetry in step length and single support time differ between the PWB group and the WBAT group?'

4. Methods

This project is part of a larger project, which aims to evaluate whether preoperative asymmetry of gait in hip OA patients is expressed differently for various gait parameters, and to evaluate which gait parameters will show changes in gait from preoperatively to one year post operatively.

4.1 Design

The design used is a longitudinal, quasi experimental design with two non-equivalent comparison groups (78)[p116-118],(79) [p98,117]. Data are collected pre-operatively; three months post operatively and six months post-operatively. In Figure 1 the Campbell and Stanley notation for the design is illustrated (80).

WBAT	O1	X1	O2	O3
....				
PWB	O1	X2	O2	O3

Figure 1 - Campbell and Stanley notation for the research design.
WBAT = weight bearing as tolerated, PWB = partial weight
Bearing, O = data collection, X = weight bearing instruction
after total hip replacement

O1 represents pre-operative data collection, O2 represents data collection three months post-operatively and O3 represents data collection six months post-operatively. X1 represents THR with instruction of WBAT, X2 represents THR with instruction of PWB; The subjects are not randomly assigned to groups (this is indicated by the dotted line in the Campbell and Stanley notation) (78).

This prospective design is meant for describing and analysing differences in changes over time in velocity and asymmetry in step length and single support time between the two groups. The-pre operative measurement is chosen to compensate for the lack of random assignment. The pre-operative data allow determination of whether the groups had similar gait patterns initially (81). From X to O2 the two groups are instructed either with PWB or WBAT. From O2 to O3 both groups are allowed to bear full weight on their operated leg.

4.2 Subjects

38 subjects, 23 women, 15 men, were recruited from the orthopeadic surgery planning list of two University hospitals in Norway on admission to the orthopeadic facility. All patients planned for primary THR at a University hospital in Oslo, and all patients planned for primary THR at a University hospital near Bergen, who were living near Bergen, were invited to participate in this research project (Supplement 1: invitation for participation). All the subjects gave informed consent (Supplement 2: invitation and consent).

Subjects were included in the research project if they were operated with the direct lateral approach, if they were able to walk ten meters without assistance or walking aids, and if they had complete data scores. Subjects were excluded if they were not able to ambulate, if they had musculoskeletal ailments other than OA of the hip that influence walking, if they were not able to walk at a walking speed of 0,9 m/s pre-operatively, three months post-operatively or six months post-operatively, and if they were not able to attend at one of the three data collections.

In Figure 2, exclusion of subjects is described. Of the 38 subjects, one subject was excluded because there were technical problems with the preoperative data collection, four subjects were excluded because they were operated with the posterolateral surgical approach. Of the remaining 33 subjects, 17 were instructed with WBAT on the operated leg, they were instructed to use crutches for six weeks and to avoid active hip abduction as an exercise for six weeks. 16 subjects were instructed with PWB, with a maximum of 20-30 kilos of load allowed on the operated leg for the first three months post operative. One subject was excluded because she was unable to walk at a velocity of 0,9 m/s three months post-operative. In one subject three months post-operative data were missing, and in four subjects, the six months post-operative data were missing. Outcome measures of twelve subjects instructed with PWB and fifteen

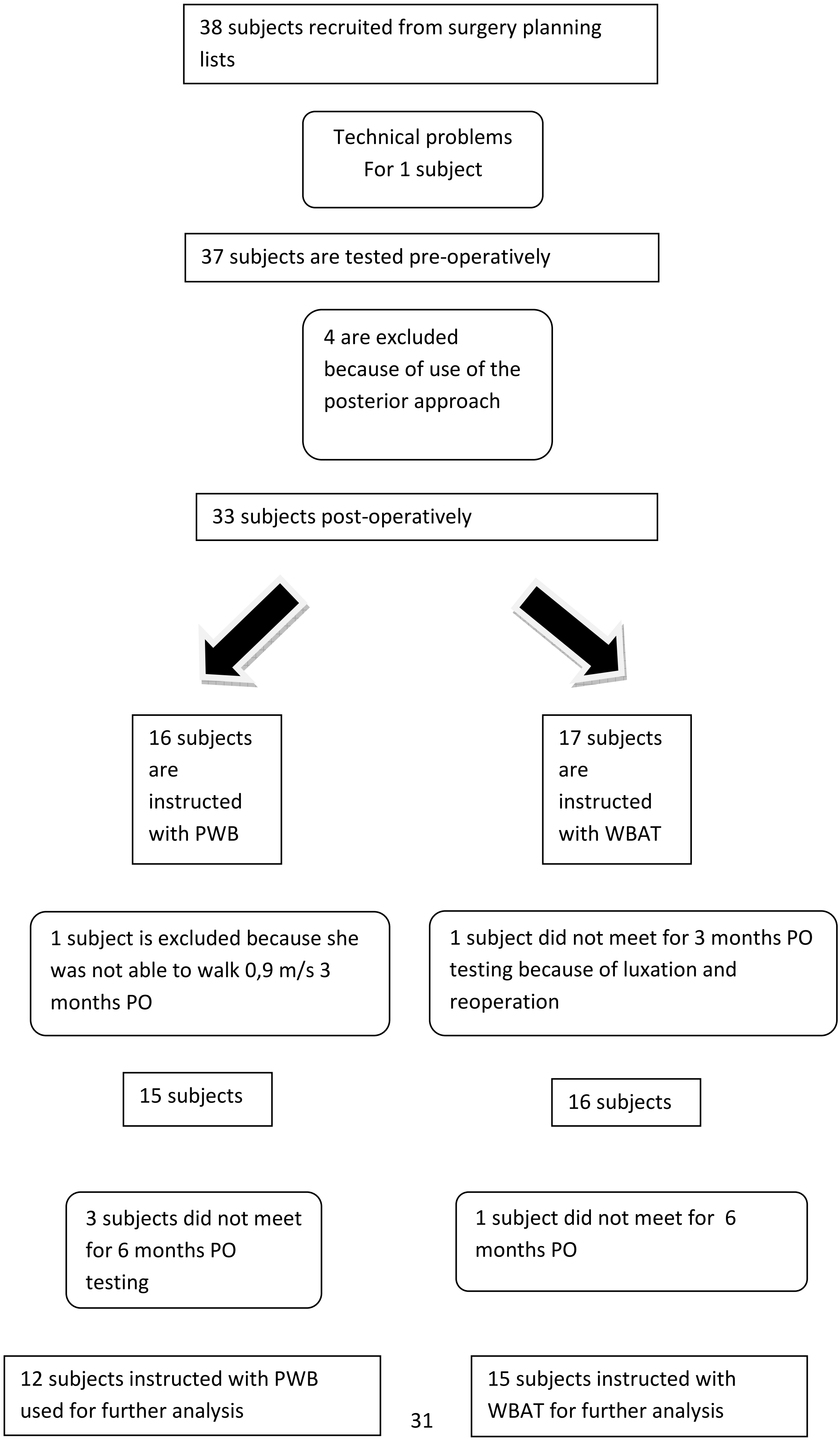


Figure 2 - Exclusion of subjects

PWB = partial weight bearing, WBAT = weight bearing as tolerated, PO = postoperatively subjects instructed with WBAT are used in further description of asymmetry and data analysis.

The weight bearing protocol was chosen by the surgeon. The reason for instruction of PWB, the instruction of use of crutches for 6 weeks in the WBAT group, and the instruction of avoiding active abduction as an exercise in the WBAT group, was in accordance with the orthopedic surgeons the use of the direct lateral approach and risk of abductor avulsion. Patients were divided into groups after surgery. Patients were instructed in PWB with use of bathroom scales. All subjects were encouraged to avoid the extremes of hip rotation, flexion and adduction. Both groups received physiotherapy post operatively during hospital stay. After discharge, some subjects exercised at a physical therapy facility near their home, while other subjects stayed at a rehabilitation center.

4.3 Variables

As measurement tools we used a GAITRite portable walkway system (CIR systems Inc, USA) for measuring spatial and temporal gait variables, a digital scale for measuring weight (kg), and a metal ruler on a wall scale for measuring height (cm).

The GAITRite portable walkway system is a portable gait carpet in which there are six sensor pads encapsulated. The electronic walkway is connected to a Personal Computer via an interface cable. The active area on the carpet used is 61 cm wide and 427 cm long, the overall dimensions are 518 x 90 x 0,6 centimeters (Length x Width x Height). The electronic walkway transfers information to the PC via the interface cable. Application software processes the raw data into footfall patterns, and computes the temporal and spatial parameters (82). Two tapes were fastened on the floor 0.9 meters from each end of the 5.2 m. walkway, so the total distance the subjects were walking was seven meters.

Primary outcome measures are the gait variables measured: Step Length (cm), Single Support (% of gait cycle time), and Velocity (m/sec), during very slow, preferred and very fast self selected speed. Height and weight are measured as personal characteristics.

Picture 1 The GAITRite walkway

The GAITRite portable walkway system is a reliable and valid method for measuring spatial and temporal gait parameters (11-15). It is a practical method because the testing equipment is portable and it does not take much time to prepare testing and collect data.

4.4 Data collection

Data collection was done in the years 2005 and 2006 in Oslo and from 2005 to 2007 in Bergen. The research sites were the University of Bergen and Ullevål University Hospital. The research settings were an orthopeadical outpatients' clinic, a basement in the hospital and a gait laboratory. Data were collected by two colleagues and myself.

Before analysing gait, subjects were asked about how they were doing, whether they were using medicines and, whether things had changed compared to last time they were tested, whether they experienced symptoms from their other hip, whether hip OA was diagnosed on X-ray in their other hip, and whether they had other illnesses or impairments. Weight and height were measured with the same shoes and clothes as used in the gait analysis. Subjects were asked to bring the same shoes every time they were tested.

Subjects were instructed to walk three times back and forth without crutches at an even speed on the seven meter walkway, starting behind the tape on the floor and walking in a constant speed until they crossed the second tape on the floor. Tapes were placed to ensure that subjects were not in acceleration or deceleration phase while walking on the active area of the carpet. This method has been used before by others (83). Subjects were instructed to first walk one time back and forth as slowly as possible as if waiting for a buss, second walk one time back and forth at their normal, preferred walking speed, and then at least walk one time back and forth as fast as they could safely walk without running. Information was given before the testing started and repeated before each walking trial. Subjects were asked to walk at three different speeds in order to compare test parameters at a common walking speed (Moe-Nilssen, Helbostad, 2004), see data analysis for further description. One practice walk was allowed before data registration in all subjects. There was a short debriefing after data collection to show subjects some results.

4.5 Data analysis

Statistical procedures were performed in SPSS 15.0 and EXCEL2007 for Windows. Electronic walkway software (GAITRite34sg 2005) was used in calculation of footfall parameters.

A curve estimate was calculated over the range of speeds for step length and single support time. Both the variables were plotted against velocity, and second degree (quadratic) curves estimates were constructed. From the curve estimate, a point estimate at a standardized speed was chosen as test parameter (84). The standard speed chosen was 0.9 m/s. The step length and single support time at 0,9 m/s were used in further analysis (Supplement 3).

The ratio between the unaffected and affected extremitys' step length (83, 85) and single support time (83, 85) at 0,9 m/s is computed. The deviation from one of the computed ratio is used to describe gait asymmetry and will in this paper be called symmetry index. At perfect symmetry, the symmetry index equals zero. A lower than zero symmetry index (negative score) indicates a larger value for the unaffected limb, while a symmetry index larger than zero (positive score) indicates a larger value for the affected limb. Similar scores are used by Hodt-Billington(2007) and Chen (2005) (83, 86). Because most statistical tests use mean values, it is not possible to use those positive and negative scores in the statistical analysis. It is possible that the mean value becomes zero or a value that is not correlating with the mean asymmetry of a group. Because of this the absolute value of the symmetry index is used in further analysis. This absolute value of the symmetry index will be called Absolute Symmetry index. In the statistical analysis information about the direction (which leg has the longer step length or single support) of the asymmetry is lost.

Single-Support-Symmetry Index = 1 - unaffected Single Support Time/ affected Single Support Time (abbreviation used in this thesis: **Single Support SI**)

Absolute Single-Support-Symmetry Index = |1 - unaffected Single Support Time/ affected Single Support Time| (abbreviation used in this thesis: **Abs. Single Support SI**)

Step-Length Symmetry Index = 1 - unaffected Step Length / affected Step Length (abbreviation in this thesis: **Step Length SI**)

Absolute Step-Length Symmetry Index =|1 - unaffected Step Length / affected Step Length| (abbreviation in this thesis: **Abs. Step Length SI**)

Plots over the Step Length SI and the Single Support SI against time are used to describe if the affected or unaffected limb had the longer step length or single support time at the three different data collections. This description will be called description of directions of asymmetry further in this thesis. If direction changed over time, e.g. if preoperative affected step length was longer then unaffected step length preoperatively, and postoperatively the unaffected step length was longer then the affected this will be called change of direction of asymmetry further in this thesis. The plots over Step Length SI and Single Support SI against time were analysed visually to see if different tendencies between groups appeared and to see what information got lost in the analysis with the absolute values of the symmetry indexes.

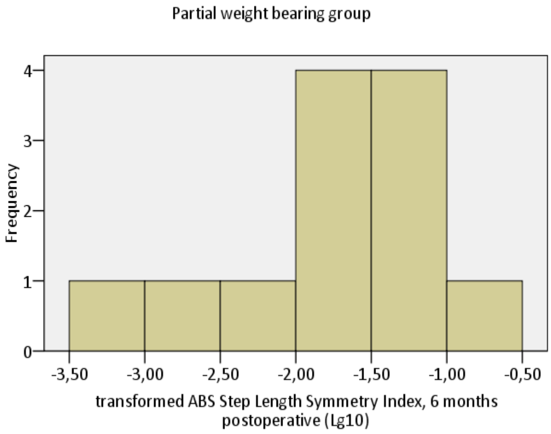
Preliminary analysis with the Kolmogorov Smirnov test of normality showed that not all variables were normally distributed. The results for the Shapiro Wilk test of normality are automatically also reported in SPSS and gave the same results. Because there is no non parametric alternative to the repeated measures analysis of variance used, in Pallants book the test used is called the mixed between within ANOVA (87), mathematical data transformation was used to meet the assumptions for use of parametric statistical tests. The transformations used are; square root (SQRT): the new variable = SQRT (old variable), The base 10 Logarithm (Lg10): the new variable = LG10 (old variable), and the inverse (1/): the new variable = 1/old variable (87). In Table I the outcome of the Kolmogorov Smirnov test before and after transformation for each variable is shown. A significant p-value on the Kolmogorov Smirnov test indicates that the variable is non normal distributed. The significant values are highlighted in Table I. Variables became normal distributed in all but 1 variable: Abs Step Length SI six months post operative for the WBAT group. Though the Shapiro Wilk test of normality was not significant, which means that according to that test the variable was normal distributed. The histogram of that transformed variable is shown in Figure 4. One initially normal distributed variable became non-normal distributed after transformation. It was necessary to transform this variable in order to compare its mean value with the mean values of the other transformed variables: Abs Single Support SI six months post operative for the PWB group. The histogram of that transformed variable is shown in Figure 3.

Table I - Transformation of variables

	Before transformation Kolmogorov - Smirnov test of normality *p*-values[1]	Transformation Formula[3]	After transformation Kolmogorov - Smirnov test of normality *p*-values[1]
Abs Step Length SI pre op[4]			
PWB	0,010	SQRT	0,058
WBAT	0,2	SQRT	0,2
Abs Step Length SI 3 months PO[4]			
PWB	0,2	SQRT	0,2
WBAT	0,098	SQRT	0,2
Abs Step Length SI 6 months PO[4]			
PWB	0,051	SQRT	0,2
WBAT	0,001	SQRT	0,032[2]
Abs Single Support SI pre-op[4]			
PWB	0,2	Lg10	0,1
WBAT	0,025	Lg10	0,2
Abs Single Support SI 3 months PO[4]			
PWB	0,020	Lg10	0,2
WBAT	0,135	Lg10	0,2
Abs Single Support SI 6 months PO[4]			
PWB	0,078	Lg10	0,019
WBAT	0,032	Lg10	0,1
Slow Velocity pre-op[4]			
PWB	0,062	1/	0,2
WBAT	0,2	1/	0,2
Slow Velocity 3 months PO[4]			
PWB	0,2	1/	0,2
WBAT	0,114	1/	0,2
Slow Velocity 6 months PO[4]			
PWB	0,033	1/	0,2
WBAT	0,2	1/	0,2

1) A *p*- value lower than 0,05 indicates that variables are non-normally distributed (highlighted in yellow).
2) Shapiro Wilk test 0, 056 which indicates that variables are normally distributed. All other results were the same for the Shapiro-Wilk test of normality.
3) SQRT =square root, Lg10 = base 10 logarithm, 1/ = inverse
4) Pre-op = preoperatively PO = post operatively, ABS = Absolute, SI = Symmetry Index

No transformation was done with preferred and fast velocity data, because Kolmogorov Smirnov showed that preferred and fast velocity data were normal distributed in both groups for all the three data collection points.



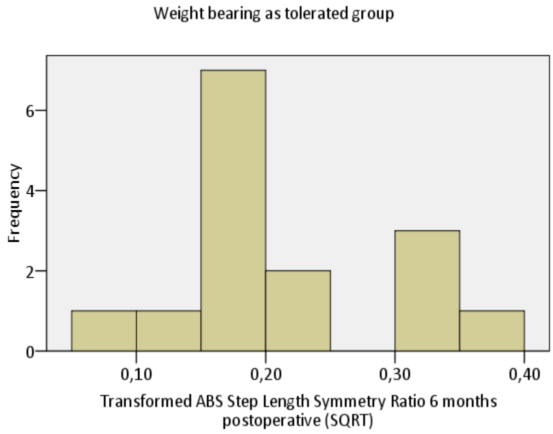


Figure 3 - Histogram of Absolute Single Support Symmetry Index, 6 months postoperatively, for the partial weight bearing group after transformation with base 10 logarithm

Figure 4 – Histogram of Absolute Step Length Symmetry Index, 6 months postoperatively, for the weight bearing as tolerated group after transformation with square root

Transformed data, as shown in Table I are used in statistical analysis. *t*-tests for independent samples and chi-square test for independence were used to compare baseline values between groups. Overall changes and changes within each of the weight bearing groups were analysed using paired *t*-tests. Analysis of changes between groups was performed in a repeated measures analysis of variance in which the Within-Subjects variables were Abs. Step Length SI, Abs Single Support SI, and slow, preferred and fast Velocity from pre-operatively to three months post-operatively, from three months post-operatively to six months post-operatively and from pre-operatively to six months post-operatively. The Between-Subjects factor was weight-bearing group, and the covariate was the pre-operative score (baseline score) when analysing from pre-operatively to three and six months postoperatively, while the three months post-operative scores were used as covariate when analysing from three months post-operatively to six months post-operatively.

Height, weight, diagnosis group, symptoms, age, operated limb and gender and prosthesis type were considered as possible covariates.

A two sided *p*-value less than or equal to 0,05 was considered to indicate statistical significance.

4.6 Research ethics

The Regional Committee for Medical Research Ethics approved the study, and all participants provided informed consent. Because this project is part of a larger project it was not possible to enclose the recommendations of the committee.

5. Results

In table II and III the descriptive statistics for subjects for each of the weight bearing groups are collected.

Table II - Descriptive statistics for nominal subjects' characteristics

	PWB		WBAT		Total	
	N=12		N=15		N=27	
	Frequency	**Percent**	**Frequency**	**Percent**	**Frequency**	**Percent**
Gender						
Male	5	42 %	5	33 %	10	37 %
Female	7	58 %	10	67 %	17	63 %
Operated hip						
Left hip	6	50 %	7	47 %	13	48 %
Right hip	6	50 %	8	53 %	14	52 %
Diagnostic group (Radiographic images)						
Unilateral OA	3	25 %	7	47 %	10	37 %
Bilateral OA 1st hip to be operated	4	33 %	5	33 %	9	23 %
Bilateral OA 2nd hip to be operated	5	42 %	3	20 %	8	30 %
Pre-operative symptoms[1]						
unilateral	8	67 %	10	67 %	18	66,7 %
bilateral	1	8 %	3	20 %	4	14,8 %
unknown	3	25 %	3	13 %	6	18,5 %
type of prosthesis[2]						
Charnley cem. F + Ogee cem. A	1	8,3 %	10	66,7 %	11	40,7 %
Spectron cem. F + Reflection A	4	33,3 %	4	26,7 %	8	29,6 %
Landos Corail F(cementl.) + Reflection	5	41,7 %			5	18,5 %
Corail cementl F +?A			1	6,7 %	1	3,7 %
Custom (cement.) F+ Reflection A	1	8,3 %			1	3,7 %
Spectron F + Opera A	1	8,3 %			1	3,7 %

1) Self reported pre-operative symptoms of subjects
2) F= Femur component, A= Acetabulum component, cem. = cemented, cement. = cementless

Diagnostic group based on radiographic images (unilateral OA, bilateral OA first hip to be operated, bilateral OA second hip to be operated) are reported in the table I. As research literature shows that there is little correlation between radiographic images and self reported symptoms in hip OA (25), the self reported symptoms are also reported in table I.

Table III - Descriptive statistics for continuous subjects' characteristics

	PWB					WBAT				
	Mean	**SD**	**Min**	**Max**	**N**	**Mean**	**SD**	**Min**	**Max**	**N**
Age (years)	64	11	43	81	12	65	6	52	76	15
Preoperative height (cm)	172	8	162	183	12	173	11	155	193	15
Preoperative weight (kg)	87	14	57	107	12	82	17	51	105	15
Pre-operative Abs Step Length SI	0,06	0,06	0,01	0,23	12	0,09	0,05	0,01	0,19	15
Pre-operative Abs Single Support SI	0,09	0,07	0,01	0,19	12	0,12	0,08	0,01	0,30	15
Pre-operative slow velocity (m/s)	0,53	0,16	0,38	0,84	12	0,53	0,13	0,33	0,83	15
Pre-operative preferred velocity (m/s)	1,02	0,26	0,55	1,47	12	0,92	0,21	0,65	1,34	15
Pre-operative fast velocity (m/s)	1,65	0,44	0,95	2,52	12	1,48	0,31	1,09	2,22	15

The self reported symptoms are the answer the subjects gave on the question 'Do you experience symptoms from your other hip?' The differences between one sided OA based on radiographic images (total 37 percent) and unilateral self reported symptoms (66,7 percent) agree with the findings of Jørring. For six subjects the self reported pre-operative symptoms are unknown. Subjects with several different types of prosthesises are included in the study.

No significant differences were found between the pre-operative groups, except for the type of prosthesis.

Figures 5 to 8 show plots over the Step Length SI and the Single Support SI against time. The plots are used to describe directions of asymmetry and change of directions of asymmetry in both groups. The 0 line is the perfect symmetry line. Negative values indicate that step length or single support on the unaffected leg is longer than the step length or single support on the affected leg. Positive values indicate that step length or single support of the affected leg is longer than step length or single support of the unaffected leg. The dotted lines at 0,1 and -0,1 are the arbitrary scale limits for what is normal as used by Balasubramanian (66). Every asymmetry between the two dotted lines can be seen as normal variation according to Balasubramanian. In Table IV directions of asymmetry are described. In Table V change of direction of asymmetry is described. Interesting is that all but one subject that change direction of asymmetry somewhere

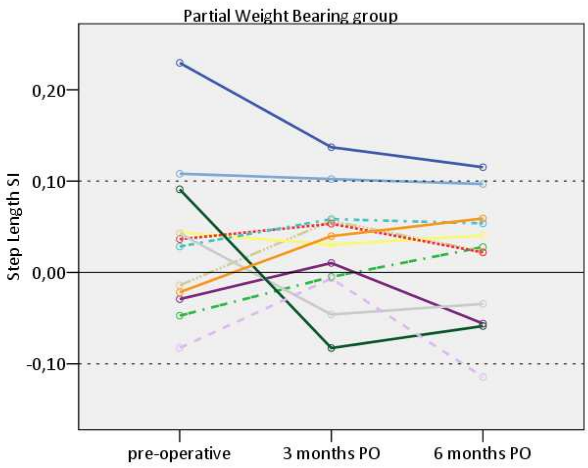


Figure 5 - Step Length SI against time for the partial weight bearing group. PO = postoperatively, SI = symmetry index

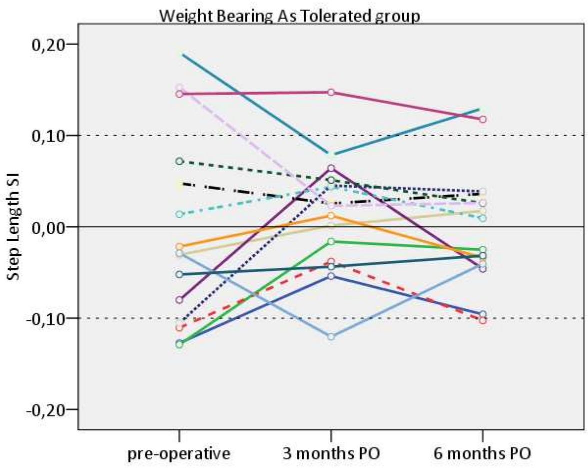


Figure 6 - Step Length SI against time for the weight bearing as tolerated group. PO = postoperatively, SI = symmetry index

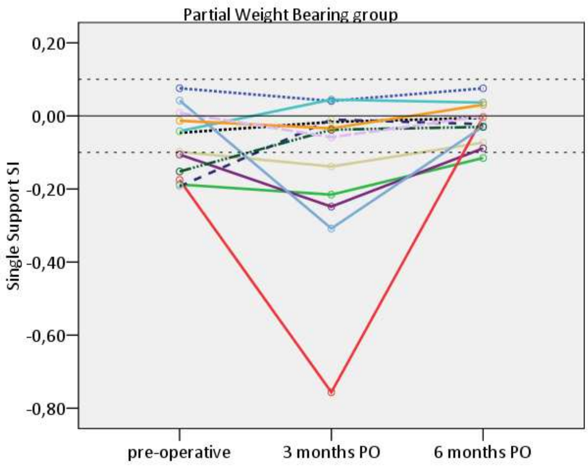


Figure 7 - Single Support SI against time for the partial weight bearing group. PO = postoperatively, SI = symmetry index

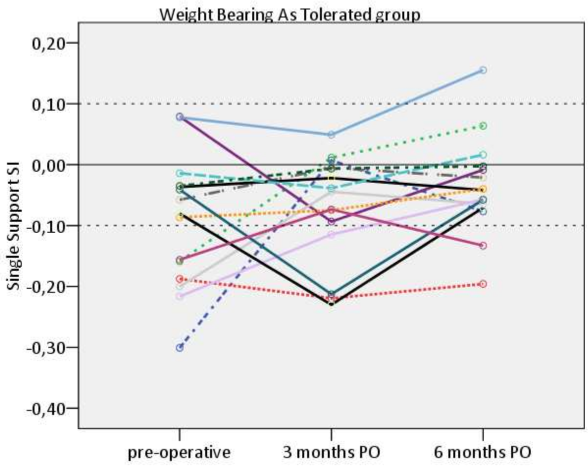


Figure 8 - Single Support SI against time for the weight bearing as tolerated group. PO = postoperatively, SI = symmetry index

between preoperatively and six months postoperatively, start with a longer unaffected Step length.

Table IV - Description of direction of asymmetry per weight bearing group

	PWB [3] N = 12			WBAT[3] N = 15		
	Pre-operative	3 months PO[3]	6 months PO[3]	Pre-operative	3 months PO[3]	6 months PO[3]
Step Length Aff.[1] > Step Length Unaff. [1]	7 (2)[2]	8 (1) [2]	8 (1) [2]	6 (3) [2]	9 (1) [2]	8 (2) [2]
Perfect symmetry in Step Length	0	1	0	0	1	0
Step length Unaff. [1]> Step Length Aff. [1]	5 (0) [2]	3 (0) [2]	4 (1) [2]	9 (4) [2]	5 (1) [2]	7
Single Support Aff. [1] > Single Support Unaff. [1]	3 (0) [2]	2 (0) [2]	3 (0) [2]	2 (0) [2]	3 (0) [2]	3 (1) [2]
Perfect symmetry in Single Support	0	0	2	0	0	1
Single Support Unaff. [1] > Single Support Aff. [1]	9 (5) [2]	10 (5) [2]	7 (1) [2]	13 (6) [2]	12 (4) [2]	11 (2) [2]

1) Aff. = Affcted, Unaff. = Unaffected
2) Numbers in brackets indicate the number of subjects that are abnormal asymmetric according to the definition of Balasubramanian.
3) PO =postoperatively, PWB = partial weight bearing, WBAT = weight bearing as tolerated

Table V - Description of change of direction of asymmetry per weight bearing group

	PWB[1]		WBAT[1]	
	between pre-operatively and 3 months PO[3]	between pre-operatively and 6 months PO[3]	between pre-operatively and 3 months PO[3]	between pre-operatively and 6 months PO[3]
Number of subjects changing from SLA [1]> SLU [1]to SLU[1] > SLA[1]	2	1	0	2
Number of subjects changing from SLU[1] > SLA[1] to SLA[1] > SLU[1]	3	1	4	0
Number of subjects changing from SSA[2] > SSU[2] to SSU[2] > SSA[2]	2	0	1	0
Number of subjects changing from SSU[2] > SSA[2] to SSA[2] > SSU[2]	1	1	2	1

1) PWB = partial weight bearing, WBAT = weight bearing as tolerated
2) SLA = Step Length Affected side, SLU = Step Length Unaffected side
3) SSA = Single Support Affected side, SSU = Single Support Unaffected side
4) PO = postoperatively

When using the criteria of Balasubramanian for what amount of asymmetry can be seen as normal, 9 of 27 subjects in total were abnormal asymmetrical in step length pre-operatively. Three months postoperatively 3 of 27 subjects had an abnormal asymmetrical step length while six months postoperatively 4 of 27 subjects had an abnormal asymmetrical step length. Pre-operatively 11 of 27 subjects had an abnormal asymmetric single support. Three months postoperatively 9 of 27 subjects had an abnormal asymmetric single support and six months postoperatively 3 of 27 subjects had an abnormal asymmetric single support.

The results from the paired *t*-tests and the repeated measures analysis of variance used for analysis of change and between group differences are presented in Table VI. No significant between group differences for change of ABS Step Length SI, ABS Single Support SI and slow, preferred and fast Velocity over time were found. There was a significant overall improvement in Abs Step Length SI from pre-operatively to three months post-operatively. From three months post-operatively to six months post-operatively there was a significant overall improvement (p<0,02) in preferred and fast velocity. From pre-operatively to six months post-operatively there was a significant overall improvement (p<0,02) in Abs Step length SI and Abs Single Support SI, and in preferred and fast velocity.

Interesting was that from pre-operatively to three months post-operatively; the WBAT group changed significantly in Abs Step Length SI, while the PWB group did not change significantly in the same period.

None of the possible covariates influenced the between group differences in change over time. And the results of testing with covariates are therefore not reported further. Figure 9-13 show the plots of the different variables against time per weight bearing group, corrected for baseline values. The non transformed data are used in the plots.

Table VI – Effect of weight bearing on Absolute Step length Symmetry Index , Absolute Single Support Symmetry Index and Velocity

	Partial Weight Bearing				Weight Bearing As Tolerated					
	N	mean	SD[3]	Change *p*-values	N	mean	SD[3]	Change *p*-values	Overall change *p*-values	Group differences in change *p*-values [2]
Abs Step Length SI[4]										
pre-operatively	12	0,06	0,06		15	0,09	0,05			
3 months PO[3]	12	0,05	0,04	0,386[1]	15	0,05	0,04	0,029[1]	0,020[1]	0,608[1]
6 months PO[3]	12	0,06	0,03	0,899[1]	15	0,05	0,04	0,004[1]	0,018[1]	0,065[1]
change 3-6 months				0,456				0,817	0,462	0,493
Abs Single Support SI[5]										
pre-operatively	12	0,09	0,07		15	0,12	0,08			
3 months PO[3]	12	0,16	0,21	0,737[1]	15	0,08	0,08	0,091[1]	0,277[1]	0,23[1]
6 months PO[3]	12	0,04	0,04	0,020[1]	15	0,07	0,06	0,015[1]	0,001[1]	0,288[1]
change 3-6 months				0,051				0,975	0,107	0,127
Slow Velocity (m/s)										
pre-operatively	12	0,53	0,16		15	0,53	0,13			
3 months PO[3]	12	0,50	0,14	0,597[1]	15	0,51	0,12	0,666[1]	0,484[1]	0,717[1]
6 months PO[3]	12	0,55	0,18	0,809[1]	15	0,58	0,13	0,325[1]	0,374[1]	0,391[1]
change 3-6 months				0,505				0,100	0,111	0,429
Preferred Velocity (m/s)										
pre-operatively	12	1,02	0,26		15	0,92	0,21			
3 months PO[3]	12	1,01	0,16	0,825[1]	15	0,90	0,18	0,621[1]	0,592[1]	0,246[1]
6 months PO[3]	12	1,12	0,19	0,061[1]	15	1,04	0,17	0,028[1]	0,003[1]	0,516[1]
change 3-6 months				0,071				0,001	0,000	0,734
Fast Velocity (m/s)										
pre-operatively	12	1,65	0,44		15	1,48	0,31			
3 months PO[3]	12	1,55	0,40	0,314[1]	15	1,49	0,39	0,842[1]	0,509[1]	0,518[1]
6 months PO[3]	12	1,81	0,44	0,023[1]	15	1,59	0,31	0,074[1]	0,003[1]	0,346[1]
change 3-6 months				0,007				0,086	0,001	0,051

Significant values are highlighted

1) Change from pre-operative values
2) Baseline value of dependent variable as co-variate.
3) PO = postoperatively, SD = standard deviation
4) Abs Step Length SI = absolute step length symmetry index
5) Abs Single Support SI = absolute single support symmetry index

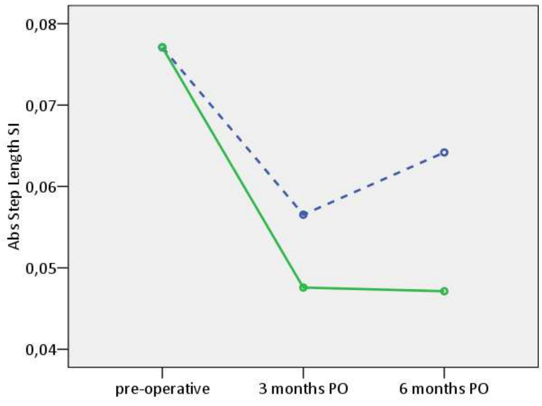


Figure 9 – Absolute Step Length Symmetry Index against time per weight bearing group. PO = postoperatively. - - - = partial weight bearing, ------- = weight bearing as tolerated

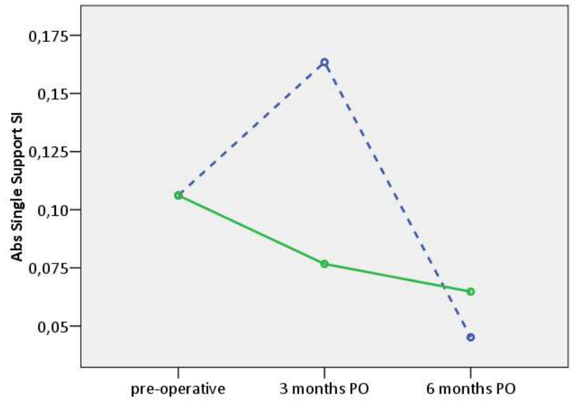


Figure 10 – Absolute Single Support Symmetry Index against time per weight bearing group. PO = postoperatively, - - - = partial weight bearing, ---- = weight bearing as tolerated

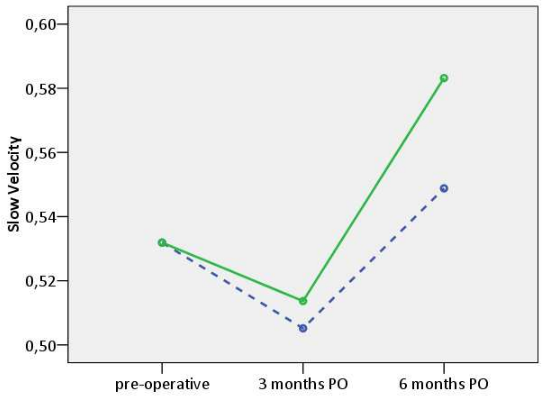


Figure 11 – Slow Velocity against time per weight bearing group. PO = postoperatively, - - - = partial weight bearing, ------- = weight bearing as tolerated

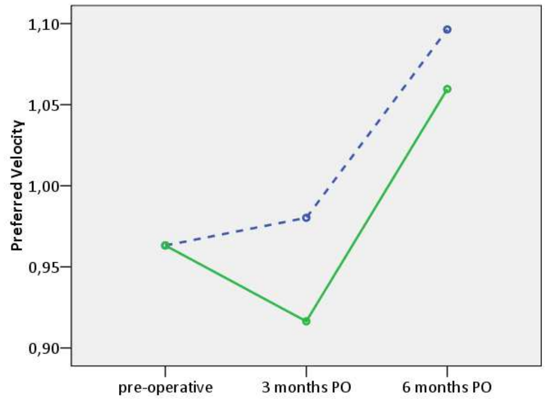


Figure 12 – Preferred Velocity against time per weight bearing group. PO = postoperatively, - - - = partial weight bearing, ------- = weight bearing as tolerated

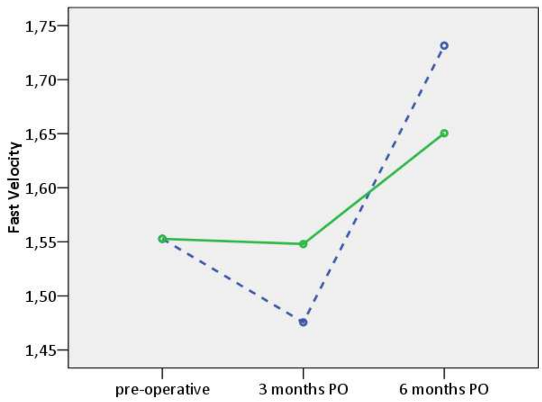


Figure 13 – Fast Velocity against time per weight bearing group. PO = postoperatively, - - - = partial weight bearing, ------- = weight bearing as tolerated

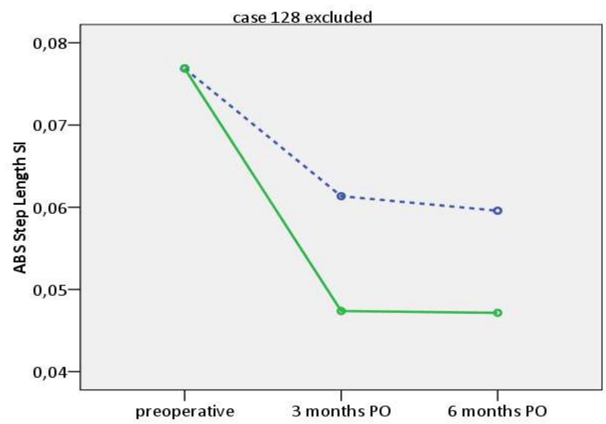


Figure 14 - Absolute Step Length Symmetry Index against time per weight bearing group. PO = postoperatively, - - - = partial weight bearing, ------- = weight bearing as tolerated

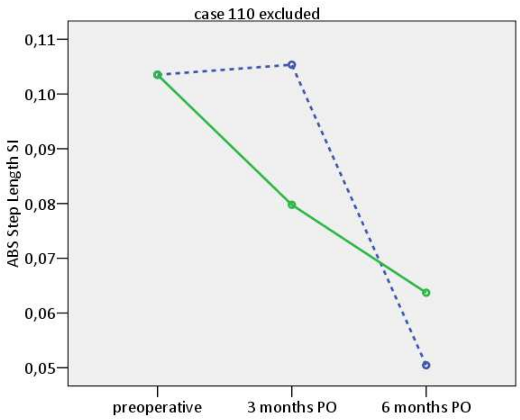


Figure 15 - Absolute Single Support Symmetry Index against time per weight bearing group. PO = postoperatively, - - - = partial weight bearing, ------- = weight bearing as tolerated

The plot for Abs Step Length SI (Fig.9) shows that both groups of subjects get slightly more symmetric from pre-operative to three months post-operative. From three months post-operative to six months post-operative though, the partial weight bearing group gets more asymmetric in step length while the weight bearing as tolerated group continues in improving in Step length symmetry. This is mainly the influence of one subject that was not defined as an outlier by SPSS. As the sample size is small, the influence from each subject on the mean score is relatively large and plots can change a lot by taking away just one subject. When plotting the mean Abs Step Length SI against time for each of the weight bearing groups, but this time with one case excluded the plot became like the plot in Figure 14. It now it seems that the subjects in the 20-30 kg weight bearing group follow the same pattern in regaining symmetry as the weight bearing as tolerated group, but they are more asymmetrical than the weight bearing as tolerated group.

In figure 10 the plot for Abs Single Support SI shows a quite different pattern in regaining symmetry for both groups compared to Abs Step Length SI. Again the WBAT group shows a steady improvement in Single support symmetry over time. But the PWB group becomes more asymmetrical (p = 0,737) from pre-operatively to three months post operatively. Again one subject influenced the mean values because of the small sample size. Figure 15 shows what the plot looks like when this subjects is excluded.

6. Discussion

Direction of asymmetry of step length and single support time

When looking at table IV the first thing that attracts attention is the variability in direction of step length and single support asymmetry pre operatively, and at three and six months post operatively in both groups. By analysing visually there were no obvious differences in direction of symmetry per weight bearing group. Though to be sure, t-tests could have been used to analyse if there were statistical differences in direction of symmetry. The majority of subjects in both groups had a longer single support time on the unaffected limb, but in both groups there is a minority of subjects that had a longer single support time on the affected limb. It would have been interesting to analyse if those subjects with a longer single support time on the affected limb, were the subjects with bilateral problems. The majority of the subjects in the PWB group had a longer step length at the affected limb preoperatively, and three and six months postoperatively, a minority of the subjects in the PWB group had a longer step length at the unaffected limb. In the WBAT group the amount of subjects having a longer step length at the affected limb is more even with the amount of subjects having a longer step length at the unaffected limb. If this is a different tendency because of different weight bearing instruction is impossible to tell without testing statistical. Table IV suggests also that having a longer single support time at the unaffected side, does not always result in a longer step length at the unaffected side, as the numbers of subjects having a single support time longer at the unaffected side is not the same as the number of subjects having a longer step length at the affected side. A possible explanation can be decreased range of motion of the affected hip.

Variability was also observed in both the weight bearing groups for change of direction of asymmetry for step length or single support. It seems that most changing of direction of asymmetry occurs between surgery and three months postoperatively. What the reasons for those changes of direction of asymmetry are is not known, again it would be interesting to analyse if those subjects that change direction of asymmetry, were the subjects with bilateral problems. This description of direction of symmetry give a more complete picture on how symmetry in THR patients is changing, than when only mean values or absolute symmetry indexes are used in data analysis. These results correspond to Kirtleys statement that it should not be assumed that the side with the longer step length is healthier (61). The variability in direction of asymmetry could be an explanation for the variation in direction of asymmetry of step length reported in literature. Because the reported values often are mean values, in case of variability it may become by chance if the mean step length of the unaffected or affected limb is longer.

Results ANOVA

No significant between group differences for change of ABS Step Length SI, ABS Single Support SI and slow, preferred and fast Velocity over time were found. Anderson et al (9) found that three months postoperatively the subjects instructed with WBAT walked faster than the subjects instructed with PWB. Surprisingly in this study, as seen in Table VI, the subjects instructed with PWB walked faster than the subjects instructed with WBAT at preferred and fast walking speed three months postoperatively, though *t*-tests for analyzing difference between the two groups postoperatively are not reported in this thesis. The results agree with the results of Anderson et al (9) that there was no difference in gait velocity between the two weight bearing groups at 6 months postoperatively.

As there is no previous research on symmetry in gait and instructions on weight bearing, the overall changes were compared with previous research on gait in hip OA and gait in THR. The significant overall improvement in Step length symmetry, Single support time symmetry from preoperatively to 6 months postoperatively agree with the results of Lindemann (67) that stance phase symmetry ratio improved after three months, and with the results of Wall (62) that the step lengths and single support time for both sides were more equal after six months. The significant overall improvement of preferred and fast velocity from three to six months postoperatively and from preoperatively to six months postoperatively agrees with the results of Miki (71) that walking speed was increased significantly in comparison with preoperatively by six months after surgery.

Plots

The plots of the different variables over time show that subjects in both the weight bearing groups improve in step length symmetry and single support time symmetry over time. Though, in Figure 9, it seems that for step length symmetry the improvement is slower in the PWB group than in the WBAT group. And in Figure 10 it seems that improvement in symmetry for single support for the PWB group starts after subjects are allowed to bear full weight. This could mean that weight bearing is an important factor for improvement of single support time symmetry. A possible reason could be that when walking with PWB and crutches the Single Support is more affected than the step length. The step length can remain normal in walking with PWB. The subjects instructed with PWB have been using crutches for three months and are then asked to walk without crutches in test situation. It seems reasonable to assume that due to disuse they then have a shorter Single support in test situation. After three months the PWB group shows an improvement in Single support symmetry better than the WBAT group ($p = 0.127$). It would be interesting to see if a larger sample size would give statistical differences for these outcome measures.

In Figure 11, the plot over slow velocity against time, the mean velocity of both groups shows the same pattern over time. They both walk slower three months post-operatively than pre-operatively and then walk faster six months post-operatively. The mean preferred velocity in Figure 12 for the WBAT group three months post-operatively is, when corrected for baseline values, lower than the PWB group. The PWB group walks faster than the WBAT at six months post-operative. The reason for this fact is unknown and could be by chance as it is not a statistical difference.

In Figure 13, the WBAT group remains relatively unchanged from pre-operatively to three months post-operatively; from three to six months post-operatively they improve in fast velocity. While the PWB group first decreases walking speed compared to preoperatively from pre-operative to three months post-operative, but then improves more from three months PO to six months PO than the total improvement in fast velocity of the WBAT group from pre-operative to six months PO.

Methodological flaws:

In this research project the instruction weight bearing a patient get postoperatively is used as group comparison. We noticed when talking with the subjects about weight bearing restrictions, that weight bearing instructions are differently explained by different patients. It is uncertain in whether all patients complied with the instructions. Several researchers have shown that there is little correlation between instruction of PWB and the actual load bared on the limb (55, 88-90). Subjects that were supervised continuously during a trial after being instructed in partial weight bearing by a physical therapist did, despite of this, not manage to stay within prescribed weight bearing limits. In addition many of them misjudged their ability to follow instructions (55). If the intention is to ensure reduced weight bearing for longer periods it is necessary to use some type of feedback device, which provides a warning when load levels have passes a predetermined threshold for a predefined time or for a certain number of steps (55). Prescription of reduced weight bearing might at least make the patient aware that they should reduce their level of activity (55). Because no shoe device was used in this study, it is unknown how long and in what amount the subjects in the PWB group were capable of PWB. The minor group differences in this project can be a confirmation of these findings. Probably patients did not bear partial weight and maybe in reality the groups were much more alike than it seemed when just looking at the instruction of weight bearing. Also in case of the subjects instructed with WBAT it is not known if they were placing full weight on the limb or if they in fact reality were walking with PWB. A WBAT group can be a very variable group where some participants may bear full weight while others bear partial weight.

Another possible reason for why weight bearing instructions did not result in between group differences in symmetry in step length and single support time can be that preoperative gait adaption that remains postoperatively may influence gait symmetry more than the weight bearing instructions. White (34) refers to Andriacchi who proposed that persons with joint pathology develop adaptive gait strategies that become habitual. Consequently these antalgic movement patterns may persist even after the patient has undergone successful treatment and rehabilitation.

In this project the symmetry index was used to measure improvement in gait. A problem can be that several patients had bilateral hip problems. The usefulness of the symmetry index may be questioned for persons with bilateral hip symptoms. Assuming that the worst hip is operated on first, a symmetry index still can be interesting. But in those patients it may be interesting to look also at the Step Length SI and Single Support SI as it says more about which limb the longest step length or single support has. Both symptoms and diagnostic groups are used as covariates in data analysis, and did not influence the between-group differences.

The amount and quality of physiotherapy patients got is not documented, so it is unsure too what amount this influences results. Too little is known about post operative physical therapy and hospital stay to use this information as a covariate. All patients got post operative physical therapy during hospital stay. After discharge some patients were staying at a rehabilitation centre, while others were training at a physical therapy clinic. Whether or not differences in post-operative exercises can influence symmetry ratios and velocity is unknown, but probably this is only one of many factors influencing gait asymmetry and velocity.

One assumption for using parametric tests is random selection. The assumption of random selection may be violated as the data sets used for analysis are relatively normally distributed (78). Because the individuals are not assigned randomly to groups, there is a possibility that the groups are non-equivalent, though this is controlled for by using pre-test values as covariates. The results may be affected by the small sample size of the study. Also wide range of variability can explain why differences are not significant.

To be included participants had to be able to walk ten meters unassisted, to have a gait speed of no less than 0,9 m/s and not have any other musculoskeletal impairments that could influence walking. Hence our sample may not be representative for all THR patients. The subjects are probably active and well functioning compared to the whole population of THR patients. This can be an explanation for the relatively low rate of subjects with asymmetry more than normal.

Comparing symmetry in step length and single support time at a corrected speed of 0,9 m/s means that theoretically a subject walking at his or her individual slow speed can be compared with a subject walking at his or her individual fast speed. Möckel et al found in their study that pathological changes in gait patterns were found at different gait speeds they investigated, with the changes more accentuated at higher speeds (91). Possibly, different results could be found when symmetry indexes from preferred and fast speed were analyzed.

Because no previous research was found on gait symmetry and different weight bearing instructions the gait parameters chosen, step length, single support time and velocity were those used in other studies on gait in OA and THR. It is however not certain that those outcome measures are the best suited to indicate differences between different weight bearing groups. Maybe a combination of other spatio-temporal gait parameters as outcome measures or spatiotemporal gait parameters in combination with accelerometer data and for example data about activity level could show between group differences. PWB may affect level of activity more than symmetry in gait.

An important issue is how to interpret the symmetry indexes. What amount of asymmetry is normal? When using symmetry indexes it is important to know what the clinical relevance of a change in symmetry index is and what asymmetry can be considered as abnormal. When using the criteria of Balasubramanian for what amount of asymmetry can be seen as normal on the data in this project, it means that the majority of subjects are normal asymmetric at all data collections. As it sounds somewhat strange that so few of hip OA patients waiting on THR have abnormal asymmetry, it could be questioned if the range of what is normal is too wide. More research is needed on what amount of asymmetry is normal and which index is the best for evaluating change in gait.

7. Conclusion

There were no observed between group differences in direction of symmetry and change of direction of symmetry for the PWB group and WBAT group in this sample. No significant between group differences were found for change over time of slow, preferred and fast Velocity, and for change over time of Abs. Single Support SI and Abs. Step Length SI.

Subjects instructed with PWB in this sample do not differ from patients instructed with WBAT, with regard to velocity and regaining symmetry in step length and single support time. They don’t need extra exercises for regaining symmetry in walking after their PWB period.

Whether bigger sample size or use of other outcome measures would give a significant difference, is unknown and will further research is needed for an answer.

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Til deg som skal sette inn totalprotese i hoften

Invitasjon til deltagelse i forskningsprosjekt

Mange med hofteleddsartrose venner seg til en haltende gange som følge av stivhet og smerte i hofte og ben. Etter innsetting av totalprotese blir det derfor viktig å gjenvinne et vanlig gangmønster slik at feilbelastninger av andre ledd kan unngås.

Ved Universitetet i Bergen er det utviklet mobilt utstyr som registrerer stegene og overkroppens bevegelser når du går over en matte.

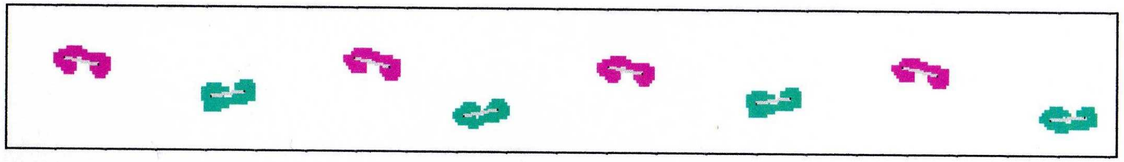
I samarbeid med Dr. Nordsletten ved Ullevål Universitetssykehus, ønsker vi å tilby deg en slik gangundersøkelse, før den planlagte operasjonen hvor du får innsatt protese i hoften, samt 3, 6 og 12 måneder etter operasjonen.

Du skal ha på deg vanlige klær og gå frem og tilbake over matten mens instrumentene samler informasjon om gangmønsteret ditt. Det er ingen ubehag ved undersøkelsen. I tillegg ønsker vi at du fyller ut et spørreskjema om dine hofteplager.

Hver undersøkelse tar ca. 20 minutter, og vil foregå på Ullevål Universitetssykehus. Tidspunkt avtales direkte med deg.

Alle opplysninger behandles konfidensielt. Det er frivillig å delta og du kan når som helst trekke deg uten nærmere forklaring.

Blir du med? Ta kontakt med Willemijn Vervaat, Caroline Hodt eller din lege på poliklinikken.



Caroline Hodt
Stipendiat, cand.scient, fysioterapeut
Sofiesgt 39, 0168 Oslo
caroline.hodt@isf.uib.no
Tlf: 22 46 42 36 Mobil: 92 24 30 01

Rolf Moe-Nilssen
Professor, dr.philos, fysioterapeut
Universitetet i Bergen

Willemijn Vervaat
Fysioterapeut, masterstudent,
Ortopedisk avdeling
Ullevål Universitetssykehus
Willemijn.Vervaat@student.uib.no
Tlf: 91 77 78 87

Supplement 1

Id nr: H ....

Forespørsel om deltakelse i forskningsprosjekt

Gangfunksjon etter innsetting av totalprotese i hoften

Mange med hofteleddsartrose venner seg til en haltende gange som følge av stivhet og smerter i hofte og ben. Etter innsetting av totalprotese blir det derfor viktig å gjenvinne et vanlig gangmønster slik at feilbelastninger av andre ledd kan unngås.

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Du skal ha på deg vanlige klær og gå frem og tilbake over matten mens instrumentene samler informasjon. Deretter skal du fylle ut et spørreskjema om dine hofteplager. Undersøkelsen tar ca 20 minutter, representerer ingen risiko og vil foregå på Ullevål Universitetssykehus. Tidspunktet for testene avtales direkte med deg.

Registrerte opplysninger behandles konfidensielt. Det er frivillig å delta. Du kan når som helst trekke deg uten nærmere forklaring. Dersom du stiller deg positiv til deltakelse ber vi deg undertegne ett eksemplar av dette skrivet. Spørsmål eller kommentarer kan rettes til undertegnede.

På forhånd takk for at du stiller opp!

Oslo, - 2005

Caroline Hodt
PhD stipendiat, fysioterapeut
Inst for samfunnsmed fag
Seksj for fysioterapivitenskap
caroline.hodt@isf.uib.no
Tlf: 92 24 30 01

Willemijn Vervaat
Fysioterapeut, masterstudent
Ortopedisk avdeling
Ullevål Universitetssykehus
Willemijn.vervaat@student.uib.no
Tlf: 91 77 78 87

Rolf Moe-Nilssen
Professor, Dr.philos, fysioterapeut
Inst for samfunnsmed fag
Seksj for fysioterapivitenskap
rolf.moe-nilssen@isf.uib.no
Tlf: 55 58 61 70

Samtykkeerklæring

Jeg har lest informasjonen på dette arket og samtykker i å delta på de premisser som er skissert. Jeg er klar over min rett til å trekke meg fra prosjektet uansett tidspunkt og uten nærmere forklaring.

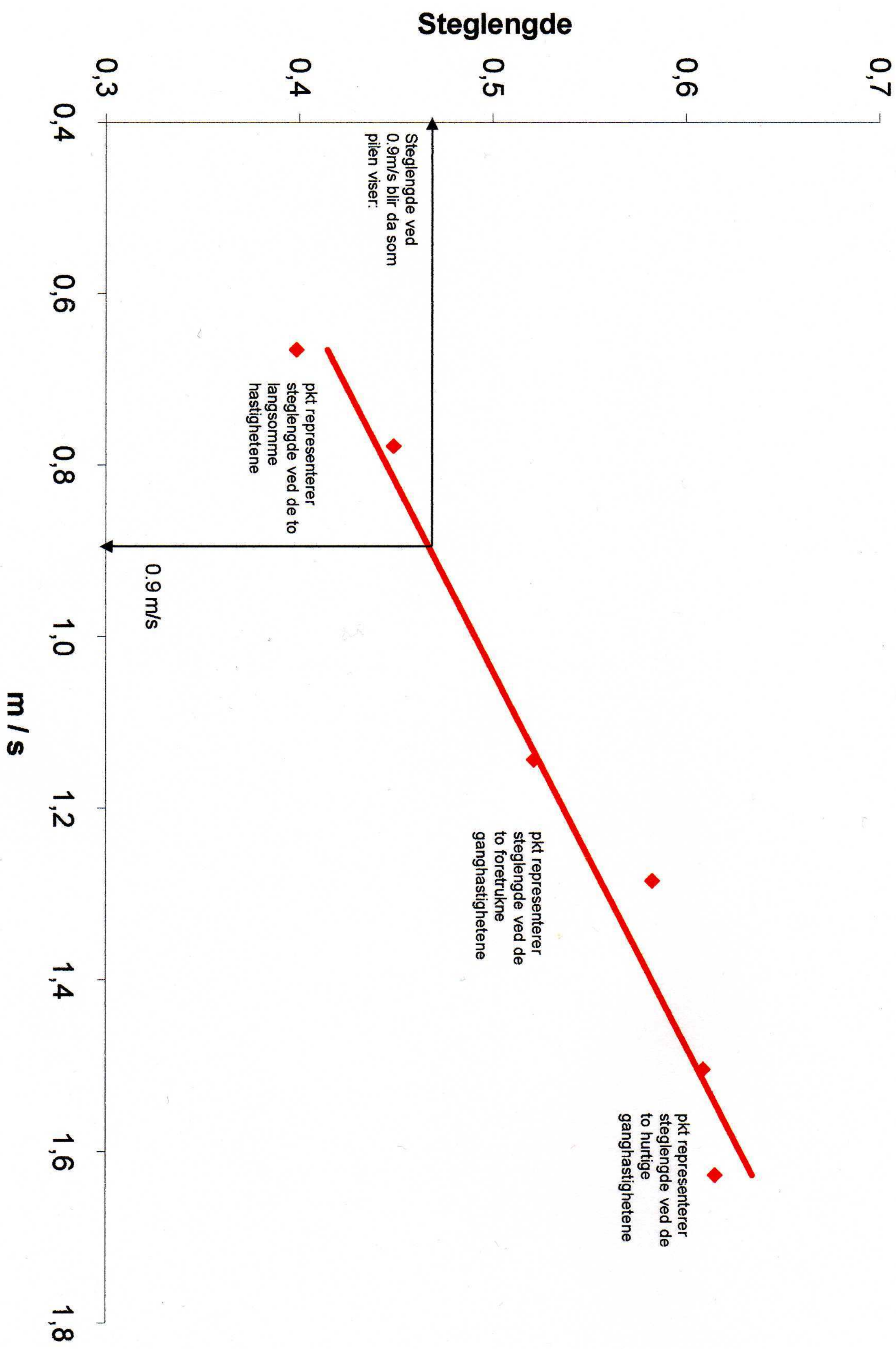
Sted: .... Dato:............................ -2005

Signatur .... Trykte bokstaver ....

Adresse: ....

Tlf: ....

Supplement 2



Supplement 3, copied from Caroline Hodt-Billington