AN EXPLORATIVE STUDY OF FACTORS INFLUENCING HEALTH-RELATED QUALITY OF LIFE IN PATIENTS WITH FEMORAL FRACTURES

RUTH SIEBRITZ

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SUPERVISORS:

ROMY PARKER MSc (Pain); BSc (Med)(Hons)Ex Sci (Phys); BSc(Phys)

THERESA BURGESS PhD (Exercise Science); MHSc (Bioethics); BSc (Phys)

UNIVERSITY OF CAPE TOWN

FACULTY OF HEALTH SCIENCES

DEPARTMENT OF HEALTH AND REHABILITATION SCIENCES

DIVISION OF PHYSIOTHERAPY

University of Cape Town

Declaration

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List of Abbreviations

ADL	Activities of Daily Living
AIDS	Acquired Immune Deficiency Syndrome
ASIS	Anterior Superior Iliac Spine
BBS	Berg Balance Scale
CT	Computed Tomography
DGI	Dynamic Gait Index
EU	European Union
FPS	Faces Pain Scale
FWB	Full Weight Bearing
GSH	Groote Schuur Hospital
GSW	Gunshot wound
HAQ	Health Assessment Questionnaire
HHD	Hand-held dynamometry
HIV	Human Immunodeficiency Virus
HRQoL	Health-related Quality of Life
ICC	Intra-class Correlation Coefficient
ICD	International Classification of Disease
ICF	International Classification of Functioning, Disability and Health
ICU	Intensive Care Unit
IM	Intramedullary
IPT	Iowa Pain Thermometer
LLD	Leg Length Discrepancy
MAD	Mobility Assistive Device
MOS	Medical Outcomes Study
MP	Muscle Power
MPQ	McGill Pain Questionnaire
MRI	Magnetic Resonance Imaging
MVA	Motor Vehicle Accident
NRS	Numerical Rating Scale
NWB	Non Weight Bearing
ORIF	Open Reduction and Internal Fixation
PWB	Partial Weight Bearing
QoL	Quality of Life

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ROM	Range of Motion
SA	South Africa
SE	Self-efficacy
SF-36	Short Form 36
S-MFA	Short Musculoskeletal Functional Assessment
TMM	Tape Measure Method
TUG	Timed Up-and-Go
TWB	Touch Weight Bearing
VAS	Visual Analogue Scale
VD/RS	Verbal Descriptor/Rating Scale
WB	Weight Bearing
WHO	World Health Organisation
WHODAS	World Health Organization Disability Assessment Scale

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Glossary of Terms

Anterior knee pain: This term refers to pain that is experienced in the front of the knee following IM nailing of the femur. It is a complication following IM nailing in femoral fractures[1-2].

Callus: A composite mass of tissue that forms at a fracture site. It establishes continuity between the bone ends. This tissue eventually becomes bone[3].

Cast braces: A specially designed plaster or plastic brace with hinges and other brace components. It is used in the management of fractures to promote early activity and joint mobility. This brace is often referred to as a functional brace[4].

Closed fracture: Often called a simple fracture. The skin overlying the fracture site remains intact[5].

Comminuted fracture: A type of fracture pattern in which the bone breaks into fragments. Lateral and longitudinal continuity of the bone is lost[5-6].

Dynamometer: An instrument used to measure muscle power[3].

Femoral cervical fracture: A fracture on the neck of the femur[4].

Fracture: A break or loss in continuity of the bone[5].

Functional muscle strength: The sufficient amount of muscle power which allows the individual to perform activities of daily living[7].

Goniometer: A calibrated instrument used to measure the arc or range of motion of a joint[3].

Goniometry: The practice of measuring joint range of motion using a goniometer[3].

High-income country: High-income countries have a gross national income above US$12 276 per capita[8].

Implant: In orthopaedics, this refers to a plastic or metal devices used in the reconstruction of bone[3].

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International Classification of Disease (ICD) – 9 coding system: This is a classification system (Ninth Revision) of specific conditions and diseases determined by an internationally representative expert committee, which advises the World Health Organisation (WHO)[9].

Internal fixation: Stabilisation of fractured bone fragments by direct fixation to each other by means of implants such as plates, screws, nails, wires, pins and rods[5].

Intertrochanteric fracture: A fracture which lies between the lesser and greater trochanter of the femur[4].

Intramedullary nail: A metal implant which fits into the medullary cavity of a long bone[6].

Isokinetic muscle strength: The muscle power produced when a muscle contracts and shortens at a constant speed[3].

Isometric strength: The muscle power produced when a muscle is contracted and held fixed so that the contraction produces increased tension at a constant overall length[3].

Isotonic muscle strength: Indicates the muscle power produced when the muscle contracts and shortens against a constant load for example such as when lifting a weight[3].

Leg length discrepancy: An alternative term for anisomelia which indicates a difference in the length of the bones of the legs causing one to be longer than the other[10].

Low-income country: A term to refer to a country with a gross national income per capita of US$1 005 or less[8].

Malalignment: The state of a bone to be abnormally aligned[11].

Malrotation: The state of a bone to be abnormally rotated[11].

Middle-income country: Refers to a country with a gross national income per capita between US$1 006 and US$12 275[8].

Midshaft: A term to indicate the middle of the shaft i.e. in the middle of the diaphysis of a bone[4].

Oblique fracture: A fracture pattern in which the fracture line runs obliquely to the axis of the bone[11].

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Open fracture: Also referred to as compound fractures. The skin overlying the fracture site is perforated and there is an open wound communicating with the fracture[5].

Open reduction and internal fixation: The procedure in which a fracture site is exposed and fixated internally using orthopaedic implants[4].

Orthoroentgenogram: Refers to an orthopaedic X-ray. A negative image or photographic film made by exposure to X-rays that have passed through matter[10].

Osteopaenic bone: Bone characterised by decreased calcification and reduced bone mass per unit volume[5].

Pathological fracture: A fracture occurring at a site on the bone weakened by a pre-existing disease[5].

Pertrochanteric fractures: A fracture occurring through the greater trochanter of the femur[4].

Prograde: Also referred to as antegrade; the term denotes the direction (superior to inferior) from which the intramedullary nail is inserted into the shaft[1].

Range of motion: A term which denotes the variation in the angles of movement through which a joint is able to move[12].

Scanogram: A radiographic technique which is used to show the true dimensions of a structure by moving a narrow orthogonal beam of x-rays along the length of the structure to be measured for example, the leg[3].

Segmental fracture: A fracture at two parts on the bone dividing the bone shaft into segments[11].

Skeletal traction: A pulling or dragging force which is applied to a limb in a distal direction. This is done by means of weights applied to a pulley via a metal pin which is inserted through the shaft of the bone[11].

Spaza shop: An informal convenience shop business often in the informal settlements of South Africa, engaged in trading consumer goods. The shop is usually run from home. The income from the shop is used to supplement the owner's income[13].

Spiral fracture: A type of fracture pattern where the fracture has a helical pattern in the bone[11].

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Statically-locked IM nails: This refers to the intramedullary nailing of fractured bones combined with percutaneous insertion of screws that interlock the bone and the nail[6].

Spicas: A brace made of plaster of Paris used to immobilize a body part, usually a limb[5].

Trendelenburg gait pattern: A walking pattern characterised by weakness of the abductor muscle of the hip causing the pelvis to drop on the unaffected side during walking[11].

Trochanteric pain: Pain experienced over the greater trochanter of the femur following IM nailing[14].

Union: The state of healing of bone when the bony ends have come together and there is minimal movement at the fracture site[4].

Weight-bearing: A term referring to the transmission of body weight through a limb[15].

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Abstract

Background: At Groote Schuur Hospital (GSH) in Cape Town, South Africa, patients with traumatic femoral fractures are surgically managed with intramedullary (IM) nails. Little is known about the factors that influence level of disability and health-related quality of life (HRQoL) following traumatic femoral fractures in a local setting.

Aim: The first aim was to document the HRQoL in patients that sustained traumatic fractures of the shaft of the femur. The second aim was to describe the factors contributing to clinical outcome following traumatic femoral shaft fractures in patients admitted to the traumatic orthopaedic wards at GSH.

Specific Objectives: The objectives of the clinical case series were: **(a)** to determine the HRQoL, pain scores, activity limitations and self-efficacy (SE) of participants that sustained traumatic femoral shaft fractures at discharge from hospital, and at two weeks, four weeks, six weeks and 12 weeks post-surgery **(b)** to determine the functional outcome variables (range of motion (ROM), muscle power (MP), oedema, weight bearing (WB) status and leg length discrepancy (LLD)) in participants that sustained traumatic femoral shaft fractures at these same time frames and **(c)** to determine whether there were differences between the mechanism of injury (gunshot wound (GSW) versus non-gunshot wound (non-GSW)) and the functional outcome variables of pain scores, activity limitations, SE and HRQoL. The objectives of the chart review study were: **(d)** to describe the socio-demographic and clinical attributes of participants that sustained an isolated traumatic femoral shaft fracture **(e)** to investigate if level of disability could be determined from the participants' medical folder history using the revised World Health Organisation Disability Assessment Schedule Version II (WHODASII) **(f)** to investigate whether revised WHODASII scores were associated with variables of gender, employment status, education, source of referral, mechanism of injury, fracture patterns, length of hospital stay, inpatient care, and outpatient care including adherence with fracture management.

Methods: This study consisted of two parts. Part one was a clinical case series. A descriptive, prospective longitudinal case series was conducted. Participants included males and females between the ages of 18 and 45 years, who had sustained a traumatic femoral shaft fracture that had been reduced using a prograde IM nail. On the day of discharge from hospital, the participant completed five questionnaires; a self-developed demographic questionnaire, the Pain Visual Numeric, the Stanford Activities/Role limitations questionnaire, the Health Assessment Questionnaire-8 Disability Index (HAQ-8) and the EQ-5D questionnaire. Medical history was recorded from the participant's medical folder. Range of motion of hip flexion and abduction, knee flexion and extension and ankle dorsiflexion of both legs were measured with a goniometer on the day of discharge. Muscle power of the thigh muscles (hip abductors and flexors) as well as knee flexors (hamstrings) and extensors (quadriceps) were also measured using a hand-held dynamometer (HHD). The WB status, oedema measurements of the thigh and leg length measurement were recorded. Each participant performed the "Timed Up and Go" (TUG) test with their mobility assistive device (MAD). The questionnaires and clinical tests were performed again at two weeks, four weeks, six weeks and 12 weeks post-surgery at the Physiotherapy Outpatient Department.

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Part two was a chart review study that consisted of a retrospective audit of patients' folders. All the folders of patients admitted to GSH Traumatic Orthopaedic wards during the period of March 2007 and March 2011 that met the inclusion criteria were included. Folders that fulfilled the inclusion criteria were analysed during a two month period.

Results: ***Clinical case series:*** Eight participants were included. Seven participants reported improvement in their HRQoL over the study period. It appeared that impairments such as MP, ROM, LLD, oedema, pain and problems with gait were associated with improvements in HRQoL. No obvious differences were observed in HRQoL outcomes regarding the mechanism of injury. A lack of post-hospital physiotherapy was noted. Non-adherence was a limiting factor in this study. Half of the participants failed to complete the post-discharge assessments. ***Chart review study:*** A total of 165 folders were included. Of the sample, 81% were male. The mean age was 27 years (± 6.4 years) at the time of fracture. Most of the patients were referred from the Trauma Unit (n = 77) followed by Community Health Centre referral (n = 64) and Secondary Hospital referral (n = 24).Significantly, more of the GSW's were referred from the Community Health Centres ($\chi^2 = 17.59$; df = 4; $p < 0.01$). Most of the fractures were sustained via MVA's (n = 71; 43%) followed by GSW's (n = 70; 42.4%). There was a significant difference in mechanism of injury when explored by gender ($\chi^2 = 28.90$; df = 7; $p < 0.01$) and the type of fracture pattern ($\chi^2 = 97.79$; df = 8; $p < 0.01$). Most of the sample (63.63%) was non-adherent with their outpatient follow up. A significant difference between gender and adherence with fracture management was found ($\chi^2 = 5.63$, df=1; $p = 0.01$). The WHODAS II was unable to detect level of disability from the medical charts due to a lack of data. Analysis of disability based on this outcome measure was limited.

Discussion: ***Clinical case series:*** Non-adherence with post-discharge physiotherapy was a major finding in the study. Participants had developed coping skills to manage pain which was associated with increased levels of self-reported SE and improvement in HRQoL. This improvement in HRQOL was noted despite deficits in the variable outcomes at the end of the study period. ***Chart review study:*** The findings of the study highlighted that medical professionals used a predominantly biomedical model of care in the management of patients with femoral fractures. The absence of a patient-centred approach within the ICF framework may lead to sub-optimal care following traumatic femoral fractures.

Conclusion: The study highlighted the impairments associated with IM nailing of femoral fractures and the issue of non-adherence with rehabilitation post-hospital discharge. The results of this study cannot be generalised to the larger population because of the small sample. A holistic approach within the ICF framework needs to be adopted in order to minimise the disability associated with impairments, activity limitations and participation restrictions that result following traumatic femoral shaft fractures. This may facilitate treatment and rehabilitation adherence. Further research is needed to investigate the factors associated with poor adherence post-hospital discharge.

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Chapter 1: Introduction and Scope of the Thesis

1.1 Introduction

South Africa is faced with the unique quadruple burden of disease[16]. Previously, local health challenges were concerned with the three burdens of chronic and degenerative diseases, infectious diseases and malnutrition and the Human Immunodeficiency Virus (HIV) along with the Acquired Immune Deficiency Syndrome (AIDS) pandemic. More recently, morbidity and mortality related to trauma and violence has added to this health burden as a fourth factor[16-17].There is growing evidence that musculoskeletal-related trauma constitutes a steadily increasing proportion of the global burden of disease[18]. The lack of reliable health statistics in South Africa has made measurement of the impact of these injuries difficult to evaluate[19].

It has been reported that the burden of traffic accidents and interpersonal violence in South Africa is higher compared to the rest of Africa and South East Asia[19]. By the year 2000, the number of road traffic injuries in South Africa was double the global rate. Injuries related to interpersonal violence and road traffic injuries were the second leading cause of loss of healthy life. It accounted for 14.3% of all disability adjusted life years (DALYs) in South Africa. Interpersonal violence accounted for 6.5% of disability adjusted life years (DALY), whereas road traffic accidents accounted for 3% of DALYs. These rates were higher than the rest of Africa during the same time period. An urgent need to incorporate the influence of non-fatal outcomes in the measure of injury in South African health systems is therefore required[19].

Femoral fractures are common in young adults following high energy injury[20], such as road traffic accidents, sports injuries[14] and gunshot wounds[21]. The incidence of femoral fractures resulting from violence and road traffic accidents in South Africa has yet to be adequately documented. An unpublished study[22] presented at the South African Orthopaedic Congress in September 2012 provided some insight regarding South African statistics. The results indicated that 12 000 (2.2%) outpatients and 14 000 (13.8%) casualty patients with traumatic orthopaedic-related injuries were managed at the hospital in 2011. Tibial and femoral fractures were the most common traumatic orthopaedic injuries. The authors concluded that orthopaedic trauma was a major burden to the local community and contributed significantly towards the escalating costs of health care[22].

The gold standard for management of femoral fractures is surgical fixation with an intramedullary (IM) nail. The use of the IM nail for surgical fixation of femoral fractures has become the norm within low- to middle-income countries[23].

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Intramedullary nailing of the femur allows for good bone healing and early mobilisation of the patient[1, 6, 24]. Surgical outcomes following IM nailing include high rates of bony union (95 - 99%)[6], infrequent malunion and infection and reduced morbidity and mortality rates[1]. However, these surgical outcomes were focussed on biomedical parameters. Functional outcomes and quality of life (QoL) following IM nailing have not been adequately investigated. The concept of QoL includes elements of the individual's functional status and well-being as well as aspects that are not directly related to health, such as finances and the environment[25]. The QoL of an individual following a femoral fracture (that may be affected by social support structures and the community) is unknown. The biomedical model of management for femoral fractures is inadequate to provide holistic care to influence QoL. The bio-psychosocial model of care, as proposed by the International Classification of Functioning, Disability and Health (ICF) framework, is therefore more applicable to these patients. It allows emphasis to be placed on health and functioning, rather than disability[9].

The ICF framework evaluates the constructs of impairment, activity limitation and participation restrictions along with contextual (personal and environmental) factors that affect disability in an individual[9]. The ICF model may be complex with feedback loops between the constructs as well as between the contextual factors[26] (Figure 1-1).

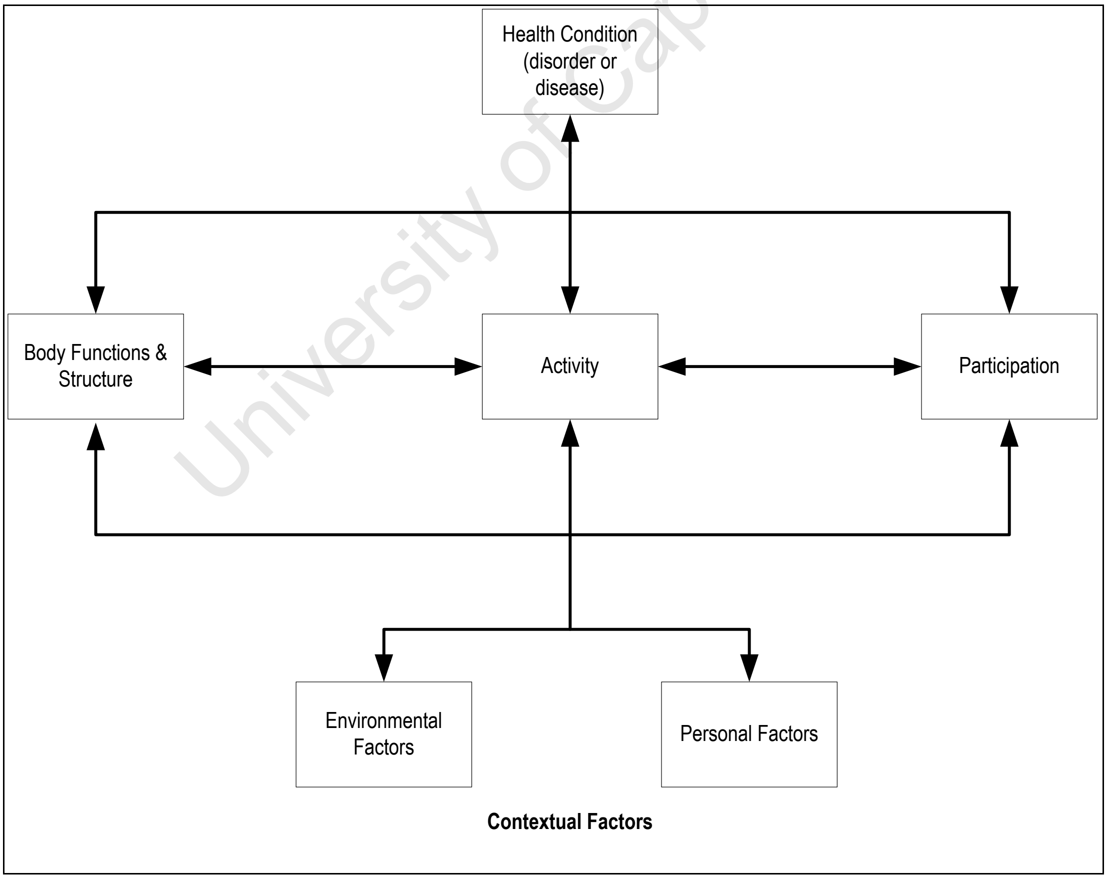

Figure 1-1: The ICF model of disability[9]

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1.2 Background to the problem

Groote Schuur Hospital (GSH) is a tertiary hospital located in the city of Cape Town in the Western Cape province of South Africa. The hospital has a trauma centre that manages a high load of trauma-related injuries from the surrounding areas. A rise in violence and accidents has burdened the hospital with increasing costs for management of the resultant musculoskeletal-related trauma[16].

Femoral fractures are common injuries in patients at GSH following motor vehicle accidents (MVA)[14] and gunshot wounds (GSW)[21] as previously reported. Groote Schuur Hospital makes use of intramedullary nailing in the surgical management of patients with femoral fractures. These patients are discharged soon after surgery and therefore have limited time for inpatient rehabilitation. Anecdotally, outpatient rehabilitation and follow up of these patients is not optimal due to poor resources in some communities and non-adherence to treatment. Therefore, information regarding the functional outcomes and QoL of these patients post-fracture is unknown.

Against the background of an increasing burden of trauma-related health issues, the current study was undertaken to investigate the health-related quality of life in patients who had sustained femoral fractures.

1.3 Aims and objectives

When the research question was conceptualised, the original study design was a descriptive, prospective longitudinal design. Based on the original design, a sample size was calculated. Unfortunately, during the data collection period, the GSH policy regarding patient admissions was changed. This was in accordance with the provincial health policy to decentralise patient care to appropriate levels of care (Comprehensive Service Plan 2020; www.westerncape.gov.za). Patients with femoral fractures were no longer referred to GSH (a tertiary hospital) but rather managed at secondary level hospitals. The sample that had already been recruited was therefore used. Furthermore, attrition contributed to the fact that only four participants completed the series of follow up sessions. For this reason, it was decided to change the study design to a clinical case series.

The current study is therefore comprised of two sub-studies. The first part is a clinical case series. The second part of the study is a chart review.

1.3.1 *Aim of the clinical case series*

The aim was to document the health-related outcomes in patients who sustained traumatic fractures of the shaft of the femur.

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1.3.2 *Specific objectives of the clinical case series*

The specific objectives of the study were to:

- Determine the HRQoL, pain scores, activity limitations and self-efficacy (SE) of patients who sustained traumatic femoral shaft fractures at discharge from hospital, and at two weeks, four weeks, six weeks and 12 weeks post-surgery.

- Determine the functional outcome variables (range of motion (ROM), muscle power (MP), oedema, weight bearing (WB) status and leg length discrepancy (LLD) in patients who have sustained traumatic femoral shaft fractures at these same time frames.

- Determine whether there were differences between the mechanism of injury (gunshot wound (GSW) versus non-gunshot wound (non-GSW)) and functional outcome variables of pain scores, activity limitations, self-efficacy and HRQoL.

Following the clinical case series, a retrospective review of medical folders was conducted to determine further detail regarding the demographic and clinical characteristics of patients who had sustained femoral fractures.

1.3.3 *Aim of the chart review study*

The aim was to describe the factors contributing to clinical outcome following traumatic femoral shaft fractures in patients admitted to the traumatic orthopaedic wards at GSH.

1.3.4 *Specific objectives of the chart review study*

The specific objectives of this study were to:

- Describe the socio-demographic and clinical attributes of patients that sustained an isolated traumatic femoral shaft fracture.

- Investigate if the level of disability could be determined from the patients' medical folder history using the revised World Health Organisation Disability Assessment Schedule Version II (WHODAS II).

- Investigate whether revised WHODAS II scores were associated with variables of gender, employment status, education, source of referral, mechanism of injury, fracture patterns, length of hospital stay and inpatient care and outpatient care including adherence with fracture management.

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1.4 Significance of the study

Literature provides extensive information regarding surgical management following fractures of the femur[1, 6, 21, 27]. However, only one study has been conducted regarding this medical condition in South Africa[28]. The results of this study will provide insight into the level of disability and morbidity of patients at GSH following traumatic femoral shaft fractures. In addition, the study may also identify potential shortcomings in rehabilitative services at GSH and in the community. This may provide the groundwork for evidence based practice for treatment of femoral fractures within a local context.

1.5 Plan of development

A review of the relevant literature relating to femoral fractures and its management will be presented in Chapter 2. This includes information regarding the epidemiology of femoral fractures, surgical management and the functional impairments associated with femoral fractures. Literature concerning the study of HRQoL, measurement of self-efficacy, pain and assessment of activity limitation and participation restriction are presented within the ICF framework.

The clinical case series is presented in Chapter 3 and the chart review study is described in Chapter 4. Due to insufficient recruitment of participants and a 50% drop out rate in the clinical case series, a chart review study was conducted as a follow up study to the clinical case series. This was an attempt to establish whether some of the observations from the clinical case series may be applicable in a larger sample of participants with femoral fractures. The chart review study was therefore informed by the clinical case series findings. A summary and conclusion to the thesis is presented in Chapter 5.

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Chapter 2: Literature Review

2.1 Introduction

The review of literature pertaining to femoral shaft fractures and the functional impact of femoral fractures will be preceded by a brief review of the ICF framework. The ICF framework will be explored to provide a background and framework to understand the holistic nature of musculoskeletal injuries in general, and femoral fractures in particular. This will be followed by an overview of the epidemiology of femoral fractures. The management of femoral shaft fractures will be presented and the functional impact of these injuries will be described. This chapter will conclude with a review of measurement instruments that may be used to document functional outcomes following femoral fractures.

A search of peer reviewed articles was conducted using the EBSCO host resource database which provided access to full-text databases. The specific databases selected included CINAHL, PubMed, Medline, Africa-Wide Information and Academic Search Premier. A combination of keywords and terms were used for the search. These terms included: "*traumatic femoral fractures*", "*health-related quality of life*", "*South Africa*", "*morbidity*", "*TUG test*", "*complications of femur fractures*", "*EQ-5D*", "*WHODAS II*", "*self-efficacy*", "*intramedullary nail*", "*oedema*", "*dynamometry*", "*goniometry*", "*leg length discrepancy*" and "*traumatic fractures*".

2.1.1 *The International Classification of Functioning, Disability and Health– a theoretical framework*

Health care and health management has changed its focus of approach over the past 20 years. Data relating to morbidity and mortality is insufficient to capture the health status of a population. Epidemiological transition from infectious to non-communicable disease has made non-fatal health outcomes more relevant for low- and middle-income countries as well as for more affluent nations[29]. In light of this shift of focus to non-fatal health outcomes, the World Health Organisation (WHO) endorsed the International Classification of Functioning and Disability and Health (ICF) in 2001[9].This classification system was to be used to report on mortality and morbidity with information on health and health-related outcomes in terms of functioning. Further, it was a comprehensive classification system designed to describe disability at different levels beyond the impairment. The first level was described at body (biological) level that incorporated physiological functions of the body systems. The second level described disability in terms of activity limitation. This explains the difficulties that the individual may experience in executing an activity. Finally, the third level described participation restrictions at a societal level. Participation restrictions were problems that the individual encountered with involvement in life situations[9].

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The ICF was able to identify environmental factors that impacted on areas of participation, such as education and transport. The classification system presented functioning as a continuum[29]. In this way, function and disability is relevant to all people to different degrees and at different times of their lives[29]. In terms of providing an example, an individual who sustained a fractured femur is limited in their function. The impairment is stiffness and weakness of the leg. The activity limitation is walking and the participation restriction is the inability to work as a manual labourer (Figure 2-1).Therefore, for a transient period of time during recuperation, this individual may be classified as disabled in terms of the ICF.

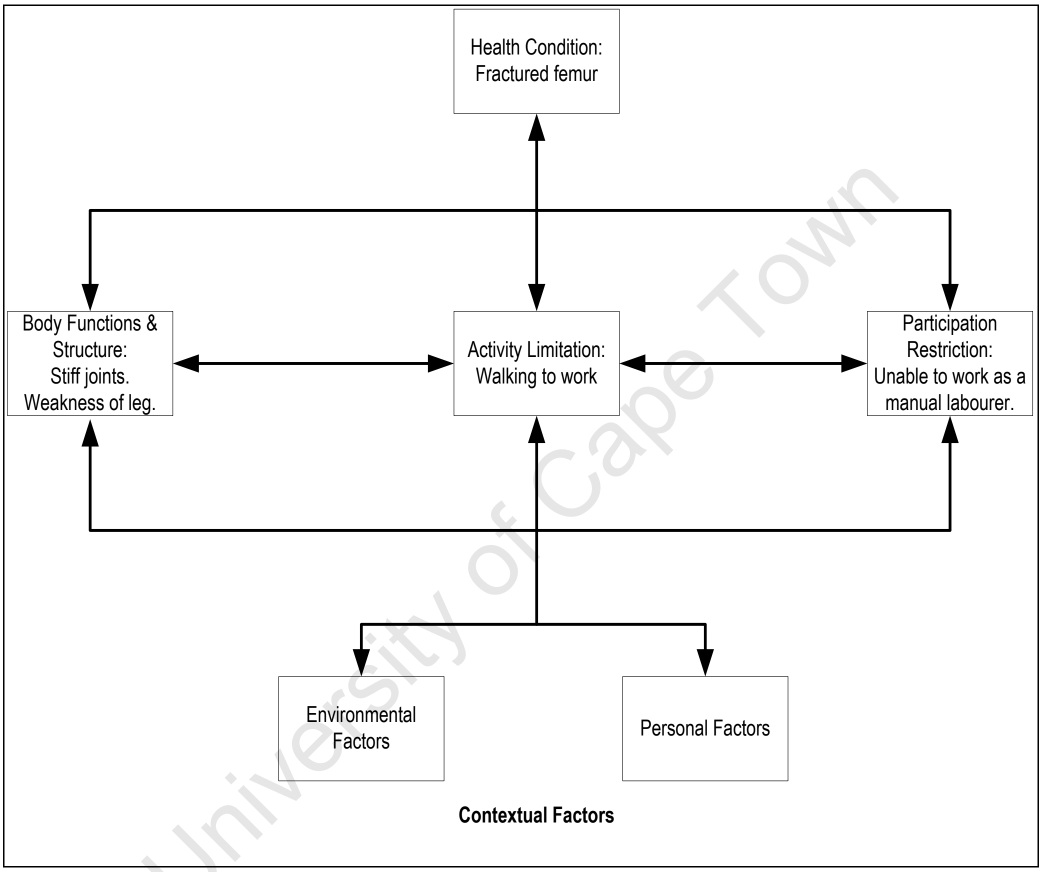

Figure 2-1:The ICF model of disability[9] for an individual with a fractured femur

The concept of disability as envisioned by the ICF framework viewed the impairment, the individual, and the social environment as equally key in the disablement process. This idea can direct the physiotherapist's clinical reasoning from understanding disability in terms of changes in body functions and structures and activity limitations, to a broader conceptualisation of disability. Contextual factors that may be internal (personal) or external (environmental) need to be included within the disability concept. Further, performance and participation will vary in different environments and are not solely influenced by impairments[30-31]. Disability should therefore no longer be viewed as an isolated topic, but rather be seen as having an impact within a societal context[30].

In addition, the activity limitation level of the ICF describes the individual's capacity to carry out activities of daily living (ADLs). Participation restriction describes the level of performance of the individual in their usual environment. The two concepts (activity limitation and participation restrictions) should therefore be viewed as distinct phenomena[31].

The majority of ICF research regarding its usage, implementation and operationalisation has been conducted in North America and Europe[29]. The American research has been theoretical whereas the European papers reflect more practical applications of the ICF[29]. Within a South African context, the ICF has been used in limited studies related to practical clinical applications[32-34] and in an explorative research context[31]. The ICF was used as a framework to investigate social aspects of living with rheumatoid arthritis in a low resource context in South Africa[32]. A sample of convenience of 60 females from Soweto, a previous dormitory town for Black[†] people[35] during the apartheid era, answered questionnaires regarding their disease and their experience of disease. The ICF proved to be a useful framework to describe and understand the complexity of these experiences. The results indicated that negative external environmental factors created significant barriers for the arthritis sufferers. These environmental factors included lack of basic services such as electricity and hot water, a lack of access to proper roads and transport and a lack of appropriate employment opportunities. Unfortunately the results cannot be generalised as a very specific sample was used[32].

Eide et al[31] explored the relationship between activity limitations, participation restrictions and environmental barriers to contribute towards the verification and development of the ICF. The authors describe the Western Cape region as being "greatly *challenged by the rural to urban migration from the Eastern Cape*". Despite the Western Cape being the wealthier of the two provinces, when comparing the two contexts, it was found that both activity limitations and participation restrictions were reported to be higher in the Western Cape. The Western Cape was reported to experience problems of rapid migration with overpopulation, informal settlements and high crime rates[31].

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2.1.2 *Research setting*

The concept of migration for employment purposes is a consequence of South African political history. The previous political regime of South Africa has had a significant impact on the health of its population and on health policy and services of the present day[36-37].

† The South African population was classified according to racial population groups prior to 1994. "*Black people*" referred to people who were relatively dark-skinned in comparison to other racial groups. Today the term refers to the ethnicity of the individual[33].

South Africa is considered a middle-income country within international standards[28, 37]. However, living standards vary widely with many patients of the tertiary hospital where this study was conducted, living in resource poor communities.

Groote Schuur Hospital (GSH) is located within the metropolitan area of Cape Town in the Western Cape province of South Africa. It provides tertiary health services on a referral and emergency basis to the inhabitants of the Cape Flats and rural hospitals. A large number of the referrals are from secondary level hospitals and community health care centres in incidences of traumatic emergencies. The majority of the patients that are treated are from low-income communities. Within the informal settlements, poverty is widespread and people live in metal or wooden shacks with no access to basic amenities. The surrounding environment consists of loose, uneven ground. Water and toilet facilities are often communal and located outside the home and there is limited access to transport. In other more developed low-income areas, amenities are available inside the home. These homes consist of multi-level blocks of apartments or maisonettes which have a flight of stairs outside the flat and no access to an elevator. These communities are notorious for high levels of unemployment, drug abuse, crime and violence[38].

The high mortality rates following trauma secondary to road accidents and interpersonal violence in South Africa have been well documented[16, 19, 39]. However, previous research does not indicate the burden of this trauma relating to its associated morbidity. In the present study, the associated morbidity will be explored using health-related quality of life (HRQoL) measurement. The concept of HRQoL focuses on well-being beyond the biomedical level[40] and therefore provides an understanding of the impact of the concept of disability within the ICF framework.

Given the paucity of literature on the epidemiology of femoral fractures in South Africa, literature reporting on the epidemiology of femoral fractures internationally will now be presented.

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2.2 Epidemiology of femoral fractures

Zirkle[23] suggested that road traffic accidents are an "*emerging disease*" in low- to middle-income countries, as many people move from the rural communities into cities for employment purposes. In addition, Zirkle[23] suggested that the increase in long bone fractures is secondary to the rise in motor vehicle accidents[23]. However, the focus of research in developing countries is often on communicable diseases and malnutrition resulting in a paucity of literature documenting the prevalence and subsequent morbidity caused by traumatic injuries. Further, there is a growing body of evidence indicating that musculoskeletal trauma is an increasing global burden[18].

In a large, prospective epidemiological study of 15000 adults in Edinburgh, Scotland[41], males below the age of 35 years were found to be 2.9 times more likely to sustain a generalised fracture than females. Furthermore, diaphyseal fractures of the femur were more common in young males, while the incidence of femoral fractures increased in older osteoporotic females[41]. Similar results for femoral fractures were found in two later studies conducted in England and Wales and in Kentucky, U.S.A. respectively[42-43].

In a retrospective study conducted over a period of ten years, the epidemiology of different types of fractures in a diverse population in England and Wales was investigated[42]. A large cohort of 103 052 males and 119 317 females was identified. Fractures were classified according to the International Classification of Disease version nine (ICD-9) categories and fracture incidence was analysed and categorised according to gender and age. Fractures were more common in females in this particular cohort. The incidence of fractures increased over the age of 35 years and occurred more commonly in females as bone density decreased, with hip and distal forearm fractures being twice as common in females in this age group. However, long bone fractures (such as fractured femurs) were more common in young people and were usually a result of trauma. Further, these long bone fractures occurred more frequently in males than females. Limitations of the study included issues of generalisation as participants were limited to the adult population (i.e. individuals older than 20 years) and the cohort only included the population of England and Wales that were permanently registered on the General Practice Research Database. This database only included records of participants that had attended one of the registered 683 general practices listed. Furthermore, only first incidence of a fracture was recorded, that is, if a participant had sustained more than one fracture over the ten year period, only the first fracture was used in the analysis of the results[42].

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A chart review study investigated the management of closed midshaft femoral fractures at trauma and non-trauma centres in Kentucky, USA[43]. According to the authors, access to emergency trauma care is problematic in rural states such as the one studied. The cohort included the records of all participants older than 16 years who sustained a closed midshaft femur fracture between the years of 2004 and 2005 in Kentucky. A total of 1 462 records were included in the final analysis. Closed midshaft fractures comprised 765 of the total fractures. The ICD-9 coding system was used to categorise the fractures into location along the femoral shaft and according to open and closed fractures. The results demonstrated that participants who presented at trauma centres were younger, most frequently male and had associated injuries. Patients at non-trauma centres were older, more frequently females and presented with more co-morbidities. The most common method of fracture management in both the trauma and non-trauma centres was internal fixation. Low mortality rates were reported in both groups. While this study provides some insight into the epidemiology of fractures, it was limited to an adult population (> 16 years) and did not include severely injured patients who had suffered multi-level femoral fractures. In addition, the authors focused on mortality as an outcome and morbidity was not reported[43].

The limited information available for South Africa reflects similar epidemiological data. According to the findings of a pilot study conducted at the secondary level GF Jooste Hospital in Cape Town by Members of the Violence and Injury Surveillance Consortium, transport-related injuries or motor vehicle accidents (MVA) accounted for 13.2% of non-fatal injuries presenting at the trauma unit[44]. Incidentally, 41.8% of these MVA-related injuries were incurred by pedestrians. This high energy trauma frequently resulted in lower limb fractures[44]. In addition to fractures sustained from the high impact trauma of MVA, GSW's contributed to the incidence of fractured femurs.

Fractures secondary to GSW have become more prevalent globally due to increasing crime levels and as a result of guns being more easily available[21]. In Cape Town at a tertiary university-affiliated public hospital setting (Tygerberg Hospital), it was found that young males (average age of 28 years) were predominantly the victims of GSW; with GSW being mainly sustained in the lower limbs[45]. Norberg et al[45] conducted a retrospective study using a sample of convenience over a three month period. All participants who sustained fire-arm injuries classified according to the ICD code, and who were admitted for more than 12 hours were included in the study. Costs were calculated according to expenditure on hospital stay in the intensive care unit (ICU) and general ward, the cost of diagnostic imaging and blood products utilised, surgical and anaesthetic procedural costs as well as ambulance service costs. It was found that the average hospital length of stay was 5.8 days with a total average cost of US$ 385 per day. The average cost per participant was US$ 2 230. Limitations of the study are notable. The cost of staff salaries, pharmacy and laboratory costs were not included. Further, average costs rather than actual costs were used in the analysis. Patients with GSW who were treated at the hospital but not admitted for more than 12 hours, were not included in the results[45]. A very limited study period was used, which may have influenced the outcome as seasonal variations could not be observed. Furthermore, no mention is made on the type of injury sustained as a result of the GSW, for example fractures, spinal cord injuries or organ damage. The study does however highlight the high costs associated with violence on the health services in a South African setting[45].

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Factors affecting the length of hospital stay following isolated femoral fractures have been investigated in an attempt to postulate solutions to alleviate costs at trauma centres in the USA[46]. The authors reasoned that due to the common presentation of femoral shaft fractures in the hospital trauma setting, a study to investigate the length of stay of a patient with an isolated femoral fracture would be warranted to reflect the economic efficiency of the care of this type of patient. A retrospective chart review was conducted to ascertain relevant information that affected the participant's length of hospital stay at the Grady Memorial Hospital in Atlanta, Georgia. The mechanisms of injury included MVA, GSW, falls from a height and miscellaneous causes. The study concluded that the average length of stay was 3.9 days. Factors prolonging length of stay included medical conditions of the participant, time delay to surgery, time delay post-surgery to physiotherapy, waiting for radiological investigations and social issues delaying discharge to a patient's home.

It was suggested that by addressing the above mentioned factors as soon as possible, length of stay would be decreased. Decreasing the length of stay would subsequently result in a reduction in hospital expenses and overcrowding[44]. Ryan et al[43] also reported on length of hospital stay in their study regarding femoral shaft fractures. In their sample younger patients with femoral fractures admitted to trauma centres, had a greater number of associated injuries, a longer length of hospital stay and accumulated higher hospital charges as compared to patients in non-trauma centres[43].

A recent South African study compared standard femoral fracture fixation in a local trauma centre to trauma centres in developed European countries. The results indicated that the leading cause of the fractures were as a result of MVA within both continents. The second highest cause in South Africa was GSW[28]. However, this was the only study identified that reported on this common fracture type within a local setting. There remains limited information regarding the morbidity subsequent to femoral fractures in South Africa.

It is clear from these data that trauma-related fractures of the femur are a common occurrence[43], with young adult males most commonly injured[41-42]. However, there remains a paucity of definitive information with regards to the burden of disease caused by trauma, crime and violence-related morbidity[19]. Groote Schuur Hospital provides a major trauma centre for Cape Town and the rest of the Western Cape Province. Based on the literature, it would seem that correct management of the patients with femoral shaft fractures may help to alleviate hospital expenditure and facilitate rapid discharge[46].Data related to injuries is thus essential to assist in decision making regarding allocation of health resources. This information is required in both the tertiary centre that provides acute care and the primary healthcare centres where rehabilitation takes place[44]. The next section will provide an overview of traumatic femoral shaft injuries, including the classification of femoral fractures and the management of femoral shaft fractures.

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2.3 Overview of femoral fractures

The classification of femoral fractures will be discussed, as this serves as a guide to management of these fractures[11].

2.3.1 *Classification of femoral fractures*

Fractures of the femur are classified according to simple and compound fractures[4]. A simple fracture occurs when the skin overlying the fracture remains intact. In contrast, a compound fracture has an open wound overlying the fracture site[4].

Femoral fractures are further classified according to fracture pattern[11], the position along the shaft of the bone[47] and the degree of comminution[6]. Femoral fracture patterns include spiral, transverse, oblique, comminuted and segmental patterns. Spiral fractures occur when a twisting force is transmitted through the femur while the foot is anchored. Transverse and oblique fractures are a result of an angular or direct force onto the femur. These fracture patterns are common following MVA. Comminuted fracture patterns result from severe force or violence (such as GSW). Segmental fractures occur when the femoral shaft is fractured in more than one place[11]. The Arbeitsgemeinschaft für Osteosynthesefragen (AO) classification is used to denote the position of the fracture along the femoral shaft[47]. The shaft is divided into three parts, namely; the proximal third, the midshaft (or middle third) and the distal third of the femur. Comminution of fractures is categorised as Types I, II, III, or IV according to the degree of comminution as described by Winquist et al[6] (Table 2-1).

Table 2-1: Winquist's classification of femoral fractures according to degree of comminution[6]

Category	Degree of comminution
Type I	Only a small piece of bone broken away.
Type II	A fracture with a larger butterfly fragment but cortex is 50% intact allowing for control of rotation and length.
Type III	A fracture with a larger butterfly fragment, precluding control of rotation or length or both.
Type IV	Severe comminution with no abutment of cortices at the level of the fracture to prevent shortening.

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2.3.2 *Management of femoral fractures*

The management of femoral fractures is presented in terms of surgical management and physiotherapy management.

i <u>Surgical management of femoral fractures</u>

Surgical management of femoral fractures includes the use of plate and screws, intramedullary (IM) nailing and external fixators[11].The use of plates and screws previously had high complication rates and required modified weight bearing (WB) post-operatively to accommodate for the weakness of the implant. External fixators are used for femoral fractures with severe soft tissue injury and when managing bone loss[11].

The gold standard of treatment for femoral shaft fractures (including GSW femoral fractures) is surgical fixation with an IM nail[1-2, 20, 48]. Intramedullary nailing is considered to be successful if union occurs within the predictable timeframe and malalignment of the fracture is prevented[2]. The use of IM nails has revolutionised the treatment of femoral fractures as it has a union rate of 95% – 99% and allows the patient to become mobile immediately post-surgery. This has limited the length of hospital stay and problems associated with prolonged bed rest[1].

Intramedullary nails can be inserted via a prograde or retrograde approach. The retrograde approach is via the intercondylar notch of the femur. The prograde approach is via the piriformis fossa or the greater trochanter[11]. Surgical techniques describing the insertion of prograde IM nails, as well as complications of the techniques, have been widely documented[1, 6, 27, 49-51]. Complications included damage to the surrounding soft tissue and vascular structures[49], and varus malalignments and malrotations[6].

Dora et al[49] reported that the entry point used should be determined by the resultant tissue damage. In addition, the authors reported that despite the piriformis fossa being geometrically ideal for the insertion of IM nails, it caused the most significant damage to muscle, muscle tendons and the blood supply[49]. Specific types of IM nails have been made available for different types of fractures[11] as well as for different surgical entry points[50]. Ricci et al[50] reported that the use of IM nails that were specifically designed for trochanteric surgical entry points eliminated surgical complications. Further, specific techniques for the insertion of IM nails via the greater trochanter should be considered as an alternative to the piriformis entry point[50].The use of prograde IM nails in a local context was demonstrated to have a high rate of union with minimal post-operative complications[28]. At GSH, the use of IM nails inserted via a trochanteric entry point has been adopted as the standard management of femoral fractures (personal communication with Dr Sithombo Maqungo; Head of Department of Traumatic Orthopaedics at GSH).

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Early physiotherapy following IM nailing has been advised in the management of femoral fractures[6, 11].

ii Physiotherapy management of femoral fractures

The objective of physiotherapy management post-fracture is to aid fracture healing, limit complications and to assist the individual to return to the pre-morbid state[4]. Physiotherapy rehabilitation should begin as soon as the femoral fracture has been surgically reduced[4, 6]. The immediate post-operative rehabilitation should include the assessment and management of respiratory and vascular status, bed mobility and an explanation of the rehabilitation process[4]. Education regarding gait patterns and the use of a mobility assistive device (MAD) should be provided. Further physiotherapy management should include strengthening of the upper limbs in preparation for crutch walking and exercises to maintain MP and ROM of the unaffected limbs[4].

Specific rehabilitation principles have been documented that has advocated treatment for hip and knee stiffness, weakness of the quadriceps, hamstrings and gluteal muscles as well as gait education post-femoral fracture[52-53]. Bain et al[14] suggested that inadequate post-operative rehabilitation may influence weakness of the hip abductors following IM nailing of the femur. In an extensive case series evaluating IM nailing in femoral fractures[6], introducing physiotherapy rehabilitation immediately post-surgery and continuing physiotherapy treatment post-hospital discharge, reduced impairments relating to MP and ROM.

Optimal rehabilitation is needed to assist in recuperation following IM nailing of the femur[54]. Holden and Daniele[55] examined the efficacy of a seven-day versus a five-day physiotherapy programme for orthopaedic patients in an acute hospital setting. In this Boston, Massachusetts-based study, an experimental-comparison group design was used to compare two groups of orthopaedic patients. Patients were divided into an experimental group who participated in a seven-day physiotherapy treatment programme, and a comparison group who participated in a five-day physiotherapy programme. There were 11 diagnostic categories in each group according to the ICD-9 code classification. Measurements included the percentage of participants who received consecutive daily treatments, the mean number of treatments per participant and the lengths of hospital stay. The results showed that the seven-day physiotherapy coverage did not decrease the length of hospital stay. The main reason for this was that there were no significant differences in the number of treatments between the two groups. The authors concluded that more physiotherapists were needed to provide extra physiotherapy treatments to decrease the length of hospital stay in acute orthopaedic patients[55].

The use of IM nailing has allowed patients to be become mobile immediately post-surgery[1]. In a recent Spanish study, the effect of starting rehabilitation within 24 hours post-surgery was investigated in orthopaedic patients following total knee replacement[56]. Similar to patients with femoral fractures, patients with total knee replacements present with quadriceps muscle weakness, loss of knee ROM and gait abnormalities post-surgery. The authors selected an experimental study with clinical trial design to compare the benefits of initiating rehabilitation treatment within 24 hours versus 48-72 hours after total knee replacement in patients with osteoarthritis. The results indicated that early physiotherapy intervention contributed to improvements in pain, ROM and MP. Further, the early intervention improved autonomy in ADLs, balance, gait, and reduced the length of hospital stay[56]. The effects of this early physiotherapy intervention could thus be beneficial in patients following IM nailing. Thomas[57] investigated the use of a clinical pathway for orthopaedic patients to assist physiotherapists to optimise service delivery and facilitate early patient discharge. This Australian-based study explored the effects of a pre-operative, post-operative and outpatient treatment plan in patients who received elective total knee replacements over a two year period. This clinical pathway assisted in improving patient care and decreased the length of hospital stay[57].

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The results of these studies[56-57] indicated that regular and frequent physiotherapy treatments on an inpatient and outpatient basis appeared to optimise rehabilitation outcomes in orthopaedic patients.

Management of femoral fractures therefore requires optimal surgical fixation[6, 11] of the fracture and physiotherapy rehabilitation[4, 52]. Despite its good treatment outcomes, IM nailing does result in impairments with subsequent activity limitations and participation restrictions. Patients have reported disability even in cases when surgery has had good technical success and bone union has been achieved[2]. Studies reporting on these impairments and their effect on function will be discussed further in the following sections.

2.4 Clinical presentation of impairments following femoral fractures

The impairments secondary to IM nailing of femoral fractures include loss of muscle power (MP)[14, 54], range of motion (ROM)[6, 14], oedema[58] and leg length discrepancies (LLD)[48, 59]. Pain[14, 60] is also a common complaint.

2.4.1 *Muscle power*

Diminished muscle power (MP) of the hip abductors and quadriceps has been documented to persist up to one year following IM nailing of the fractured femur[14, 54]. Soft tissue pathology is common due to the high energy and traumatic nature of the injury and the resultant surgical intervention[53]. In a Texan study, the evaluation of bone density and quadriceps strength following prograde IM nailing of the femur was investigated[54]. Seventeen participants (13 males and four females) with a mean age of 29 years participated in the study. All participants were required to have returned to their normal pre-injury level of function and activity to be included in the study. A dynamometer was used to measure muscle strength of the quadriceps, hamstrings, hip flexors and extensors as well as the hip abductors and adductors on both lower limbs. There was a significant reduction in isometric quadriceps strength of the affected leg compared to the unaffected leg ($p = 0.0006$). There were no other significant differences in muscle strength found between the affected and unaffected leg for the hamstrings ($p = 0.1507$), hip abductors ($p = 0.4251$), hip adductors ($p = 0.0896$), hip flexors ($p = 0.9910$) and hip extensors ($p = 0.443$). Although participants in this study had returned to their pre-injury levels of function and activities, bone density and muscle strength had not normalised. A limitation of this study was that no measures of functioning or HRQoL were obtained. The focus was on impairments and not on activity limitations or participation restrictions[54].

The early study by Mira et al[61] investigated differences in quadriceps MP between femoral fractures reduced with non-surgical management and open reduction and internal fixation (ORIF).

A total of 32 participants between the ages of 15 and 64 (average age 25.1 years), were recruited. Three patients were lost to follow up leaving 29 participants (22 males and seven females). The minimum time to follow up was 16 months post-fracture. Dynamometry was used to assess MP of the quadriceps. The quadriceps strength was found to relate to the type (pattern) of fracture and its position along the femoral shaft. Simple and more proximal fractures had improved quadriceps MP compared with comminuted and distal fractures. Youth, exercise and non-delayed bone healing were all positively associated with improved quadriceps strength[61]. The influence of the different fracture management methods on MP of the quadriceps was not clearly indicated. The use of a standardised surgical fracture fixation would have been beneficial to evaluate the influence of the fracture pattern and position along the femoral shaft on the quadriceps MP.

Weakness of the hip abductor muscles has been linked to the type of surgical approach for femoral fractures, specifically the prograde approach[62]. This approach involves an incision being made through the fascia of the gluteus maximus muscle and the muscle being divided in line with its fibres until access is gained to the piriformis fossa. The gluteus medius and minimus muscles must also be divided to gain access to the tip of the greater trochanter for the surgical entry point[1]. It has been proposed that the compromised abductor muscle complex (gluteus medius and minimus) fatigues when it is challenged and thus causes pain and a Trendelenburg gait pattern[14]. In this retrospective clinical review, two groups of participants with fractured femurs were compared to a control group with respect to hip abductor strength. The two intervention groups consisted of participants with an isolated femoral fracture fixed with an IM nail (n = 32), and the second with closed femoral shortening for leg length discrepancy by means of an IM nail (n = 14) respectively. In the femoral fracture group, the majority of the participants were male with a mean age of 28 years. The fractures were sustained during MVA, playing sports and work accidents. In the femoral shortening group, there were nine males and five females with a mean age of 22 years. All participants were assessed for pain, stiffness, limp, walking distance, the use of walking aids, leg length discrepancies and malrotation. The Trendelenburg gait pattern was also observed. The differences in abductor strength between the control group and the affected legs of the intervention groups were analysed. The hip abductors of the affected legs in the intervention groups were found to be much weaker than the hip abductors of the control group. The differences in hip abductor MP were significant for the femoral fracture group ($p < 0.05$) and the closed femoral shortening group ($p < 0.01$) compared to the control group. In addition, the participants with femoral fractures also reported trochanteric pain, stiffness, limp, a reduced walking distance and difficulty with stair climbing. In this particular study, participants with the above complaints had more hip abductor weakness as compared to those without complaints although this difference was not significant. However, there was a weak, positive correlation between the incidence of complaints and marked abductor weakness. A limitation of this study was that only isometric maximal strength of the abductors was tested. This would not indicate the weakness that could develop after continuous physical exertion associated with fatigue.

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The authors proposed that greater abductor weakness would be evident if measurements were repeated after strenuous activity as many patients complained of fatigue pain (pain that occurs as the muscle begins to fatigue) associated with a limp that only occurred after strenuous activity[14].

An extensive review of the literature on femoral shaft fractures suggested that inadequate post-operative rehabilitation is a cause of MP deficits[53]. However, treatment protocols were not always recorded in the studies reviewed, limiting the generalisation of this hypothesis[6]. Paterno and Archdeacon[52] reported a case study of a 28 year old manual labourer who sustained a femoral shaft fracture following a MVA. The fracture was reduced with a prograde IM nail. Range of motion of the affected hip and knee; muscle strength of the hip abductors, knee flexors and extensors; and 3-D motion analysis of gait were assessed at four, eight and 16 weeks, and eight months post-surgery. The patient participated in a rehabilitation programme formulated for femoral fractures. The report concluded that the implementation of programmes that promote early and aggressive weight bearing as well as rehabilitation will address impairments and minimise the disability following IM nailing. However, the single case study limits the generalisability of these findings. The authors designed a treatment guideline following femoral IM nailing[53]. It was postulated that a rehabilitation protocol targeted to address the documented impairments following IM nailing may lead to more predictable outcomes following femoral shaft fractures. A rehabilitation programme was formulated and explained in this paper but it was not tested clinically. Future randomised control trials are needed to validate the intervention[53].

Kapp et al[54] has suggested that the early stability and mobilisation that is made possible by IM nailing is not sufficient to restore full muscle power of the quadriceps. For this reason, more effort to specifically rehabilitate the quadriceps muscles is recommended following femoral fractures to prevent muscle weakness[54] with a focus on endurance to prevent fatigue pain[14] and early quadriceps rehabilitation[6]. In a 10 year (1968 – 1979) prospective study of 520 femoral shaft fractures in 500 participants, all participants received IM nails[6]. All participants were reviewed from admission to hospital discharge and then followed up until they were discharged from the orthopaedic department. The authors describe "*quadriceps setting*" and "*straight-leg raising*" exercises as being implemented on day one post-surgery. Participants were allowed to walk with the assistance of crutches and began protected weight bearing as soon as quadriceps control (that is, the ability to control the extremity by maintaining a straight-leg raise) was achieved. Early in the study period, it was found that minimal attention was given to rehabilitation post-discharge. Later in the study period, the investigators realised the importance for on-going physiotherapy to regain quadriceps strength and increase knee control and ROM. The focus of only having inpatient rehabilitation of the quadriceps muscle had a limited effect on knee ROM and MP[6].

In addition, it has been reported that fractured femurs managed with IM nails also result in a negative outcome on joint ROM at the hip[14] and knee[28]. This will now be discussed further.

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2.4.2 *Range of motion*

As discussed previously, an emphasis on quadriceps strengthening in rehabilitation has been shown to improve post-operative knee ROM following femoral fractures[6]. Winquist et al[6] suggested that loss of ROM is closely associated with muscle power. Further, in a study exploring the effects of IM nailing for femoral fractures and femoral shortening, a positive correlation was found between stiffness (loss of ROM) at the hip and weakness in the hip abductors[14]. However, the main study limitation was that the reported loss of ROM was observed by default in that the patients complained of stiffness at the hip joint. The actual measurement of ROM at the hip joint was not recorded in the study[14].

Further, outcomes following femoral fractures were compared in a multi-centre study in South Africa and the European Union[28]. Measurements of ROM were recorded at the time of surgery and at the follow up sessions. Ten of the 12 ROM measurements of the hip and knee showed significant differences between the study groups, with better results observed in SA. There was no significant improvement noted in the overall ROM measurements between the three month and one year follow up. Geographical location was the only relevant factor that influenced ROM. Age, body mass index, type of fracture and the occurrence of complications had no impact on ROM outcomes. Unfortunately, the relationship between MP and ROM measurements could not be determined as MP was not recorded in this study[28].

In a prospective observational study of patients with femoral shaft fractures, an analysis of quadriceps functioning was undertaken by means of ROM and muscle strength determination[61]. A group of 29 participants (22 males and seven females) with an average age of 25 years who had sustained non-pathological fractures were followed up for a minimum of 16 months. Decreased ROM of knee flexion at follow up was negatively correlated to the rate of healing of the fracture. The study included fractures that had been reduced by various types of orthopaedic implants including IM nails, ORIF with plates and screws and the use of skeletal traction, hip spicas and functional bracing. Comparisons regarding the loss of ROM of the knee were not specified as to the type of fixation used and thus no conclusions could be made regarding the most superior type of fixation to ensure a good functional outcome. Furthermore, there was a lack of information regarding the extent of loss of ROM and its associated functional implications[61]. One of the factors theorised to influence ROM is oedema[63]. The occurrence of oedema and its effects will now be discussed.

2.4.3 *Oedema*

Oedema is a general occurrence post-surgery in fractured femurs[63]. Post-operative oedema has been reported to be the cause of discomfort, joint stiffness and a feeling of heaviness in the limb[56].

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These factors subsequently limits mobilisation and prolongs hospital stay[58]. In a prospective study thigh oedema was investigated in 49 elderly participants with femoral cervical fractures and pertrochanteric fractures. It was suggested that the magnitude of oedema formation was related to the severity of the primary trauma as well as the type of surgery performed[58]. A 17% volume increase in the operated thigh compared to the uninjured thigh of pertrochanteric fractures was regarded to be considerable. Respectively, in femoral cervical fractures, a volume increase of 9% was viewed as considerable. The study reported that age and sex were not correlated with oedema volume[58].

In a small study (n = 20) of fractures of the proximal femur, the significance of identifying the influence of thigh swelling on function was highlighted[63]. It was found that the extent of oedema differed according to fracture type. Participants with intertrochanteric fractures were found to have greater oedema (111% of non-fractured limb) as compared to cervical fractures of the femur (104% of non-fractured limb). Furthermore, those participants with the least amount of thigh oedema had the lowest reduction in quadriceps strength. Knee extension and thigh oedema were significantly negatively correlated. The decreased knee extension muscle power was significantly correlated with scores of all measures of basic mobility, including the Timed up and Go (TUG) test. From this limited study, the researchers concluded that knee extension strength and physical performance following surgery for fractures at the hip were related to fracture type and the associated thigh oedema[63].

In addition, the management of femoral fractures with IM nailing may result in a leg length discrepancy (LLD). A LLD may affect gait and impact function. The following section will discuss LLD associated with femoral fractures in more detail.

2.4.4 *Leg length discrepancy*

Leg length discrepancy (LLD) is a common occurrence following femoral fractures fixed with IM nails[6, 24, 59]. Limping secondary to a LLD, combined with the long term effects of impairments in MP and ROM, results in activity limitations such inability to do strenuous type walking and difficulty with stair climbing[14]. The functional limitations from a LLD exceeding 10 mm are regarded as being so severe that the LLD should be classified as a post-operative complication[24].

In a prospective study to investigate outcomes following IM nailing of femoral shafts in Australia, participants with a LLD were one and a half times more likely to complain of a limp as compared to those with equal leg lengths[48]. In this study, skeletally mature participants with femoral shaft fractures were recruited between January 1997 and December 1999. A sample size of 88 participants (average age of 32 years) with 92 fractures were included (65 males and 23 females).

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The mechanisms of injury included MVA, motor cycle accidents, pedestrian-vehicle accidents, falls, pathological fractures, blunt injuries and GSW. A total of 54 participants underwent a telephonic interview, and 35 participants presented for a clinical review. Fifteen of those participants had a measurable LLD. There was a significant correlation between perceived limp and perceived LLD[48].

From the above discussion it is clear that the impairments of loss of MP and ROM, post-operative oedema and LLD contribute to functional disability following femoral fractures[14, 48, 54, 63]. Pain has also been described as an impairment following femoral fractures[14, 52, 64]. The influence of pain as an impairment following femoral fractures is presented in the next section.

2.4.5 *Pain*

Pain is a phenomenon following a traumatic fracture[60]. Despite femoral fractures being very common, minimal information is available about the pain experience associated with these fractures[60]. Kazmi et al[64] observed that post-operative pain localised to the surgical site is the main hindrance in the effective mobilisation of patients with proximal femoral fractures[64]. Patients also reported pain associated with fatigue and a subsequent limp following abductor weakness with prograde IM nailing[14]. Anterior knee pain was also identified as an impairment of femoral fractures fixed with IM nailing. The authors concurred that this pain may cause an altered gait pattern individually or in association with other impairments[52].

Another factor to be considered is the impairment of weight bearing (WB) status that results in activity limitations. While it could be argued that WB status is not an impairment, it is dictated by the stability of the fracture and may be viewed as a proxy of this impairment.

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2.4.6 *Weight bearing status*

The use of IM nailing of femoral shaft fractures allows for early mobilisation of patients[1] and early WB which enhances the rate of union of the fracture[52, 65]. Paterno and Archdeacon[53] suggested that early WB following femoral shaft fractures allows the rehabilitation therapist to progress rehabilitation beyond the non-weight bearing strengthening and ROM activities. This will limit post-operative impairments which may result in disability[53].

Brumback et al[66] conducted a two-part clinical study (biomechanical and a clinical study) to investigate the efficacy of early WB. Twenty nine participants with comminuted femoral fractures that were fixated with statically locked IM nails were included in the study. In the biomechanical study, there was high endurance of the 12 mm IM nail that was statically locked with two distal screws.

All the fractures united without any implant failure when participants were allowed to fully WB immediately post-surgery. The authors recommended early WB following comminuted femoral fractures as it increased the potential to walk; especially when multiple limb injuries were sustained. Delayed mobilisation secondary to WB restrictions will result in slow rehabilitation and subsequently a prolonged hospital stay and increased medical costs. These findings are clinically relevant, but cannot be generalised to osteopaenic bone[66].

Arazi et al[65] observed similar findings regarding WB status following comminuted femoral fractures. In this Turkish based study, 30 participants with comminuted diaphyseal femoral fractures were managed with a static reamed IM nail. Six participants were lost to follow up. The remaining cohort consisted of skeletally mature participants who were followed up for at least one year. This study, like that of Brumback et al[66], concluded that early WB after reamed statically locked IM nailing of comminuted femoral fractures is safe[65]. Based on the findings of these two studies[65-66], it appears that early WB following comminuted fractures is a safe practice and also promotes healing. Allowing early WB in comminuted fractures will impact on the individual's functioning and disability by promoting healing and allowing mobilisation to occur with fewer restrictions. This in turn will permit faster rehabilitation[53] and subsequently a more rapid return to pre-injury activity and participation[53].

Similarly, a Norwegian clinical study[24] reviewed the management of 116 participants (31 females and 85 males) with 120 femoral fractures treated with reamed IM nailing over a ten year period. The mean age was 29 years at the time of injury and 32 years at the time of review. The study focused on the problems related to the surgical method. It was established that WB could be safely allowed almost immediately post-surgery in stable fractures. Weight bearing was also safe in unstable fractures after evidence of visible callus[24]. Early WB is therefore an advantage of managing femoral fractures with IM nailing. However, early WB may not translate directly into fully functional gait .This study did not report on functional outcomes but rather focused on fracture healing as an outcome. This is a limited view that does not account for activity limitation and participation restrictions as integral components of health.

In the following section, problems associated with activity limitations (with a specific emphasis on gait) will be discussed.

2.5 Activity limitations following femoral fractures

Activity limitations are defined as '*difficulties an individual may have in executing tasks or actions*"[9]. It has been found that the impairment following injury will influence the activity limitations of the individual[26, 32, 67]. There is a lack of information regarding the effect of impairments on activity limitations following lower limb fractures.

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Literature concerning this topic has mainly been investigated in chronic orthopaedic conditions[26, 32] and sports injuries[68].

Pollard et al[26] explored the basic ICF pathways in patients with osteoarthritis prior to joint replacement surgery. The sample included 413 participants (188 males and 225 females) with an average age of 68 years. Each participant completed the Aberdeen questionnaire for impairment, activity limitations and participation restrictions. Significant associations were found between impairment and activity limitation in this sample[26]. Helgeson and Smith[68] reported that walking long distances was the activity limitation following a recurrent patella dislocation. This problem with gait was associated with the inability to partake in recreational activities (participation restriction)[68].

A previously mentioned South African study[32], described the activity limitations of participants with rheumatoid arthritis. These limitations, based on the ICF framework, included limitations with mobility (walking, kneeling and standing); self-care and domestic chores (washing clothes, dressing and bathing); commuting and use of public transport; and use of time. Concerning public transport, participants reported that they were reliant on the taxi system for transport due to an inability to walk to shops and places of interest. They experienced difficulty when getting in and out of the taxi. Further, their effective use of time was affected as activities took longer to perform due to impairments. This study highlighted activity limitations related to gait (inability to walk and stand) within the South African context[32]. Similar high levels of activity limitation due to mobility barriers have been reported in the Western Cape province of South Africa[31].

Based on these findings[26, 32, 68], it appears that impairments that negatively influence gait may lead to activity limitation in patients following femoral fractures. The impact of these impairments on gait following femoral fractures will now be briefly discussed.

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2.5.1 *Muscle power*

Poor muscle power of the quadriceps may contribute to alterations in gait mechanics[54, 61]. Weak hip abductors, theorised to be a causative factor for a Trendelenburg gait following IM nailing[14], is a critical impairment that is related to pelvic stabilisation in the stance phase of the gait pattern[52].

2.5.2 *Range of motion*

In a case study presented by Paterno et al[52], a lack of knee ROM following IM nailing of the femur was found to negatively influence gait. A loss of hip ROM secondary to hip abductor weakness was also postulated to affect the gait pattern following prograde IM nailing[14].

2.5.3 *Oedema*

In a recent study, increasing amounts of lower limb oedema was identified several days after surgery in patients with proximal femoral fractures[64]. This post-operative oedema may cause stiffness and discomfort of the knee and ankle joints. These issues may prevent effective mobilisation of these patients post-operatively[64].

2.5.4 *Leg length discrepancy*

Leg length discrepancies are common following femoral shaft fractures and result in a limp during gait[59]. Patients develop compensatory mechanisms at the hip, knee and ankle joints of either limb to attempt to minimise the abnormal components of their gait[69]. Gurney et al[70] investigated the effects of LLD on gait economy. This study highlighted the major effects on the energy cost of gait due to compensatory mechanisms secondary to a LLD[70]. In addition, during gait with a LLD, the shorter limb bears weight for a shorter period than the longer limb, with stance time asymmetry being closely associated with the amount of limb length discrepancy[71]. Consequently, the longer limb bears a greater load than the shorter limb. The cumulative effect of increased weight bearing time on the longer limb may be a contributing factor to the development of degenerative arthritis[71].

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2.5.5 *Pain*

Post-operative pain has been reported to be a hindrance in the effective mobilisation of patients with proximal femoral fractures[64]. Pain associated with fatigue and a limp secondary to abductor weakness following prograde IM nailing has also been documented[14]. Paterno et al[52] and Sanders et al[2] identified anterior knee pain as an impairment of femoral fractures fixed with IM nailing. This pain can cause an altered gait pattern individually as well as in association with other impairments[52].

2.5.6 *Weight bearing status*

It has been demonstrated that rising from a chair and walking with an assistive device, and the type of assistive device used may impede functional mobility in patients following lower limb fractures[72].

In two studies focusing on elderly patients who had sustained neck of femur and intertrochanteric fractures, the Timed Up and Go (TUG) test was used to assess post-operative mobility[72-73]. In both studies the use of mobility assistive devices affected the participant's ability to walk as well as the gait speed[72-73]. In people with disabilities (as with patients during the recovery period post-femoral fracture), the ability to vary walking speed is often diminished[74]. This affects the "*use of time*" to perform activities as highlighted by Schneider et al[32]. Therefore, longer periods of time are needed to perform ADLs that incorporate walking. This may cause participation restrictions such as attending outpatient clinics for follow up and returning to work.

The result of all the impairments post IM nailing may collectively and individually cause alterations in the gait pattern and consequently result in activity limitations and increased risk for future complications and injuries[52]. Within the South African context, impairments that affect gait as well as the use of an assistive device post-operatively may have significant consequences for individuals living in informal settlements where the ground is uneven and there is poor access to walk to transport and shops[31]. This will consequently impact on their participation in society[31] and their perceptions of well-being and quality of life[32].

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2.6 Participation restrictions

Participation restrictions refer to the "*problems an individual may experience in involvement in life situations*"[9]. Within orthopaedic literature, participation restrictions have been investigated in relation to impairment and activity limitations after distal radius fractures[75]. There is a lack of information regarding participation restrictions following traumatic fractures of the lower limbs. A discussion of participation restrictions associated with chronic orthopaedic conditions will therefore be described.

In a study that has been previously described, patients with rheumatoid arthritis reported participation restrictions related to their impairments and activity limitations[32]. Difficulty with mobility made it hard for these patients to participate in community gatherings, interact socially (visiting friends and family) and fulfil social roles by earning a living[32]. Significant associations within the ICF framework were also found between impairment and activity limitations, and between activity limitation and participation restrictions in patients with osteoarthritis[26].

Eide et al[31] explored the components of the ICF in a survey among Xhosa speakers on the Eastern and Western Cape of South Africa. The results indicated that participation restriction was reported to be higher in the Western Cape, and was more prevalent among male respondents[31]. These participation restrictions were reportedly due to environmental barriers. This result has implications for the current study as it is set in the Western Cape, and as femoral fractures are more common in young males[41-42].

Impairment, activity limitation and participation has been reported to be related to the self-reported physical health status of the individual[75]. In addition to these factors, environmental factors may contribute to perceived health status and quality of life in the individual[32].This concept of quality of life will be discussed in the next section.

2.7 Health-related quality of life (HRQoL)

The traditional practice of medicine has focused on clinical tests to assess information regarding disease. However, it is not possible to separate the disease from an individual's personal and social context[76]. Quality of life is an extensive concept that not only includes functional status and well-being, but also involves aspects not directly related to an individual's health. These aspects may include income, freedom and the environment[25]. Subsequently, in the early 1970's and 1980's, the rubric of quality of life (QoL) was used to try to achieve a holistic view of the impact of clinical intervention on the emotional and social well-being of individuals[77].

There is no gold standard, normal range or mean value for QoL, as there is no agreement concerning the meaning of the term[40]. A questionnaire design survey study conducted amongst health professionals (doctors, physiotherapists and occupational therapists) treating stroke patients in 2003 asked these professionals to define QoL[78]. All the professionals were involved in the care of the elderly in various hospitals in Wales and England. Responders indicated personal happiness and fulfilment as their definition of QoL. More therapists than doctors indicated social aspects in their definition of the term. Furthermore, the physiotherapists and the doctors included more physical function in their definition, compared to the occupational therapists. These differences may have reflected the professional culture of the different health care professionals or the aspects of care that each professional delivered to the patient. These results suggested that there were difficulties in defining the concept of QoL among health care professionals[78].

In an attempt to resolve this issue, the term health-related quality of life (HRQoL) was developed[40]. Health-related quality of life is intended to refer selectively to aspects of individuals' lives that may be related to their health[77]. Health-related quality of health is therefore a narrower concept than QoL, where QoL is seen as the overall concept and HRQoL a predictor thereof[79]. The assumption is thus that aspects of functional health status must have an impact on QoL[40]. Health-related quality of life involves the maintenance of physical, emotional and intellectual function[80]. Psychological morbidity and litigation have been found to be associated with poor HRQoL following fractures[81].

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Researchers and clinicians have investigated HRQoL in patients with a wide variety of health conditions including incontinence[82], stroke[83], cardiac disease[80], spinal cord injuries[84] and orthopaedic conditions[81, 85-86]. Bhandari et al[81] assessed a cohort of 215 patients who had suffered orthopaedic trauma for HRQoL (Short Form-36) and psychological symptoms (Symptom Checklist- 90 Revised). In these patients, 94% of the orthopaedic reductions had been successful. The researchers found that despite good clinical results, one in five orthopaedic patients met the criteria for psychological illness and that these psychological factors were associated with a reduced HRQoL[81]. Similarly, in a prospective study concerning patients with pelvic fractures, HRQoL and life satisfaction were measured using the SF-36 and LiSat-11 questionnaires respectively. These patients reported a lower HRQoL compared to a reference population despite good radiographic results. Lower scores in both the physical and mental domains were reported, compared to the normative values[85]. A further HRQoL study investigating patients with hip and knee arthroplasties reinforced these findings, reporting that responses were not related to the physical state of the patients[87].

In a retrospective observational study using the SF-36, there was a significant decline in general health and function following fractures of the femoral shaft[48]. In this study, skeletally mature patients with a femoral fracture managed with an IM nail were sought from a sample of convenience at the Liverpool Hospital. A total of 88 participants were followed up telephonically for a minimum of six months post-injury. In addition, a clinical review was conducted; however, it should be noted that only 35 participants presented for clinical review. The clinical review included the measurement of leg length, the use of a computerised tomography scanogram to determine femoral anteversion, and the completion of the SF-36 questionnaire to measure HRQoL. On the SF-36 HRQoL measure, scores for patients with an isolated femoral fracture were not significantly lower than population norms; whereas multi-trauma patients had significantly lower scores. The clinical study was limited by the lack of physical objective data other than leg length discrepancy, which would have influenced these patients' functional outcomes and subsequently the SF-36 findings. It also focused on a very small and specific population and thus the findings cannot be generalised. In addition, the patients were at various stages of healing (six to 40 months) post-injury. This large range in post-operative time makes it difficult to compare results of the SF-36 between patients as variables that fluctuate over time may influence scores[48].

Socio-economic background may also influence patient-assessed outcomes of HRQoL. Gross et al[28] found that South African patients with femoral fractures had lower expectations of HRQoL (related to the physical component of the SF-36 instrument) than their European counterparts. According to another South African HRQoL study[88], socio-economic grouping was found to be a determinant of reported health state. Participants with a lower socio-economic status in a diverse population report poorer HRQoL. However, ethic group, religion, gender and number of years of schooling did not influence HRQoL[88].

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Therefore the findings reported by Gross et al[28] may be a reflection of socio-economic status rather than a reflection on standard of care and physical outcome.

This prospective, observational multi-centre study[28] conducted in Europe and South Africa demonstrated several major differences in management outcomes between two financially and culturally diverse regions for the treatment of the same injury using an identical implant. Eleven European Union (EU) hospitals and one South African (SA) hospital participated in this study. All patients older than 18 years with femoral shaft fractures that were surgically fixated with prograde IM femoral nails were recruited. Each hospital used a standard surgical protocol and identical data collection sheets. Data were collected at baseline, six weeks, 12 weeks and at one year post-operatively. Recorded data included participant-reported measures of pain and HRQoL. A sample of 175 participants was recruited. More than half of the sample (86 in EU and 89 in SA) was recruited from the single SA hospital. The SA sample was younger (average age 33 years) with fewer co-morbidities but more severe open fractures. Motor vehicle accidents were the major mechanism of injury. In SA the second most common mechanism of injury was GSW. The SA surgeons were less qualified than the EU surgeons and worked unsupervised. The surgical time in SA was significantly shorter. In both groups, the SF-36 scores at one year were not restored to baseline values. However, the SA group had a poor follow up rate (63%) compared to the EU (84%)[28].This study highlighted the high incidence of fractured femurs in SA and the frequent occurrence of subsequent loss of function and decreased HRQoL[28].

It is evident that HRQoL is not necessarily restored by improving the impairments (fracture healing, MP, ROM, oedema, LLD) associated with femoral fractures and intramedullary nailing[28]. It seems that despite the improvement in impairment, diminished HRQoL is still reported[28, 48, 81]. Addressing impairment alone does not automatically lead to restoration of activity and participation[75] levels that are associated with HRQoL. This may be linked to inherent characteristics of the individual in terms of ability to cope with disability or chronic disease and to adhere to rehabilitation[89]. These characteristics may be associated with self-efficacy[90] and will be discussed in the next section.

2.8 Self-efficacy

Self-efficacy (SE) is a measure of an individual's self-confidence for performing a task[90]. It represents their perceptions or beliefs regarding their capability to perform a specific task[91]. Previous studies have demonstrated a positive correlation between SE and HRQoL in patients with cancer, and inpatients with cardiac and respiratory conditions[80, 92-93]. Importantly, Kohler et al[92] showed that patients with equally severe disease had differences in functional activities based on their levels of perceived SE[92].

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In patients with chronic lower back pain, gains in SE as a result of rehabilitation were associated with increased function and lower levels of self-reported pain[94]. Patients with low SE beliefs were more functionally impaired than their counterparts who had high SE beliefs[94]. Similar results were found in patients with musculoskeletal injuries[95]. Gender, age and pain duration were unrelated to levels of disability. Instead, SE beliefs were more important determinant of disability compared with fear and avoidance beliefs. Evidence of the concept of SE was demonstrated in an orthopaedic study following recovery from neck of femur fractures in a cohort of 55 community-dwelling older adults in Connecticut, USA[96]. The study investigated rehabilitation therapy SE and functional recovery after hip fractures. Participants were interviewed during the acute hospital admission and assessed regarding their pre-fracture functional level, their current level of SE for performing rehabilitation therapy, their current level of depression and other measures of physical and mental well-being. Six months after the initial interview, a telephonic interview was conducted to determine the patients' current level of function. It was found that after six months, there was a significant association between higher reported rehabilitation SE scores during hospital admission and recovery of mobility[96]. SE is thus an important component for the clinician to be cognisant of when planning rehabilitation programmes[94]. In addition, Borsbo et al[89] investigated the impact of the interaction between SE, clinical symptoms and catastrophising on disability, health and QoL in patients with chronic pain. The authors concluded that an individual's perceptions of SE will affect thoughts in either self-enhancing or self-debilitating ways. This means that the level of SE will determine how the individual will motivate themselves and persevere when faced with difficulties. Further, the study showed that it is important to assess and enhance SE as this will reduce disability and effectively enhance QoL and health[89].

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Further research regarding rehabilitation should investigate the variables of SE, HRQoL and depression as these have been recognised to influence the recovery process and the success of the rehabilitation programme[83]. An increase in SE beliefs may enhance the long term benefits of rehabilitation[94]. Self-efficacy beliefs may be associated with behavioural changes[97]. Behavioural changes coupled with feedback and reinforcement were found to be positively associated with better health outcomes in cardiac patients[97]. Sumartojo[98] suggested that a change in behaviour will dictate whether an individual will be compliant with treatment. Achieving changes in behaviour may be difficult for people who have competing difficulties such as poverty, homelessness and substance abuse[98]. Kagee et al[99] conducted a qualitative study in primary health care patients in a disadvantaged community in the Western Cape, South Africa, to investigate adherence with medical treatment. Social support, health literacy and financial implications were found to be the causative themes that influenced compliance[99]. In light of the poor socio-economic status due to unemployment[31] and the lack of social support for residents of the Western Cape[99], these circumstances may influence the individual's experience of low levels of SE.

In summary, femoral shaft fractures are a common occurrence within the global community[28, 41-42]. It is a complex injury when viewed holistically[1, 6]. Despite advances in surgical management[6], the impairments associated with femoral fractures including decreasedMP[54, 61], decreased ROM[14, 52], oedema[58], altered WB[66] and LLD[59]; and the activity limitation of gait[14] may still be associated with considerable disability. Furthermore, the effect of these fractures on HRQoL[28] and an individual's SE[96] cannot be discounted as being secondary to the physical deficits. More research is required to provide an understanding of the mechanisms that influence HRQoL in these individuals. This will provide evidence for treatment protocols to overcome the issues that prevent these individuals from returning to normal ADL's and participation in life roles. This evidence is especially needed in South Africa where standards of living and access to health care may be significant challenges[37]. In the following section, measurement instruments that are appropriate for use in such research will be discussed.

2.9 Instrumentation

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To facilitate the assessment of the physical and psychological variables discussed in the previous sections, accurate measurement instruments are required. Current literature presents the clinician and researcher with a considerable number of parameters that may assess progression and change in outcome over time with regards to femoral fractures. To obtain the most accurate measurement of these parameters, it is important to use instruments that are valid and reliable. The instruments and methods that may be used to obtain these measures will now be discussed.

2.9.1 *Muscle power*

The assessment of MP may be divided into three categories namely tertiary, secondary and primary[100]. Tertiary methods include isokinetic devices, which are regarded as the highest level of strength testing[101]. It is considered a valid measure to evaluate muscle performance[7]. Isokinetic muscle tests are limited in that they are expensive, the equipment is not portable and it does not always reflect functional performance[7]. Secondary methods of MP testing such as hand-held dynamometry (HHD) are objective, portable and require minimal time to set up. It is easy to use for group testing and in a clinical setting. These small dynamometers are non-invasive and less susceptible to tester bias as in the case of manual muscle testing[102]. High reliability across multiple patient populations has been demonstrated using HHD. This provides evidence of the versatility of HHD in a clinical setting[103]. Primary strength assessments such as manual muscle testing are subjective and are used when secondary and tertiary methods are not feasible or unavailable[101]. The reliability of manual muscle testing has been debated[104-106].

Following Beasley's research in the 1950's[107], in which he describes the "*ceiling effect*" of manual muscle tests, there was a systematic investigation into using more quantitative muscle strength measurement devices to increase the objectivity, precision and reliability of the techniques used to measure strength[108].

Hand-held dynamometry (HHD) has been described as being a reliable and valid measurement of muscle strength[104]. It was found to be a superior method when accuracy was needed to determine MP differences between the right and left side of the body, and deficits in knee extension force[104]. Within orthopaedics, the hand-held dynamometer has been used to determine knee extensor muscle strength following hip fractures with high reliability (intra-class correlation co-efficient for fractured leg = 0.91 and un-fractured leg = 0.90) and evidence of validity. It proved an effective measure of muscle strength in a fractured limb[103]. Procedures to ensure validity and reliability include: having both the tester and the HHD adequately stabilised, a testing protocol should be adhered to, the HHD must be held perpendicular to the tested limb, repeated measures be conducted with the same HHD, and lastly that appropriate trials be run to achieve the best or representative value[109]. Hand held dynamometry is relatively inexpensive, easily portable and requires no-set up time. It may also be effectively applied in any setting[103, 109]. The use of HHD to evaluate MP is thus preferred to the use of manual muscle testing in research as well as clinical rehabilitation settings[104].

2.9.2 *Range of motion*

Range of motion may be assessed using by various methods. These include simple methods such as visual estimation and the use of a goniometer, inclinometer or tape measure; and more sophisticated methods such as still photography and radiographic methods. The gold standard is radiographic measurement[110], which includes X-rays, fluoroscopy and other imaging modalities such as magnetic resonance imaging (MRI) and computed tomography (CT). These modalities are very accurate but they are expensive and expose the individual to radiation[111]. Visual estimations have also been found to be less precise and reliable than goniometric measurements[110, 112].

The goniometer and the inclinometer are still the most commonly used tools for measuring joint ROM[113]. The inclinometer has been found to be highly reliable in the measurement of hip abduction in children with cerebral palsy[113]. However, the inclinometer was limited in measuring all movements at the hip as it uses the force of gravity and thus the angle to be measured always needed to be perpendicular to the floor. This may be problematic as patients are not always able to adapt their position to ensure accurate positioning of the inclinometer to measure joint ROM[113].

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Goniometry is used for measuring joint ROM due to its practical application and its ease of use[112]. The measurement of ROM has been used by physiotherapists and orthopaedic surgeons to quantify limitations before treatment and then as an outcome measure to assess effectiveness of interventions[114]. Goniometry has been reported in the literature as a reliable method of measuring ROM of knee flexion and extension and hip abduction following femoral fractures[52]. However, there is still much debate regarding the reliability of goniometry[112-113, 115]. Somers et al[116] investigated the influence of experience on the reliability of goniometry and visual measurement of the forefoot. Experience did not influence inter-tester or intra-tester reliability[116]. The influence of tester experience regarding goniometry was further explored by Jakobsen et al[117]. In this study, intra-tester, inter-tester and intra-day reliability was assessed. Nineteen patients with knee arthroplasties from the Copenhagen University hospital were included in the study. An inexperienced tester (final year physiotherapy student) and an experienced tester (a physiotherapist with 10 years of experience in physiotherapy and orthopaedics) measured knee circumference and ROM of the same patients on the same day. It was found that repeated knee goniometric measurements should be recorded by the same physiotherapist in individual patients as there was some intra-tester variability. However, the experience of the tester did not influence the inter-tester reliability[117].

Gajdosik and Bohannon[118] suggested that the average of several goniometric measurements and standardised testing procedures may increase the reliability of ROM[118]. Concerns about the accuracy of goniometric measurements have been raised, but the instrument has been found to be a reliable[110, 115], accessible and moderately valid[110] to measure ROM in the hip and knee. In particular, its high inter-tester reliability means it is a useful instrument to measure changes in ROM over time[110].

2.9.3 *Oedema*

The literature describes multiple methods to quantify oedema[119]. This includes both dynamic and static methods[119]. Although the water displacement technique has been reported to be the gold standard for leg volume measurement, it has its shortcomings[120]. It is time consuming, cumbersome to apply and is not suitable for candidates who have open wounds, as is often the case in the early post-operative period[120].

The Truncated cone or "*Frustrum method*" is an example of a static measurement to establish leg volume[58]. The technique is reported as being simple as it is easy to apply in the supine and prone positions, it requires minimal technology, imposes minimal discomfort to the patient, and may be used pre- or post-operatively[120]. The circumference of the thigh and calf is measured at four levels; at the widest circumference of the thigh and calf (*C*); and at the smallest circumference of the thigh and calf (*c*) respectively. By measuring at the widest and narrowest points of the leg, the leg will most likely resemble a cone shape.

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The distance between these two points is also measured (h').These measurements are then applied to a mathematical equation (Equation 1) to calculate the volume (*V*) of the leg[119-120].

$$V = \frac{\pi}{3}\ h\ \ R^2 + Rr + r^2 \quad \textit{where}\ h = \sqrt{h'^2 - (R-r)^2};R = \frac{C}{2\pi}\ \textit{and}\ r = \frac{c}{2\pi}$$

Equation 1: Mathematical equation to calculate limb volume using the Frustrum method[64]

The Frustrum method does have limitations. It can be time consuming and is operator dependant, which may affect its reliability. It is also based on the assumption that the shape of the individual's leg is a cone. This is a problem in diseased legs and with individual leg deformities[120]. This method also does not account for oedema in the foot[119]. However, it has been used in the calculation of leg volume following femoral fracture as the oedema is recognised to be localised above the ankle following this type of injury[58]. Further, the Frustrum method has been found to overestimate limb volume[119-120]. There is also a lack of information regarding the validity and reliability of this measurement tool.

The gold standard of water displacement volumetry is impractical for acute post-operative patients because of pain and open wounds and as it is difficult to use this method to the level of the thigh[120]. The Frustrum method was thus considered as a favourable tool in traumatic orthopaedic clinical settings[58].

2.9.4 *Leg length discrepancy*

Several methods have been described for the measuring of LLD[59, 121]. These methods are divided into radiographic methods and clinical methods. Radiographic methods include the orthoroentgenogram, the scanogram and computerised tomography (CT). Although these imaging techniques are considered most accurate, they are costly, time consuming and expose the individual to radiation. Clinical methods include the tape measure method (TMM) and the block (book) correction method. The latter "*Iliac crest palpation and book correction method*"[121] has been found to be highly reliable but only moderately valid making its use in either research or clinical settings questionable[121]. The TMM involves measuring the distance between the anterior superior iliac spine (ASIS) and the medial malleolus as well as between the ASIS and the lateral malleolus. There is disagreement regarding the validity and reliability of the TMM. When the TMM is used as a screening tool to determine leg length discrepancy, the average of two measurements between the distance of the ASIS and medial malleolus appears to have acceptable validity and reliability. However, the TMM does not accommodate for length contributions of the ankle and foot which are incorporated in the indirect book correction method[10, 122].

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Harris et al[59] examined 35 participants following femoral shaft fractures. The TMM as well as the block test and a scanogram was used to evaluate LLD[59]. The ASIS and medial malleolus were used as reference points for the TMM. The study found that the clinical examination was more clinically relevant than the scanogram measurement in the assessment of LLD, suggesting that this is a valid, quick, reliable and simple method for clinical research[59]. This study reinforces the findings of an earlier study that validated the use of TMM[122].

In an early study, Beattie et al[122] determined LLD using the TMM. Scanograms were also used to establish the validity of the TMM. The sample consisted of ten participants in the patient group who had known LLD's. Their age range was 25 to 60 years. The control group had nine healthy participants with an age range of 22 to 34 years. These participants had no history of LLD or pelvic dysfunction. Each participant underwent scanograms of the lower limbs. The ICC values for the TMM mean values and the scanograms were 0.852 for the patient group and 0.637 for the control group. The overall ICC value for all participants was 0.793. The authors concluded that the use of TMM to measure LLD is relatively valid when the mean of two measurements are used. The study had limitations. A small sample size was used. Evidence from the data indicated that error associated with the measurement of LLD with the TMM may be "*highly consequential*" when small LLD's are measured as the TMM was unable to detect a LLD smaller than five millimetres. The authors suggested TMM be used in conjunction with specific functional activities, such as walking and running, to evaluate the effect of LLD[122]. However, a LLD less than five millimetres maybe inconsequential following femoral fractures as only a LLD more than ten millimetres is considered to be a complication[24]. Therefore the TMM appears to be an appropriate tool for the clinical setting.

2.9.5 *Functional mobility*

Traditionally, treatment outcomes have been based on tests of physical impairments. Functional ability is subsequently derived from these measurements although it may have little relation to activity levels and participation. The use of physical performance measures should be used as these measures may improve the reporting of treatment outcomes[123]. The use of actual task performance measurements is thus recommended for measuring functional mobility[124]. The most commonly used mobility scales are the Berg Balance Scale, the Six-Minute Walk Test, Comfortable and Fast Gait Speeds, the Dynamic Gait Index and the TUG test[74, 125].

The Six-Minute Walk Test measures the maximum distance that an individual is able to walk in six minutes[125]. It is most commonly used in the assessment and treatment of patients with cardiovascular and pulmonary disease as a measure of functional capacity and endurance[126].

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A limitation of this test in a developing country context is that it is performed in a controlled environment with no environmental challenges such as stairs, steps or uneven surfaces. Patients encounter these challenges on a daily basis[32]and so the test gives limited insight into true activity limitations.

The Dynamic Gait Index (DGI) was developed to assess gait, balance and the risk of falling. The DGI is graded using a four point scale with "*severely impaired*" scored as zero and "*normal performance*" scored as three[125]. The DGI is most appropriately used to assess function in the elderly, in individuals with balance and co-ordination problems following stroke, and in vestibular rehabilitation[127]. Similarly, the Berg Balance Scale (BBS) is a performance-orientated measure of balance mainly used to predict falls in the elderly[74]. Although the scale incorporates elements of balance and transfers that are important following femoral fractures, it does require that the individual be able to fully WB on both lower limbs. Unfortunately, full WB is not always permitted in the acute stage following fractures[11].

Comfortable and Fast Gait Speeds are gait tests to measure the ability to increase and decrease gait speed to adapt to varying environments and tasks[74]. This type of gait measurement has been used in two studies for the assessment of function in patients with cancer[124] and lower back pain[123] respectively. Participants walk at a preferred speed for 50 feet (walk forwards for 25 feet and then turn around and walk back for 25 feet) followed by walking the same route and distance at their fastest speed. The gait tests were simple to perform, inexpensive and fast to use, and had high reliability and validity[123-124]. However, like the Six Minute Walk test, it evaluates walking ability in a controlled environment[123].

The TUG test is a measurement of the time it takes to rise from a chair and walk to a line three metres away and then return to the seated position. The time is measured with a stopwatch[72, 74]. The TUG test is a combination of tasks required for independent mobility, namely; sit to stand, walking, stopping and turning and stand to sit[128]. It has been used in orthopaedic settings mostly to assess functional mobility with elderly participants[72, 129]. Test performance was found to be dependent on the type of assistive device used and the pre-morbid function of the participants[72]. It was advised to use standardised assistive devices when re-testing to evaluate changes over time[73]. Participants who completed the test in less than 10 seconds were classified as freely independent in physical mobility. The test is quick, requires no special equipment or training and is valid and reliable for quantifying mobility if the above factors are considered[130]. It is also a useful tool to quantify change over an extended period of time[130]. The combination functional of tasks required to perform the TUG test allows for a more thorough assessment of function[128], which may more accurately reflect walking ability in challenging environments. The TUG test was thus selected as an appropriate measure to use in patients following femoral fractures as it considers the use of assistive devices, and is able to provide information regarding the combination task of rising from a chair, walking and then returning to the seated position[72].

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The TUG test may be viewed as a measure of activity limitation. In this study it was used to measure functional mobility at the level of impairment.

2.9.6 *Health–related quality of life*

Reliable and valid instruments need to be used to measure HRQoL[76]. Measurement instruments should be able to measure responses to clinical changes and be easily interpreted[131]. Current measurements are flawed in that they measure changes over short periods of time for research purposes, whereas long term measurement is needed in a clinical setting[76].

Measurement instruments that are to be used internationally need to be culturally relevant[132]. It is a challenge to design a health survey that is to be used by all ages and for populations who are healthy and ill[133]. One survey that was constructed to provide a foundation for such comparisons is the 36-Item Short-Form Health Survey (SF-36). This questionnaire is a multi-purpose health survey which contains 36 questions. It is a generic measure of health status in that it is not targeted at a specific disease, age group or treatment group. The 36 statements included in the instrument concern dysfunction in eight categories[134] that affect the outcome of disease and treatment. These categories have been selected from many others that have been included in the Medical Outcomes Study (MOS)[133]. The SF-36 is brief but comprehensive[133, 135]. Reliability and validity of the SF-36 has been demonstrated in measuring HRQoL following traumatic fractures[134, 136].

The Euro-QoL 5D (EQ-5D) is an assessment tool developed by the Euro-QoL Group to investigate issues relating to HRQoL[137]. It is a standardised, non-disease specific instrument[138]. The South African version of the instrument consists of three parts. The first two parts entails the health status part (EQ-5D) and the visual analogue scale (EQ VAS). The third part provides background data of the individual. The health status part is divided into five domains of function, namely; mobility, self-care, usual activities, pain and/or discomfort, and anxiety and/or depression. Each domain has three sub-categories indicating the degree of the problem for each domain, namely; none, moderate or extreme problems. The individual's unique health state is then calculated by combining the responses of each of the five domains[137]. The EQ VAS is a vertical ruler ranging from zero ("*worst imaginable state of health")* to 100 ("*best imaginable state of health*"). The individual is asked to mark along the ruler where their current state of health is at that particular point in time[138]. The EQ-5D has been found to have good responsiveness in the physical, psychological and social domains following neck of femur fractures in the elderly[138]. The tool is short and easy to administer and displays good psychometric properties[137]. Further, it is a reliable and valid as an assessment tool to measure HRQoL within a South African research context[139] and internationally[86, 137-138].

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The EQ-5D is much easier to complete than the SF-36 due to its brevity and simplicity[137]. It is also available at no cost to non-profit organisations with a variety of versions in different languages[88]. It has been demonstrated to be suitable for use in studies in both the low- to middle-income countries and high-income countries[140]. Based on these favourable factors, familiarity with the instrument and its clinical utility (personal communication; Professor Jennifer Jelsma, University of Cape Town), it was decided that the South African version of the EQ-5D will be used for the purposes of the current study.

2.9.7 *Activity limitation, self-reported function and self-efficacy*

The assessment tool used to measure activities that an individual performs in daily life is referred to as a functional status measure[141]. A change in terminology from disability to activity has removed the negative perceptions associated with disability. Many functional status measures have been developed for use within rehabilitation sciences to measure outcomes. It is important that the measurement tool be sensitive to detect changes over time[141].

The Barthel Index is a functional status measure that was first published in 1965. It was developed to assess the changes in individuals with musculoskeletal and neurological type conditions who were undergoing rehabilitation. It is a rating index which evaluates the individual by means of direct observation (typically by a professional caregiver) and by reviewing medical records[142]. The Barthel Index has become the benchmark against which other functional measures have been developed. It has been extensively tested to be a valid, reliable and sensitive tool. The limitation of this scale is that its focus is on inpatient rehabilitation. It unfortunately has a ceiling effect (large concentration of scores at the upper limit of potential responses) when applied to an outpatient population[141]. The scale is unable to detect change once the patient is fully independent.

The Stanford Health Assessment Questionnaire (HAQ) is a commonly used, comprehensive and validated patient-oriented assessment instrument[131]. It is available in long or short forms from the Stanford University patient education website (http://patienteducation.stanford.edu/research). The HAQ was first published in 1980 and was intended to assess self-reported disability outcome based on activity limitations. It is a valuable, effective and sensitive tool for the measurement of self-perceived health status[131]. The HAQ Disability Index (HAQ-DI) that was developed in the late 1970s, was the original HAQ section to be validated[143].The HAQ 8-Item Disability Index (HAQ-8) is the short form of the original 22-Item Disability Index Scale. The HAQ-8 consists of eight questions each with four levels of responses indicating level of disability, namely; without any difficulty, with some difficulty, with much difficulty and unable to do. Each response is scored from zero to three. A higher score indicates more disability. The average score of the responses is used as the final score for the questionnaire[131, 143]. Self-efficacy is the individual's belief as to how they can perform a task[90-91].

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It has been reported that SE is inversely related to disability[89, 95] (lower levels of self-reported disability are noted when there are high levels of SE). The HAQ-8 may therefore be used to measure the individual's perceived degree of disability as a proxy method of evaluating SE[144]. The HAQ-8 has been found to be valid and reliable in diverse settings[143]. It is also not a "disease specific" measure[131] and was therefore found to be suitable for the current study.

2.9.8 *Participation restriction*

The Stanford Social/Role Activities Limitation Scale is a shortened version of the original Health Assessment Questionnaire (HAQ)[145]. It is used to assess participation restrictions. It is a measure of how much the individual's illness interferes with their social role. This links to the individual's participation in society. The scale consists of four questions with five levels of responses. The questionnaire asks the individual to indicate how much their illness has affected their role. The responses range from "*not at all*" to "*almost totally*". A score from zero to four is given for each response. A higher score indicates more restrictions. The total score is averaged to obtain a final score[145]. The scale is accessible via the Stanford University website (http://patienteducation.stanford.edu/research) at no cost to the user. Instructions regarding how to use and score the scale are also included on the website. This allows easy access and usage of these tools for research and clinical assessment purposes[143]. This questionnaire has been successfully translated into other languages[146-147]. Its four questions are specific to enquire about participation limitations making it a suitable tool for use in the current study.

The World Health Organisation Disability and Assessment Schedule II (WHODAS II) is an assessment tool to assess behavioural limitations to participation experienced by an individual. The tool was developed by the WHO with reference to the ICF model[9]. It aims to provide a holistic approach to the manner of assessment of impairments and disabilities. It addresses activities as well as function and participation in context of the environment[148]. The WHODAS II is a generic multi-dimensional questionnaire that is able to measure disability across various medical conditions (diagnosis independent). The questionnaire assesses functioning and disability in six life domains during the previous 30 days. These domains include: understanding and communicating (six items), getting around (five items), self-care (four items), getting along with others (five items), household and work activities (eight items) and participation in society (eight items). A total score is produced for the WHODAS II, as well as sub-scores for each of the six domains. The domains reflect disability in two dimensions, namely activity limitation and participation. The scores are calculated from a five point rating scale for each domain. A score of "*1*" indicates no difficulty and progresses to a score of "*5*" indicating extreme difficulty or inability to perform the activity[149]. The WHODAS II has been validated in German and Italian[149-150].

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In a recent literature review[151] the WHODAS II was found to have population norms available and was tested in multiple countries. Further, it had construct validity and it had the greatest body of literature to support its use in clinical studies[151]. Following a thorough search of the literature it appears that the WHODAS II has not been used to assess disability and functioning from information contained in a patient's medical folder. An unpublished final year undergraduate physiotherapy thesis[152] used a revised version of the WHODAS II to obtain information regarding disability and functioning from patients' charts. It was established that the revised version of the WHODAS II was able to assess disability and functioning in patients admitted to the trauma wards of GSH by accessing information in the patients folders[152]. Therefore, this revised version of the WHODAS II was used in the current study to assess disability, functioning and participation from the medical folders of patients with femoral shaft fractures admitted in the traumatic orthopaedic wards.

2.9.9 *Pain*

The American Pain Society has suggested that pain ratings be regarded as the "*fifth vital sign*"[153]. A pain assessment tool should be easy to understand, valid, reliable and should also be able to account for the health status of the patient. Appropriateness and feasibility should also be considered for each individual context[154], as not all pain measures are equally valid in all situations. Situations may occur in which pain measures are inadequately sensitive[155].

The McGill Pain questionnaire (MPQ) is a multidimensional tool that accounts for three main components of pain. Its pitfall is that it takes approximately 30 minutes to complete[154], which could be problematic with patients who are acutely ill and may have short concentration spans. Furthermore, respondents are also required to have good verbal skills to complete the MPQ. This may lead to cultural and educational bias[156]. For this reason, one-dimensional scales that only measure the sensory component of the respondents pain experience are often used in research[156]. The most commonly used pain scales measure pain intensity[155]. They are also known as pain rating scales and include the Visual Analogue Scale (VAS), the Numerical Rating Scale (NRS) and the Verbal Descriptor/Rater Scale (VD/RS)[154, 156]. Traditionally the VAS has been a horizontal line without markings but an alternative vertical line has been introduced[154]. The VAS is able to provide data that is useful for serial measurements in the same individual, if progression from the individual's baseline is the important outcome measure[156]. However, the VAS has been identified as somewhat problematic when used in an elderly population[157]. In a quasi-experimental study[157], the psychometric properties of five selected pain scales were evaluated in younger (21 - 55 years) and older adults (65 years or older) experiencing chronic joint pain. The five pain scales used were the Iowa Pain Thermometer (IPT), the Numeric Rating scale (NRS), the Verbal Numeric Scale (VNS), the Visual Analogue Scale (VAS) and the Faces Pain Scale (FPS).

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The end points of all the scales were worded with the same anchors, "*no pain*" and "t*he most intense pain imaginable*" to facilitate comparison between the scales. Failure rates for the VAS were high (13.1% - 18.0%) in both the younger and older cohorts. The authors suggested that despite the VAS being able to detect change in pain intensity, it is not recommended for research in the older population due to its high failure rate as a consequence of difficulties encountered with the use of the VAS in the older population. The study was limited by a small sample size (61 younger participants and 36 older participants) which led to limited racial diversity in the sample[157].

Cultural differences should also be accounted for when assessing pain, as culture may influence how a patient responds to pain and reports pain. Cultural background is an important factor which influences pain expression and behaviour[158]. This notion is affirmed by Todd[159] who commented that "*language is a major barrier to accurate measurement in cross-cultural research*". He postulated that all pain instruments are language dependant to some extent. Furthermore, pain assessment in different ethnic groups needs to be accurate, and should include specific categorisation of ethnicity and measurement of variables that include socio-economic status and acculturation[159].

The Visual Numeric Scale (VNS) is a valid and reliable measure of pain that combines visual and numeric components, using height and shaded bars which are associated with a numerical value[160]. The use of visual cues in the form of the height and shading of the bars make it possible for it to be used in an illiterate population. The scale has 11 possible responses which range from zero ("*no pain*") to 10 ("*severe pain*"). When compared to the commonly used Visual Analogue scale (VAS), it was found that the VNS was easier to administer, easier to code and less prone to coding errors. The VNS has less practical problems associated with its administration. It also showed appropriate sensitivity to changes in pain. The scale can also be self-administered[160]. The VAS was found to be "*conceptually complex*" and therefore led to non-compliance due to the lack of understanding[156]. Due to the ease of application of the VNS scale and its associated ease of coding, it was found suitable for use in the current study.

The measurement of data in research necessitates the use of accurate and suitable measurement instruments. Through a thorough review of the literature, many instruments were found suitable for use in the current study. These instruments were evaluated based on its benefits as well as its limitations. The instruments that were selected for the study were therefore chosen based on ease of use, the validity and reliability of the instrument, and applicability to the current clinical setting.

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2.10 Summary of the literature review

Historically, medical literature indicates that femoral shaft fractures are common particularly in young adults internationally[20, 41-42] as well as in South Africa[28]. The main causative factors are MVA[24, 43] and GSW[21, 28] and to a lesser extent, falls and recreational activities[24]. In South Africa, the high incidence of crime and violence has contributed towards this phenomenon[19]. There is a paucity of information regarding the burden of femoral fractures on the health care system in South Africa, with particular reference to the effects of morbidity on HRQoL. The surgical management of femoral fractures has been revolutionised with the introduction of the IM nail[6, 27]. This orthopaedic device has excellent rates of bony union post fracture, even in complex femoral fractures[6, 24]. Intramedullary nailing has allowed for earlier mobilisation of the patient[1] thus facilitating earlier discharge from hospital to alleviate hospital costs[46]. The use of IM nailing has been accepted locally and internationally as the gold standard for the surgical management of femoral fractures[1, 28].

However, there are some disadvantages to the use of IM nails. Clinical studies investigating functional impairments following IM nailing have identified common areas of concern, namely: loss of MP of the quadriceps[6, 54, 61] and hip abductor[14, 52] muscles, loss of ROM at the hip and knee joints[6, 14, 52], LLD[6, 48] and prolonged periods of swelling post-operatively causing pain and discomfort[58].These impairments have contributed towards problems associated with gait[14] following femoral shaft fractures, with associated activity limitations and participation restrictions[52]. Restrictions placed on WB on the affected limb following surgery have also impacted on gait patterns[6] and subsequent activity levels. These factors influence the individual's return to normal, pre-morbid activities. Adequate physiotherapy rehabilitation is required to assist return to the pre-morbid state[4].

The assessment of objective measures alone is inadequate to assess the extent of disability following femoral fractures[30]. The importance of a holistic approach to health care has been emphasised with the shift in the health care paradigm to incorporate the concept of QoL[77]. The concept of HRQoL has been favourably adopted for use in clinical practice[40]. Recognition of the many factors such as ethnicity, socio-economic status, culture and educational levels[88] that are present in the South African population should be considered when evaluating outcomes, as these factors may influence HRQoL. However, only a few studies have investigated the concept of HRQoL in orthopaedic surgery[81, 85-86]. There is a lack of information regarding HRQoL following traumatic fractures in a South African setting. Further, the concept of SE may influence a patient's HRQoL and disability[89] post-fracture. Self-efficacy is often neglected when assessing function and is an important consideration in the holistic management of patients[83].

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Groote Schuur Hospital has a tertiary orthopaedic centre in the metropolitan area of Cape Town in South Africa. The patients admitted to these traumatic orthopaedic wards have diverse socio-economic and cultural backgrounds.

Based on literature and the lack of information regarding functional outcomes following surgical management of femoral fractures in a South African setting, a study to describe the characteristics of patients admitted to the hospital with traumatic femoral fractures is required. Furthermore, the extent of disability following this traumatic orthopaedic injury requires critical investigation.

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Chapter 3: Clinical case series

3.1 Introduction

There is a high prevalence of femoral fractures[41-42]. In South Africa, femoral fractures are commonly managed with surgical fixation using an IM nail, which is the accepted gold standard[20,1,2, 48]. Impairments affecting gait and functional mobility following this surgery have been well documented[2, 14, 48]. These impairments may impact on activity limitations and participation restrictions in the environment where patients live and work[30]. The HRQoL of such patients may consequently be affected. Only one study has described HRQoL following traumatic femoral fractures in a local South African setting[28]. However, the factors that influenced the HRQoL were not described and are therefore unknown. Accordingly, the aim of this clinical case series was to document the health-related outcomes in patients who sustained traumatic fractures of the shaft of the femur. The specific objectives of this study are described in Section 1.3.2 page 4.

3.2 Methodology

Ethical approval was obtained from the UCT Faculty of Health Sciences Human Research Ethics Committee (HREC REF: 357/2010) and from the GSH management (Appendix A 1).

3.2.1 *Study design and participants*

A descriptive, prospective longitudinal study in the form of a case series was conducted.

i Inclusion criteria

Participants included males and females between the ages of 18 and 45 years, who had sustained a traumatic femoral shaft fracture that had been reduced using a pro-grade IM nail. All patients below 20 years of age were required to have reached skeletal maturity. Skeletal maturity was assessed radiologically by the researcher. Skeletal maturity was observed on the x-ray by the absence of epiphysial plates (growth plates). Participants were required to have been mobilising using a mobility assistive device (MAD) at the time of discharge from hospital. All participants needed to be able to communicate verbally in either English or Afrikaans, but were not required to have had these languages as their first language, or be able to read or write in these languages.

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ii Exclusion criteria

Participants who had co-morbidities that affected bone healing (for example bone pathologies, diabetes, previous ipsilateral knee injuries or fractures, cancer) were excluded from this study. Participants were also excluded if they had mobilised using MAD prior to the current hospital admission, or if they had sustained neurological damage to the affected leg (whether pre- or post-surgery). Furthermore, participants who presented with a history of psychiatric illness, intellectual disability and/or head injury were excluded from this study, as these conditions may have affected their ability to accurately answer the questionnaires.

3.2.2 *Instrumentation*

The following instruments were used in this study:

- A self-designed demographic questionnaire
- A self-designed medical history data collection sheet
- The South African version of the EQ-5D
- The Stanford Pain Visual Numeric (PVN) Scale
- The Stanford Social/Role activities limitation questionnaire
- The Stanford Health Assessment Questionnaire HAQ 8-Item Disability Index (HAQ-8)
- Goniometer to measure ROM
- Hand-held dynamometer (HHD) to assess MP
- Tape measure to record leg length and the circumference of the thigh and calf
- Frustrum method of limb volume measurement to measure oedema
- Timed up and go (TUG) test to measure functional mobility

The instrumentation was selected to assess outcome measures for the three domains of the ICF framework. These domains were assessed as follows:

- Impairments:
    - Goniometry was used for the assessment of hip, knee and ankle ROM.
    - Dynamometry was used for the assessment of MP of the hip flexors and abductors, quadriceps and hamstrings.
    - The TMM was used to measure the leg length.
    - The Frustrum method was used to measure the oedema in the limb.
    - The TUG test was used to assess the level of functional mobility.
    - The PVN scale was used to assess pain.

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- Activity limitations:
    - The Stanford HAQ-8 questionnaire was used to assess activity limitations. This questionnaire was also used as a proxy for measurement of SE.
- Participation restrictions:
    - The Stanford Social/Role activities limitation questionnaire was used to assess participation restrictions.
- Health-related quality of life
    - The EQ-5D questionnaire was used to measure HRQoL.

i Questionnaires

A self-developed demographic questionnaire (Appendix 7) was completed by each participant. The demographic questionnaire was divided into information required for contact purposes and information required for research purposes. The researcher completed the section concerning the current medical history based on information from the medical folder. Relevant history with regards to mode of injury, date and time of surgery as well as the surgeon's qualification details was recorded from the participant's medical folder (Appendix A 8).Each participant also completed a series of questionnaires with regards to HRQoL, pain, activity limitations and participation (Appendix A 9). On the request of the participant, the researcher assisted each participant to complete the questionnaires. The participants were given the option to use the English, Afrikaans or isiXhosa versions of the EQ-5D questionnaire.

ii Range of motion

Range of motion measurements were performed according to standard described goniometry techniques[12]. The active and passive ROM of knee flexion, extension, hip flexion and abduction and ankle dorsiflexion was measured bilaterally using a standard goniometer, and these methods are described in Appendix A 2. Three measurements of each ROM were taken, and the average was recorded. Participants were allowed to rest for a minimum of one minute and a maximum of two minutes between each measurement. The minimum resting period was dictated by the participant's comfort levels.

iii Muscle power

The participants' ability to actively move their limbs was observed during the ROM assessment. This allowed the researcher to approximate the participants' MP status according to the Medical Research Council scale[161] (Appendix A 3). This information was then used to determine how much resistance to apply with the HHD. Manual muscle testing of the affected and unaffected hip flexors and abductors, the hamstrings and quadriceps was performed using a hand-held *Lafayette Muscle tester* dynamometer[102]. The MP measurement methods are described in Appendix A 4.

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Participants were required to perform a sustained isometric contraction at the midpoint of the available, pain free ROM. Each contraction was held for a maximum of five seconds. Each muscle was tested three times and the average was recorded. The participants were allowed to rest for a minimum of one minute and a maximum of three minutes between each MP measurement.

iv Weight-bearing status

Self-reported WB status was recorded at each contact assessment. Full weight bearing (FWB) was defined as the patient loading the affected limb with his full body weight during gait. Partial weight bearing (PWB) was defined as anything less than the full weight of the body being transferred through the affected limb. Touch weight bearing (TWB) was defined as the affected limb being allowed to touch the floor during the gait pattern, without any bodyweight being transmitted through the affected limb. Non-weight bearing (NWB) was defined as no weight being transferred through the affected limb during gait. The affected leg was held up off the floor during gait[15].

v Leg length discrepancy

Leg length (millimetres) was measured with a tape measure[59], and this method has been described in Section 2.9.4, page 33. The average of three measurements was recorded. These measurements were conducted bilaterally for comparison.

vi Oedema

Oedema of both the affected and unaffected thigh and calf was measured using the Frustum method of volume measurement, which has been described in Section 2.9.3, page 32. The circumference of the thigh and the lower leg was measured with a tape measure[58]. This measurement was performed three times and the average was recorded. The same tape measure was used for all measurements.

vii Timed up and go test

The TUG test was performed with the MAD that the participant was using at the time of discharge from hospital. The testing procedure required that the participant rise from a seated position on a chair, walk to a line three metres ahead of the chair, turned around and then returned to the sitting position on the chair[73]. The time (seconds) taken to perform this task was recorded with a *Monaco hand-held stopwatch* (GAME, S-086). The participant first performed a trial run of the task to familiarise themselves with the required activity before embarking on the test. Only one attempt of the TUG test was performed after the trial run at the initial evaluation and at each follow up assessment. With each follow up assessment, the type of MAD used was recorded.

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Later in the study period, if participants were FWB at the time of testing, they were still required to use their MAD for reasons of comparison[72].The same chair was used for every participant from hospital discharge until the final 12 week follow up.

3.2.3 *Physiotherapy interventions*

Every attempt was made to standardise the physiotherapy intervention by ensuring a similar level of orthopaedic physiotherapy experience and training of the physiotherapists. Each physiotherapist had a minimum of one year of experience within orthopaedics. The three physiotherapists who were working in the orthopaedic wards were included in the study. The physiotherapists were required to attend two training sessions. In the first training session, the physiotherapists received practical demonstrations of the standardised physiotherapy interventions (Appendix A 11). This included a demonstration of assessment techniques for ROM, leg length measurement and MP grading. The GSH treatment protocol was also explained. In the second training session, the physiotherapists were instructed regarding the standardised documentation of assessment findings and treatment record keeping. A standardised home exercise programme was issued to all participants as per the protocol of femoral fracture rehabilitation at the hospital (Appendix A 11). Each physiotherapist explained and demonstrated the home exercise programme to participants at discharge. The treatment intervention and home exercise programme were based on evidence in the literature for the rehabilitation of patients following femoral fractures[14,6,52].

A summary of the physiotherapy intervention was documented at discharge (Appendix A 5). This information included the years of experience of the physiotherapist, the number of physiotherapy sessions and discharge interventions including home programmes and referral letters. Compliance with the home exercise programme was recorded with the physiotherapy intervention. The participant was asked to report whether or not he had been compliant with the home exercise programme. The researcher's role was to conduct the research assessments for all participants. For this reason, the researcher did not treat any of the participants.

3.2.4 *Testing procedure*

Data were collected over a consecutive seven-month period from March 2011 to September 2011. Participants were recruited from the traumatic orthopaedic wards of GSH. Potential participants were identified on daily ward-rounds during the study period. Participants were invited to volunteer for the study. Participants were approached individually at their bedside for an interview. Each interview session served to introduce the participant to the researcher, and to explain the nature, procedure and purpose of the study.

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Participants were required to sign an informed consent form (Appendix A 6) after the nature and purpose of the study had been thoroughly explained. Following the explanatory interview, participants completed a demographic questionnaire (Appendix A 7).

On the day of discharge from hospital, participants completed four questionnaires, namely the PVN, the Stanford Activities/Role limitations questionnaire, the HAQ-8 and the EQ-5D questionnaire (Appendix A 9). Range of motion of hip flexion and abduction, knee flexion and extension, and ankle dorsiflexion of the both lower limbs were measured with a goniometer. Muscle power of the bilateral thigh muscles (hip abductors and flexors), knee flexors and extensors were also measured using a hand-held dynamometer. The WB status, oedema measurements of both lower limbs and leg length measurement were recorded. Each participant then performed the TUG test with their MAD. These tests were also performed at follow up sessions at two, four, six and 12 weeks post-discharge (Appendix A 10). All outcome measures were assessed by the researcher, to maintain reliability of measurements.

All participants received a standardised physiotherapy intervention during the inpatient hospital stay (Section 3.2.3 page 47). Participants were issued with a home exercise programme and referred for further outpatient physiotherapy treatment at discharge from GSH.

At discharge, each participant received an appointment card documenting the date, time and venue of the follow up sessions. These appointments were scheduled to coincide with participants' routine orthopaedic (medical) follow up appointments at two, four, six, and 12 weeks post-discharge from the hospital. Participants were contacted telephonically two days prior to each follow up session to remind them of the appointment. Follow up assessments were conducted in the GSH Department of Physiotherapy Outpatient Clinic. The location of where outpatient physiotherapy treatment was received and the amount of physiotherapy treatment sessions received after discharge from hospital until 12 weeks post-surgery (including number of treatment sessions between each contact assessment) was recorded at each follow up assessment (Appendix A 5).

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3.2.5 *Feasibility study*

A feasibility study was conducted to ensure that participants would be able to cope with the testing procedure. Three participants were recruited for the feasibility study. All functional impairments (ROM, MP, LLD) and oedema were measured three times allowing time for the participant to rest between each measurement. A minimum rest period of one minute and a maximum rest period of three minutes were allowed. The TUG test was only performed once. The study assisted the researcher to scrutinise the testing procedure and eliminate practical difficulties. No changes were made to the testing procedure following the feasibility study.

Recruitment of participants and data collection began following the feasibility study. Data from the feasibility study was not included in the data analysis of the main study.

3.2.6 *Data analyses*

Data were entered and analysed in Microsoft Excel 2007(Microsoft Corporation, Redmond, USA). Due to the small sample size, summary statistics could not be employed. Line graphs were used to indicate the trend in variable outcomes in relation to time. The EQ-5D score to measure HRQoL was used as the primary outcome and was consequently plotted on each line graph. The variable outcomes were grouped to reflect any associations between variables. Six different groupings of results have been presented. The first grouping consists of the EQ-5D index, the EQ VAS state of health and PVN score. The second group includes the EQ-5D index, activity limitations, HAQ-8 and TUG test scores. The last two groupings are the EQ-5D index and hip function (hip flexion, hip abduction, volume of limb and MP of hip flexors and hip abductors); and the EQ-5D index and knee function (knee flexion and extension, volume of limb and MP of quadriceps and hamstrings respectively. In the figures, the EQ-5D index, the HAQ-8 score and the PVN score are presented as actual values as scored from the questionnaires.

The EQ VAS score, TUG test time, as well as the percentage differences in active ROM (AROM), limb volume and MP are presented as the actual measured value divided by a factor of 10 for purposes of graphical presentation. If MP and ROM values are negative, there was an increased MP and ROM in the injured limb compared to the uninjured limb. In all the figures, limb volume, hip ROM and MP are normalised compared to the uninjured limb, with a score of zero indicating no difference between the injured and uninjured limb. Scores below zero for limb volume indicate that volume in the injured leg was less that the uninjured leg.

In addition, although passive ROM (PROM) was recorded, these line graphs are included in the appendix (from Appendix A 20 through to Appendix A 35).The PROM outcomes are not included in the body of the thesis as it had minimal impact on the primary outcome measure. Measurements of active and passive ankle ROM are also included in the tables of variable outcomes for each participant in the appendix (Appendix A 12 to Appendix A 19). These measurements had no impact on the primary outcome.

3.2.7 *Ethical considerations*

Consent forms and a participant information sheet (including the study procedure and testing methods) were issued to each participant (Appendix 6).The researcher personally explained all risks and benefits of the study and stated clearly that the participant had the right to withdraw from the study at any time.

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It was also emphasised that inclusion or exclusion from the study would not influence the participants' physiotherapy treatment any way. Time was allocated to allow each participant the opportunity to question the researcher with regards to their concerns, prior to signing the informed consent forms. Only relevant personal information from the demographic questionnaire was used so as to guarantee confidentiality. All data were regarded as confidential. Data files were stored in a locked cupboard in the Physiotherapy Outpatient Department. Only the researcher and her supervisors had access to the information.

i Risks

There were no physical harms associated with the completion of the questionnaires. However, if participants became distressed while completing the questionnaires, appropriate referrals to a psychologist or a social work officer were provided. The MP tests required that participants apply their maximal effort during testing. Occasionally this MP was tested against a resistance. The resistance that was applied was no more than individual participants could tolerate. This could have resulted in muscle soreness and fatigue and may have been painful. Participants were educated regarding the pain (causes of pain and the safety of the procedure) they may have experienced to reassure them and minimise their pain experience. Range of movement was carefully performed to avoid pain and discomfort. To avoid fatigue, participants were allowed resting periods throughout the testing procedure.

There were no risks involved with measurement of LLD, WB status and oedema. There was a risk of falling when performing the TUG test particularly with the use of a MAD. This risk was minimised by familiarising participants with the test and the use of the MAD, and allowing them to practice the test while the tester provided support using a gait belt. During the actual test, participants were closely monitored by the tester.

ii Benefits

Participants were reimbursed for travel costs each time they arrived for their follow up assessment appointments. There were no further direct benefits for the participant as there was no intervention involved in the study. The study may have served as a reminder to the participants to be more aware of their condition and their follow up physiotherapy appointments. During the study assessments, if any post-surgery complication was observed, the participants were referred to the orthopaedic surgeon. Similarly, if the researcher determined any major problems associated with participation restriction post- discharge, the participants were referred to a social work officer.

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3.3 Results

A summary of the sample collection process is described. This will be followed by a detailed description of each participant. For each participant, the demographic information will be presented first, followed by the relevant clinical characteristics. Finally, a tabular summary of the variable outcomes for discharge, week two, week four, week six and week 12 will be presented. In this section, the term "mechanism of injury", refers to the aetiology of the fracture.

3.3.1 *Process of sampling and data collection*

Data were collected from1st March 2011 to 1st September 2011. There were 491 patients who sustained lower limb fractures during this time period. A total of 40 patients sustained femoral shaft fractures. Only 11 patients were eligible for the clinical case series (Figure 3-1). During the data collection period, only men were found to be eligible for inclusion. Eight participants consented to be included in the clinical case series. Four participants completed the study. The other four participants were lost to follow up.

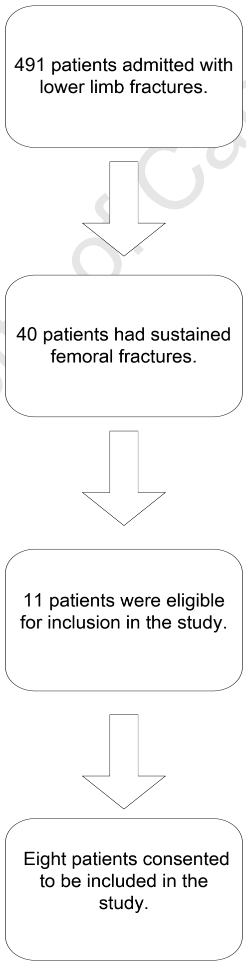

Figure 3-1: Process of sample collection for the clinical case series.

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3.3.2 *Participant One*

i Demographic information

Participant One was a 29 year old man. He lived in Phillipi (an informal housing settlement) in the Cape Flats area of Cape Town. The participant lived alone in a self-made hut (shack) with water and toilet facilities outside the hut. He was unmarried and was formally employed as a security guard for a private company. His work involved walking and standing. He was able to return to his work at the end of the study. He had been granted a new position at work that required less walking. The participant made use of public transport, mainly in the form of a mini-bus taxi. His highest level of education was Grade 12 (this is the full period of schooling in South Africa). He had completed a computer literacy course after secondary school, for which he received a diploma. He reported having never smoked and never having experienced any form of serious illness (self, family or other).This participant was able to return to work before his 12 week follow-up assessment.

ii Clinical information

Participant One had sustained a GSW to the distal third of his right thigh during an armed assault. The assault was unrelated to the participant's employment. He was admitted at GSH via the trauma unit on the day of injury with a comminuted fracture of the distal third of the femur. His surgery was delayed by two days post-admission because of a lack of theatre availability. The surgery was performed by a surgeon with two years of experience. The length of surgical time was 80 minutes and the anaesthetic time was 130 minutes. A prograde IM nail was inserted via a trochanteric entry point. The participant had a five day length of hospital stay. His objective clinical variable outcomes were measured on the day of discharge by the researcher. This participant returned for each of his follow up evaluation sessions at weeks two, four, six and 12, thus completing the series. At the time of discharge, the participant was ambulating with axillary crutches and was NWB on his right leg. He had a LLD of 1.67 mm.

A table of all relevant data of the outcome variables (the impairments, activity limitations and participation restrictions) and HRQoL (primary outcome) are presented for all participants. This is followed by graphical presentation of these outcome variables in the form of line graphs.

The variable outcomes for Participant One are shown in Table 3-1. A comprehensive table of all outcome variables is found in Appendix A 12.

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Table 3-1: Variable outcomes for Participant One

Week	**0**	**2**	**4**	**6**	**12**
Questionnaires					
Pain (scores 0 – 10)	8	4	2	2	0
Stanford activity limitations (scores 0 - 4)	0.75	0.5	0.25	0	0
HAQ 8 (scores 0 - 3)	0.125	0.25	0	0	0
EQ-5D index (scores -0.594 -1)	0.725	0.796	1	1	1
EQ-5D State of health	Worse	Better	Better	Better	Better
EQ VAS State of health (scores 0 – 100)	60	80	90	90	97
Muscle Power					
Percentage difference in hip flexors	50.0	29.2	26.1	38.8	28.0
Percentage difference in hip abductors	51.4	27.6	30.3	23.9	23.4
Percentage difference in quadriceps	57.2	64.6	50.4	21.4	20.0
Percentage difference in hamstrings	60.6	39.9	0.4	-24.2	20.9
Limb volume					
Percentage difference of limb volume of uninjured limb	17.8	10.9	-0.3	-12.9	0.0
Range of Motion					
Percentage difference in hip flexion AROM	55.9	17.2	2.2	2.9	9.0
Percentage difference in hip abduction AROM	11.1	22.8	11.0	5.6	-8.4
Percentage difference in knee flexion AROM	35.7	17.3	14.8	11.1	4.8
Percentage difference in knee extension AROM	5.6	44.4	3.3	2.4	0.0
TUG test time (seconds)	34.5	14.9	12.0	10.2	10.2
Leg length discrepancy (mm)	1.7	0.0	1.7	0.0	5.0

Pain scores "0" = no pain; "10" = severe pain
Stanford activity limitations scores "0" = no activity limitations; "4" = maximum activity limitation
HAQ 8 scores "0" = able to perform activity without difficulty; "3" = unable to perform activity
EQ-5D index scores "-0.594" = worst HRQoL; "1" = best HRQoL
EQ-5D VAS state of health scores "0" = worst imaginable state of health; "100" = best imaginable state of health
Negative values for MP and ROM indicate where the injured limb had better results than the uninjured limb.
Scores below zero for limb volume indicate that volume in the injured leg was less that the uninjured leg.
The MP, ROM and limb volume values are percentage differences between values of the affected and unaffected limbs.

Graphical presentation of the outcome variables are presented in the line graphs. They are presented in relation to hip function and knee function. The EQ-5D index is the primary outcome and is presented on each graph.

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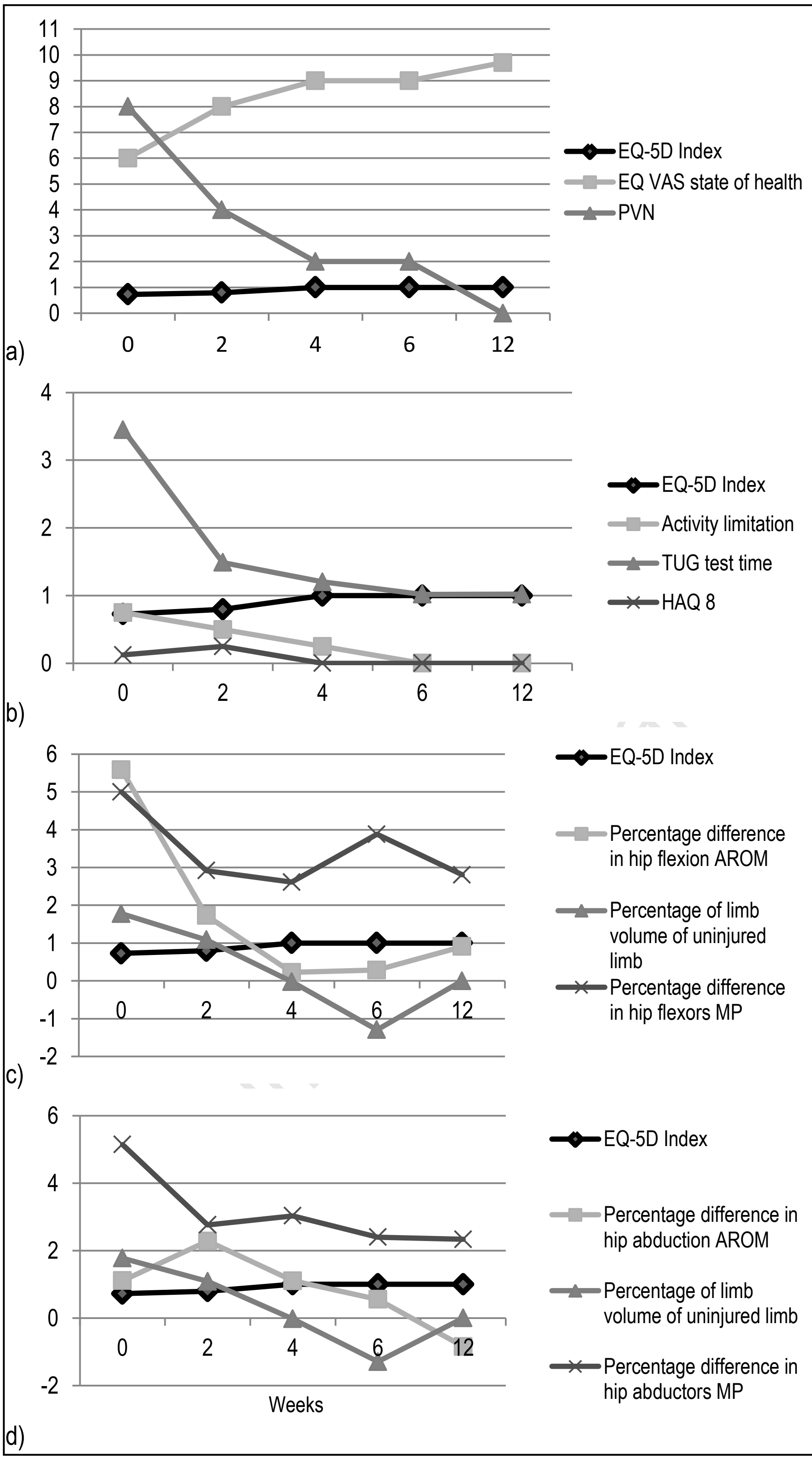
iii EQ-5D, state of health, pain and activity limitation scores, TUG test time and hip function



Key:

EQ-5D index (scores -0.594 – 1)
EQ VAS state of health (scores 0 - 100)

PVN (scores 0 – 10)

Activity limitation (scores 0 – 4)

HAQ 8 (scores 0 -3)

Note: An increase in the EQ-5D index and the EQ VAS reflects an improvement.

A decrease in the PVN score, TUG test time, activity limitations and HAQ-8 score indicates an improvement.

All values for EQ-5D VAS, TUG test and percentage differences for MP, AROM and volume are x 10

Figure 3-2 Participant One: EQ-5D index and outcome variables of (a)EQ VAS state of health and pain scores (b)activity limitation score, HAQ 8 score and TUG test time and(c, d) hip function.

The line graph (Figure 3-2 a) shows that there was an overall improvement in the EQ-5D index over the study period. At weeks four, six and 12, the score was one (1), indicating that the participant reported full health as early as week four. Despite the fact that the participant had reported full health by weeks four and six (EQ-5D = 1), he still experienced some pain. The EQ-5D index and VAS scores indicated a simultaneous improvement in relation to time. The TUG test time improved over the study period (Figure 3-2 b). A score of zero for activity limitations and the HAQ-8 indicated no disability at week six and week 12. A similar pattern of improvement was demonstrated between these variable outcomes over time.

Figure 3-2 (c) indicates that limb volume was highest at week zero. The lowest measurement was noted at week six where the volume of the injured leg was less than that of the uninjured leg. Figure 3-2 (d) shows that the percentage difference in hip abduction AROM was at its highest at week two (higher than at hospital discharge). By the end of the study, the percentage difference in hip abductor MP indicated that the injured limb remained weaker than the uninjured limb. The percentage differences in hip abductor MP and AROM at the hip as well as the EQ-5D index improved as percentage difference in limb volume levels decreased.

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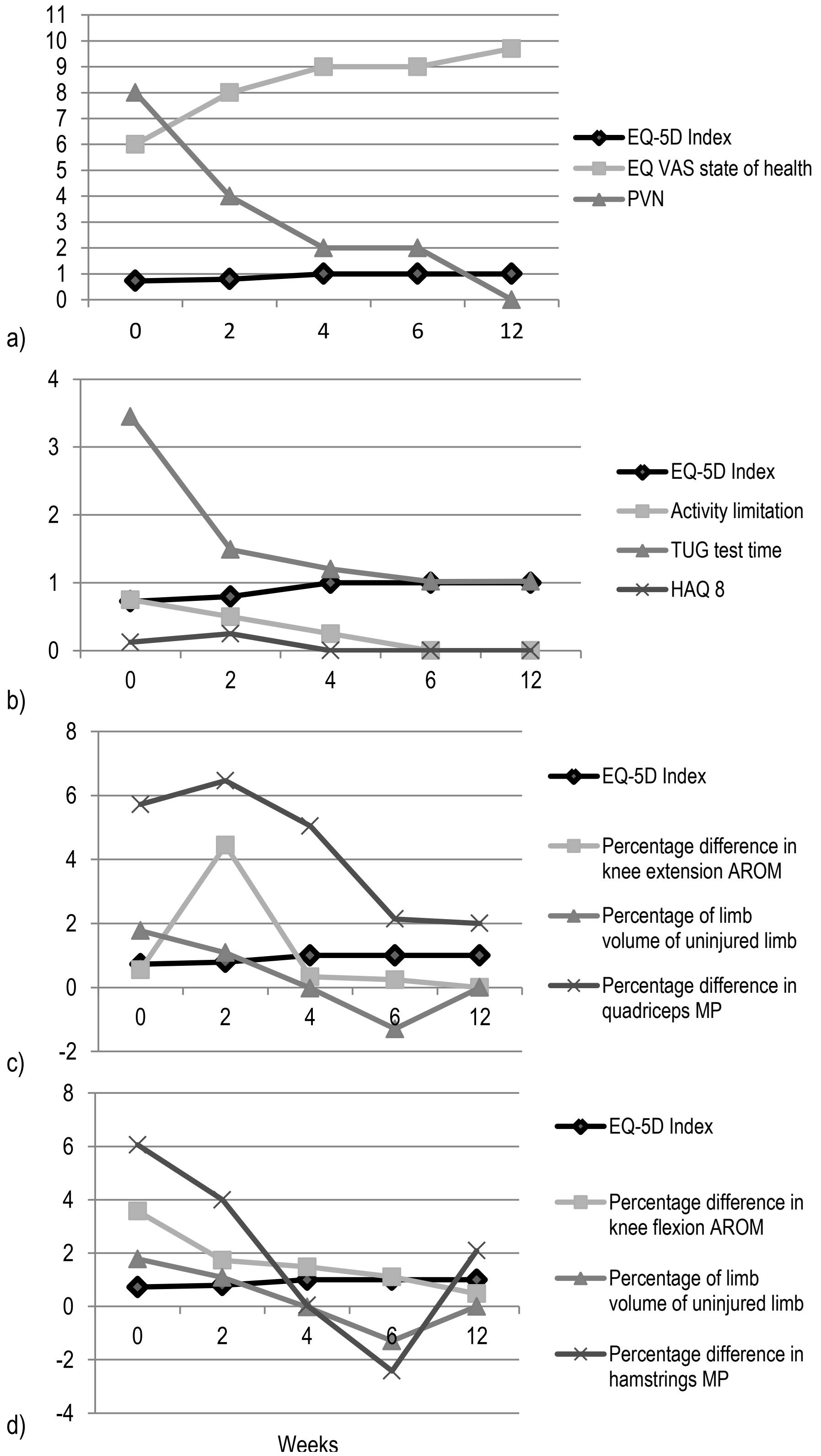
iv EQ-5D, state of health, pain and activity limitation scores, TUG test time and knee function



Key:

EQ-5D index (scores -0.594 – 1)

EQ VAS state of health (scores 0 - 100)

PVN (scores 0 – 10)

Activity limitation (scores 0 – 4)

HAQ 8 (scores 0 -3)

Note: An increase in the EQ-5D index and the EQ VAS reflects an improvement.

A decrease in the PVN score, TUG test time, activity limitations and HAQ-8 score indicates an improvement.

All values for EQ-5D VAS, TUG test and percentage differences for MP, AROM and volume are x 10

Figure 3-3 Participant One: EQ-5D index and outcome variables of (a)EQ VAS state of health and pain scores (b)activity limitation score, HAQ 8 score and TUG test time and (c, d) knee function.

Figure 3-3 (c) indicates an overall improvement in active knee extension over the 12 weeks. The tracing between percentage difference in quadriceps MP and knee extension AROM was proportional. These two variables appeared to have improved along with the EQ-5D index over the 12 week period.

The percentage difference of knee flexion AROM score (Figure 3-3 d) indicates that the knee flexion AROM of the injured limb improved over the study period but was less than that of the uninjured limb by week 12. The tracing of percentage difference in hamstring MP and limb volume follow a similar curve suggesting a potential association between these two variables. The EQ-5D index and percentage difference in knee flexion AROM appeared to have improved at similar time frames.

v Physiotherapy intervention

During his hospital stay, three physiotherapy treatments were given to the participant on consecutive days. The treating physiotherapist had five years of experience. Upon discharge, he was issued with a home exercise programme and a referral letter to continue physiotherapy at the community health centre. The participant reported that he was compliant with his home exercise programme. He had not received any further physiotherapy treatment on an outpatient basis throughout the study period. He considered his attendance with the research study follow up assessments to be his rehabilitation.

vi Weight bearing status

His WB status changed from NWB at weeks zero and two to TWB at week four, PWB at week six and FWB at week 12.

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3.3.3 *Participant Two*

i Demographic information

Participant Two was a 28 year old man. He lived in Guguletu (a resource-poor residential area) in the Cape Flats area of Cape Town. He was not a South African citizen. He was originally from Somalia and came to live in South Africa three years prior to his admission at GSH. The participant lived with friends in a formal house. Water and toilet facilities were inside the house. He was unmarried and was self-employed. The participant co-owned a spaza shop (an informal convenience shop run from home) in the community where he worked as a shop assistant. The work involved walking and standing. The participant made use of private transport (he and his friends shared a motor car). His highest level of education was equivalent to a South African Grade 12. He had obtained no further formal education. He reported that he used to smoke and had never had any form of serious illness (self, family or other). After his discharge from hospital, the participant went to live in Wynberg (a middle-class suburb) with friends who were willing to care of him.

ii Clinical information

Participant Two had sustained a GSW to the distal third of his left thigh during an armed robbery of the shop where he worked. He was admitted at GSH via the trauma unit one day after the day of injury. He had sustained a comminuted fracture of the distal third of the femur. He had surgery on the day of admission. The surgery was performed by a surgeon who had two years of experience. The length of surgical time was 65 minutes and the anaesthetic time was 105 minutes. A prograde IM nail was inserted via a trochanteric entry point. The participant had a six day length of hospital stay. His objective clinical variable outcomes were measured on the day of discharge by the researcher. This participant returned for follow up evaluation sessions at week two, four and six but did not arrive at week 12. He was contacted via telephone to attend but still did not arrive despite confirming that he would attend. He thus did not complete the series. At the time of discharge, the participant was ambulating with axillary crutches and was NWB on his left leg. He had a LLD of 10 mm.

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The variable outcomes for Participant Two are shown in Table 3-2. A comprehensive table of all outcome variables is found in Appendix A 13.

Table 3-2: Variable outcomes for Participant Two

Week	0	2	4	6
Questionnaires				
Pain (scores 0 - 10)	4	0	0	0
Stanford activity limitation (scores 0 - 4)	3.5	2.75	2.75	1.25
HAQ 8 (scores 0 - 3)	0.625	0.75	0	0
EQ-5D index (scores -0.594 - 1)	0.189	0.312	0.883	0.883
EQ-5D state of health	Worse	Worse	Worse	Worse
EQ VAS state of health (scores 0 - 100)	60.00	80.00	95.00	95.00
Muscle Power				
Percentage difference in hip flexors	66.2	14.6	12.1	-17.1
Percentage difference in hip abductors	66.0	52.9	-5.5	19.6
Percentage difference in quadriceps	66.8	39.5	36.0	39.7
Percentage difference in hamstrings	73.9	22.4	26.0	25.7
Limb Volume				
Percentage of limb volume of uninjured limb	39.6	3.9	29.2	69.7
Range of Motion				
Percentage difference in hip flexion AROM	64.9	33.3	-2.6	0.0
Percentage difference in hip abduction AROM	47.5	67.6	0.0	-0.58
Percentage difference in knee flexion AROM	52.6	33.3	3.3	0.3
Percentage difference in knee extension AROM	15.0	10.7	0.6	0.0
TUG test time (seconds)	24.6	16.8	9.4	10.1
Leg length discrepancy (mm)	10	20	10	0

Pain scores "0" = no pain; "10" = severe pain
Stanford activity limitations scores "0" = no activity limitations; "4" = maximum activity limitation
HAQ 8 scores "0" = able to perform activity without difficulty; "3" = unable to perform activity
EQ-5D index scores "-0.594" = worst HRQoL; "1" = best HRQoL
EQ-5D VAS state of health scores "0" = worst imaginable state of health; "100" = best imaginable state of health
Negative values for MP and ROM indicate where the injured limb had better results than the uninjured limb.
Scores below zero for limb volume indicate that volume in the injured leg was less that the uninjured leg.
The MP, ROM and limb volume values are percentage differences between values of the affected and unaffected limbs.

Graphical presentation of the outcome variables are presented in the line graphs. They are presented in relation to hip function and knee function. The EQ-5D index is the primary outcome and is presented on each graph.

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iii EQ-5D, state of health, pain and activity limitation scores, TUG test time and hip function

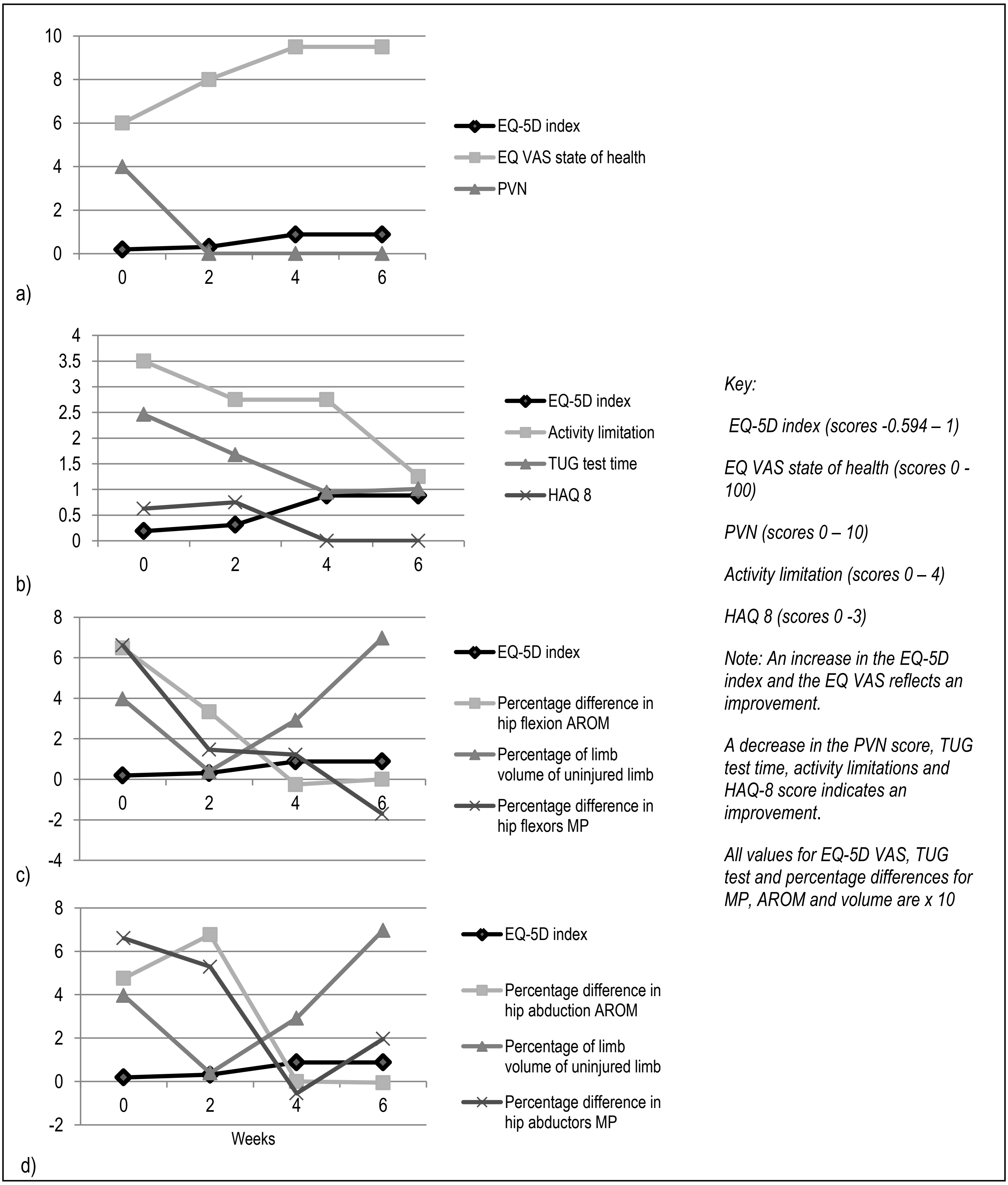

Figure 3-4 Participant Two: EQ-5D index and outcome variables of (a)EQ VAS state of health and pain scores (b)activity limitation score, HAQ 8 score and TUG test time and(c, d) hip function

Figure 3-4 (a) suggests that the EQ-5D index, EQ VAS score and the PVN score all improved simultaneously in this participant. In Figure 3-4 (b) the EQ-5D index, the activity limitations score and the HAQ-8 score each followed a similar trend. TUG test time decreased over the study period indicating an improvement in gait function.

Hip flexion AROM improved over the study period (Figure 3-4 c). The percentage difference in volume at week six indicates that the volume of the injured limb remained substantially more than the uninjured limb. The improvements in the percentage differences of the hip flexors MP and the hip flexion AROM corresponds with the improvement of the EQ-5D index between weeks four and six. Figure 3-4 (d) indicates that the percentage difference in hip abduction AROM and hip abductor MP appear to improve in a similar trend to the EQ-5D index. These variables do not appear to be related to the percentage difference in limb volume.

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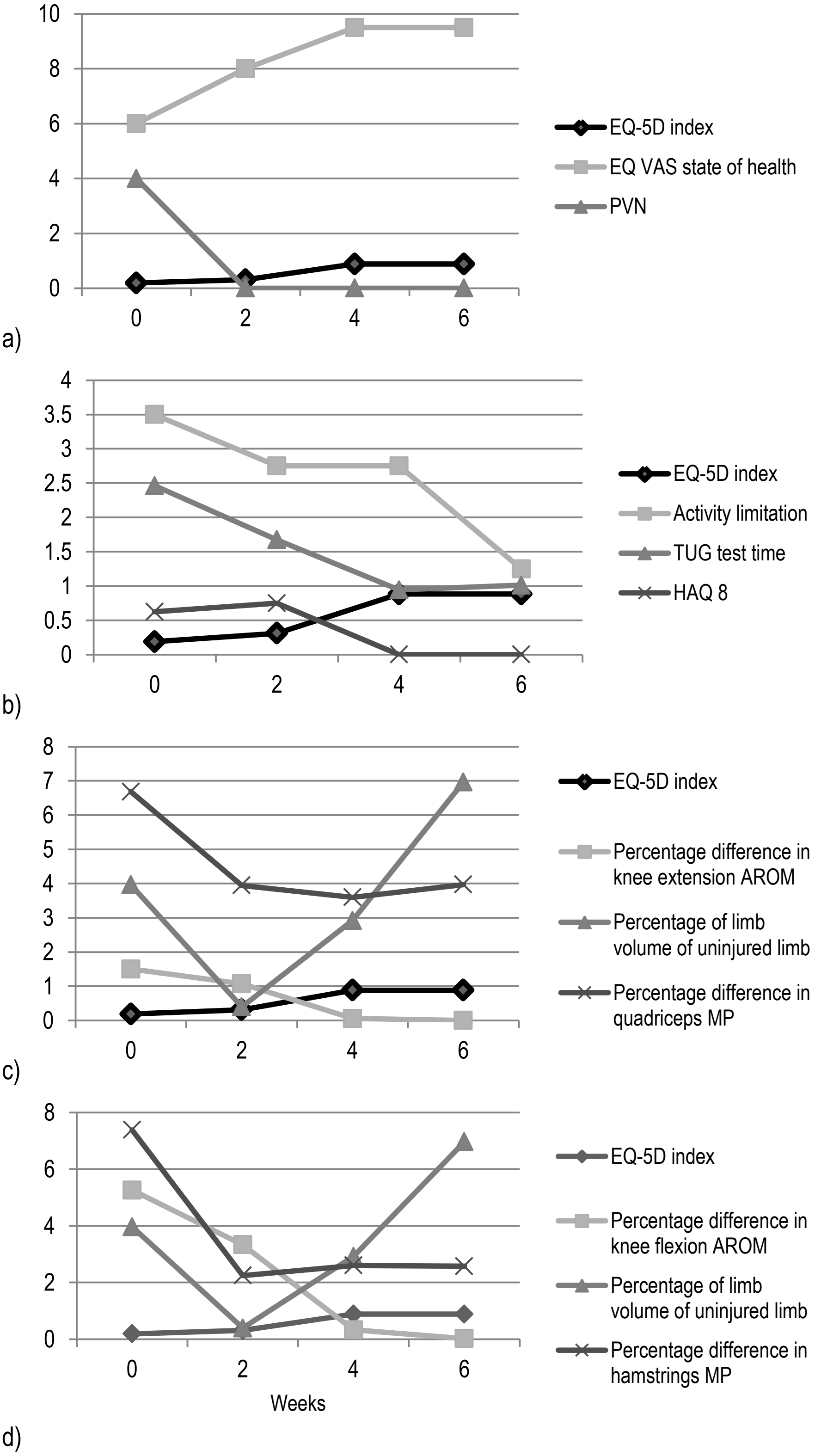
iv EQ-5D, state of health, pain and activity limitation scores, TUG test time and knee function



Key:

EQ-5D index (scores -0.594 – 1)

EQ VAS state of health (scores 0 - 100)

PVN (scores 0 – 10)

Activity limitation (scores 0 – 4)

HAQ 8 (scores 0 -3)

Note: An increase in the EQ-5D index and the EQ VAS reflects an improvement.

A decrease in the PVN score, TUG test time, activity limitations and HAQ-8 score indicates an improvement.

All values for EQ-5D VAS, TUG test and percentage differences for MP, AROM and volume are x 10

Figure 3-5 Participant Two: EQ-5D index and outcome variables of (a)EQ VAS state of health and pain scores (b)activity limitation score, HAQ 8 score and TUG test time and (c, d) knee function.

Figure 3-5 (c) indicates that the EQ-5D index and percentage difference in knee extension AROM follow a similar trend suggesting a potential relationship between these two variables. Figure 3-5 (d) indicates a similar trend of improvement between the knee flexion AROM and the EQ-5D index.

v Physiotherapy intervention

This participant had a two day delay to physiotherapy treatment due to no physiotherapy services being offered over the weekend. During his hospital stay, three physiotherapy treatments were given to the participant (two consecutive treatments and the final treatment following the weekend). The treating physiotherapist had two years of experience. At discharge, he was issued with a home exercise programme and a referral letter to continue physiotherapy at the community health centre. The participant reported that he was non-compliant with his home exercise programme. He had not made any contact with the physiotherapist in the community and had not received any outpatient physiotherapy. Participant Three reported that the follow up assessment sessions with the researcher would suffice as outpatient physiotherapy treatment.

vi Weight-bearing status

The participant remained NWB on his left leg at hospital discharge and at week two. He reported that at week four he was TWB on the left leg. By week six, the participant had returned to NWB on the left leg.

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3.3.4 *Participant Three*

i Demographic information

Participant Three was a 31 year old man. He lived in Khayelitsha (a resource-poor residential area) in the Cape Flats area of Cape Town. The participant lived alone in a self-made hut with water and toilet facilities outside the hut. He was unmarried and was employed as a security officer. His work involved walking and standing. The participant made use of public transport in the form of a mini-bus taxi. His highest level of education was Grade 12. He had obtained no further formal education after completing Grade 12. He reported having never smoked and never having experienced any form of serious illness (self, family or other).

ii Clinical information

Participant Three reported that he had sustained a GSW to his right thigh. It was unknown if the injury was related to his type of employment based on the information in the medical folder. The participant was first seen at the community health centre from where he was referred to GSH. He was admitted at GSH via the trauma unit one day after the date of injury. He had sustained a comminuted fracture of the proximal third of the femur. He had surgery on the day of admission. The surgery was performed by a surgeon who had one year and nine months of experience. The length of surgical time was 85 minutes and the anaesthetic time was 125 minutes. A prograde IM nail was inserted via a trochanteric entry point. The participant had a three day length of hospital stay. His objective clinical variable outcomes were measured on the day of discharge by the researcher. This participant returned for follow up evaluation sessions at week two and four but did not arrive at weeks six and 12. The researcher tried to contact him telephonically via his cousin. The cousin had managed to contact the participant. By this time, he had moved to the Eastern Cape Province to his childhood home to live with his mother. He thus did not complete the series. At the time of discharge, the participant was ambulating with axillary crutches and was NWB on his right leg. He had a LLD of 20 mm.

The variable outcomes for Participant Three are shown in Table 3-3. A comprehensive table of all outcome variables is found in Appendix A 14.

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Table 3-3: Variable outcomes for Participant Three

Week	**0**	**2**	**4**
Questionnaires			
Pain (scores 0 - 10)	5	3	2
Stanford activity limitation (scores 0 - 4)	1.75	1.5	0.5
HAQ 8 (scores 0 - 3)	0.625	0.375	0.125
EQ-5D index(scores -0.594 – 1)	-0.17	0.585	0.689
EQ-5D state of health	Better	Better	Better
EQ VAS state of health (scores 0 - 100)	50	70	80
Muscle Power			
Percentage difference in hip flexors	60.4	65.8	32.5
Percentage difference in hip abductors	48.0	50.6	-6.7
Percentage difference in quadriceps	76.0	35.0	17.5
Percentage difference in hamstrings	22.6	26.5	-5.8
Limb Volume			
Percentage of limb volume of uninjured limb	-1.3	18.4	6.5
Range of Motion			
Percentage difference in hip flexion AROM	63.2	33.3	9.9
Percentage difference in hip abduction AROM	85.8	60.6	40.0
Percentage difference in knee flexion AROM	49.6	33.3	10.7
Percentage difference in knee extension AROM	3.3	8.9	0.0
TUG test time (seconds)	29.6	12.5	9.3
Leg length discrepancy (mm)	20.0	10.0	0.0

Pain scores "0" = no pain; "10" = severe pain
Stanford activity limitations scores "0" = no activity limitations; "4" = maximum activity limitation
HAQ 8 scores "0" = able to perform activity without difficulty; "3" = unable to perform activity
EQ-5D index scores "-0.594" = worst HRQoL; "1" = best HRQoL
EQ-5D VAS state of health scores "0" = worst imaginable state of health; "100" = best imaginable state of health
Negative values for MP and ROM indicate where the injured limb had better results than the uninjured limb.
Scores below zero for limb volume indicate that volume in the injured leg was less that the uninjured leg.
The MP, ROM and limb volume values are percentage differences between values of the affected and unaffected limbs.

Graphical presentation of the outcome variables are presented in the line graphs. They are presented in relation to hip function and knee function. The EQ-5D index is the primary outcome and is presented on each graph.

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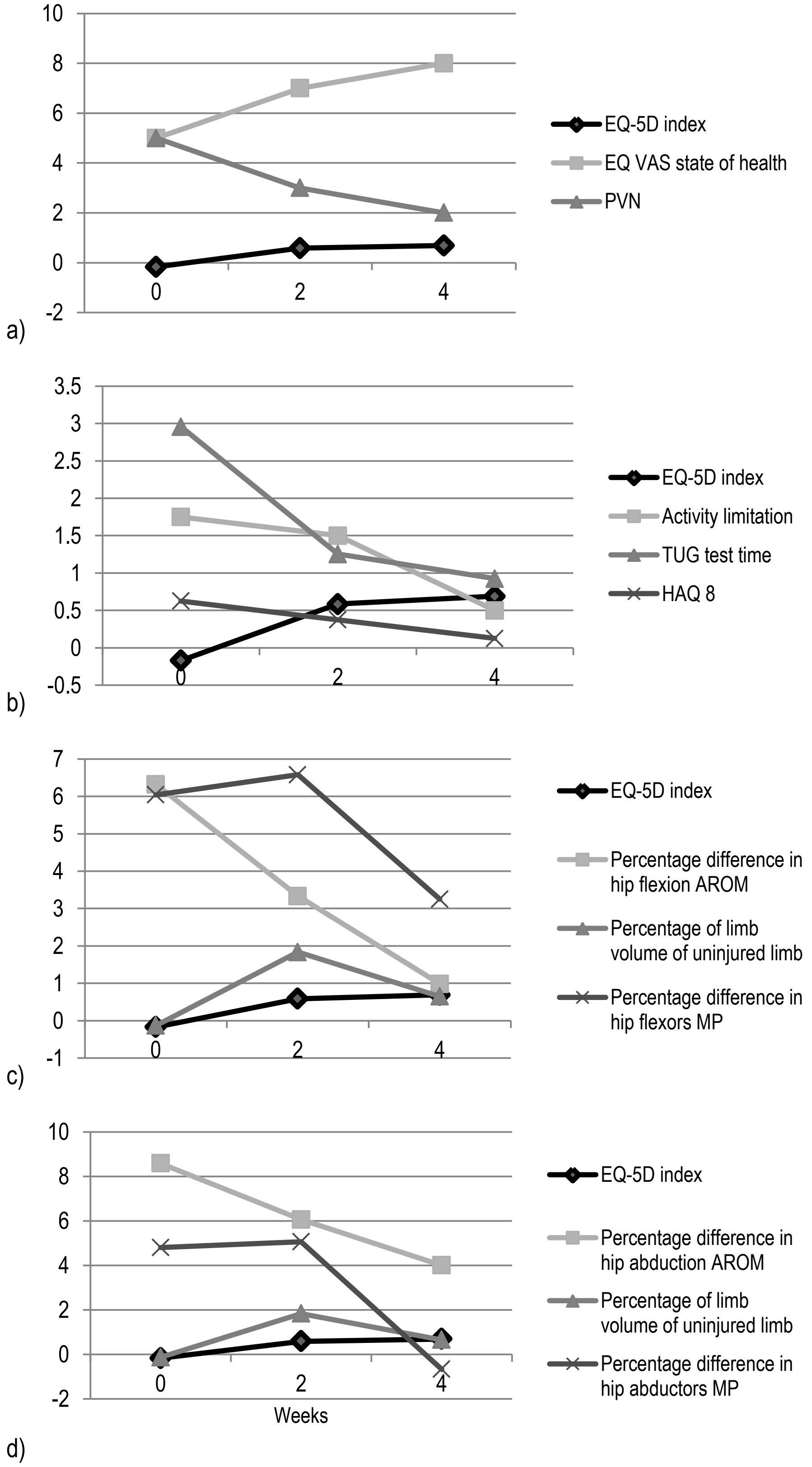
iii EQ-5D, state of health, pain and activity limitation scores, TUG test time and hip function



Key:

EQ-5D index (scores -0.594 – 1)

EQ VAS state of health (scores 0 - 100)

PVN (scores 0 – 10)

Activity limitation (scores 0 – 4)

HAQ 8 (scores 0 -3)

Note: An increase in the EQ-5D index and the EQ VAS reflects an improvement.

A decrease in the PVN score, TUG test time, activity limitations and HAQ-8 score indicates an improvement.

All values for EQ-5D VAS, TUG test and percentage differences for MP, AROM and volume are x 10

Figure 3-6 Participant Three: EQ-5D index and outcome variables of (a)EQ VAS state of health and pain scores (b)activity limitation score, HAQ 8 score and TUG test time and (c, d) hip function.

Figure 3-6 (a) indicates that the EQ-5D score, EQ-5D state of health VAS score and pain scores all showed an improvement over the four week study period. Figure 3-6 (b) demonstrates that the activity limitations score, the TUG test time and the HAQ-8 scores all appeared to improve over the same time frame as the EQ-5D index. Figure 3-6 (c) shows that the percentage difference in hip flexion AROM and EQ-5D index follow a similar trend. The percentage difference in hip abduction AROM decreased in a similar pattern to the hip flexion AROM (Figure 3-6 d) over the four weeks. The percentage differences in limb volume and hip abductor MP appeared to increase and decrease at similar time frames.

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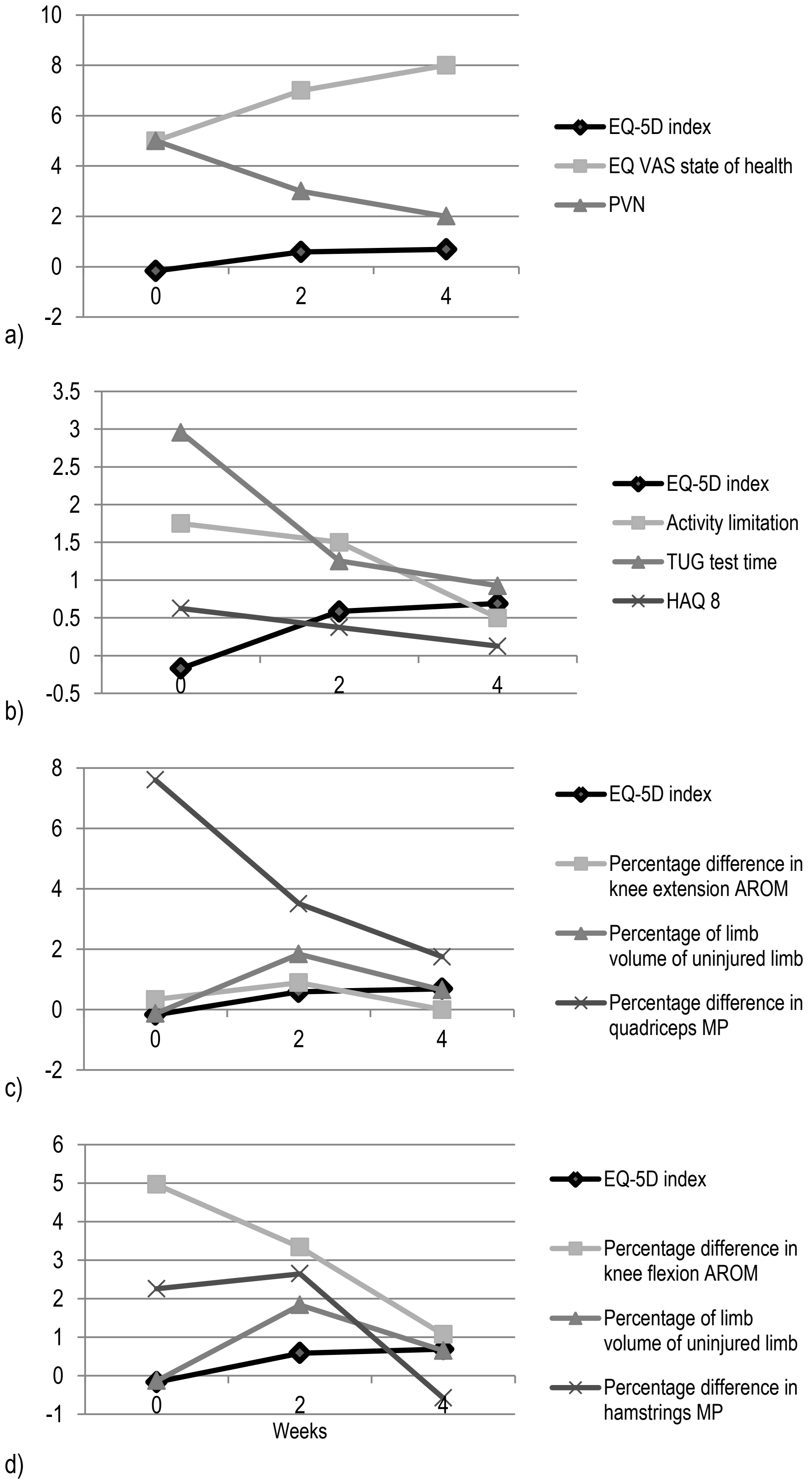
iv EQ-5D, state of health, pain and activity limitation scores, TUG test time and knee function



Key:

EQ-5D index (scores -0.594 – 1)

EQ VAS state of health (scores 0 - 100)

PVN (scores 0 – 10)

Activity limitation (scores 0 – 4)

HAQ 8 (scores 0 -3)

Note: An increase in the EQ-5D index and the EQ VAS reflects an improvement.

A decrease in the PVN score, TUG test time, activity limitations and HAQ-8 score indicates an improvement.

All values for EQ-5D VAS, TUG test and percentage differences for MP, AROM and volume are x 10

Figure 3-7 Participant Three: EQ-5D index and outcome variables of (a)EQ VAS state of health and pain scores (b)activity limitation score, HAQ 8 score and TUG test time and (c, d) knee function.

Figure 3-7(c) demonstrates that the EQ-5D index and the percentage difference in quadriceps MP both improved over the same time frame in this participant. The percentage differences of limb volume and knee extension AROM had the same trend, suggesting a potential relationship between these variables. Figure 3-7 (d) indicates that the EQ-5D index and knee flexion AROM both improved at similar time frames. In addition, the percentage differences in limb volume and hamstring MP appeared to be potentially related in that both scores follow the same trend.

v Physiotherapy intervention

During his hospital stay, three physiotherapy treatments were given to the participant on consecutive days. The treating physiotherapist had two years of experience. At discharge, he was issued with a home exercise programme and a referral letter to continue physiotherapy at the community health centre. The participant had not had any further physiotherapy treatments since discharge from hospital. He had not made an appointment to see the physiotherapist at the community health centre. Participant Three reported that he considered his follow up sessions for the research study to be his treatment. He reported that he was compliant with his home exercise programme.

vi Weight-bearing status

The participant changed his WB status from NWB at discharge, to TWB at week two and PWB at week four. He reported that he had changed his WB status according to comfort and not upon instruction by the surgeon.

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3.3.5 *Participant Four*

i Demographic information

Participant Four was a 26 year old man. He lived in Khayelitsha (a resource-poor residential area) in the Cape Flats area of Cape Town. The participant lived alone in a self-made hut with water and toilet facilities outside the hut. He was unmarried and unemployed but was seeking work. The participant made use of his bicycle as transport or walked as an alternative. His highest level of education was Grade 12. He had obtained no further formal education after completing Grade 12. Participant Four was a smoker. The participant reported that he was a Rastafarian and therefore he smoked marijuana daily in accordance with his religion. He emphasised that leading a healthy lifestyle was important to him according to his religious beliefs. He therefore exercised on a regularly basis prior to his injury. He had never experienced any form of serious illness (self, family or other).

ii Clinical information

Participant Four was involved in a MVA as a cyclist. He was admitted at GSH via the trauma unit on the day of injury. He had sustained a comminuted fracture of the middle third of the left femur. The participant had surgery on the day of admission. The surgery was performed by a surgeon who had six years of experience. The length of surgical time was 55 minutes and the anaesthetic time was 100 minutes. A prograde IM nail was inserted via a trochanteric entry point. The participant had a three day length of hospital stay. His objective clinical variable outcomes were measured on the day of discharge by the researcher. This participant returned for follow up evaluation sessions at week two, four, six and 12 thus completing the series. At the time of discharge, the participant was ambulating with axillary crutches and was NWB on his left leg. He had a LLD of 20 mm.

The variable outcomes for Participant Four are shown in Table 3-4. A more comprehensive table of the variable outcomes is found in Appendix A 15.

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Table 3-4 Variable outcomes for Participant Four

Week	**0**	**2**	**4**	**6**	**12**
Questionnaires					
Pain (scores 0 - 10)	3	2	1	1	0
Stanford activity limitation (scores 0 - 4)	1.5	0.5	0.25	0.25	0.25
HAQ 8 (scores 0 - 3)	0.125	0	0	0	0
EQ-5D index (scores -0.594 – 1)	0.656	0.516	0.796	0.727	1
EQ-5D state of health	Much the same	Better	Better	Much the same	Better
EQ VAS state of health (scores 0 – 100)	60	30	70	85	95
Muscle Power					
Percentage difference in hip flexors	37.3	23.7	34.5	11.5	0.0
Percentage difference in hip abductors	41.8	8.0	-9.9	19.9	7.1
Percentage difference in quadriceps	27.7	30.2	23.4	18.0	4.5
Percentage difference in hamstrings	46.5	19.4	29.7	15.9	10.7
Limb Volume					
Percentage of limb volume of uninjured limb	33.1	18.6	12.1	2.4	0.0
Range of Motion					
Percentage difference in hip flexion AROM	-2.1	6.2	-1.4	-4.4	-1.5
Percentage difference in hip abduction AROM	48.9	0.0	0.0	4.6	0.0
Percentage difference in knee flexion AROM	20.9	6.2	6.2	1.9	10.7
Percentage difference in knee extension AROM	0.9	5.9	4.8	5.6	0.0
TUG test time (seconds)	36.2	20.3	21.4	12.9	9.2
Leg length discrepancy (mm)	20.0	0.0	0.0	0.0	0.0

Pain scores “0” = no pain; “10” = severe pain
Stanford activity limitations scores “0” = no activity limitations; “4” = maximum activity limitation
HAQ 8 scores “0” = able to perform activity without difficulty; “3” = unable to perform activity
EQ-5D index scores “-0.594” = worst HRQoL; “1” = best HRQoL
EQ-5D VAS state of health scores “0” = worst imaginable state of health; “100” = best imaginable state of health
Negative values for MP and ROM indicate where the injured limb had better results than the uninjured limb.
Scores below zero for limb volume indicate that volume in the injured leg was less that the uninjured leg.
The MP, ROM and limb volume values are percentage differences between values of the affected and unaffected limbs.

Graphical presentation of the outcome variables are presented in the line graphs. They are presented in relation to hip function and knee function. The EQ-5D index is the primary outcome and is presented on each graph.

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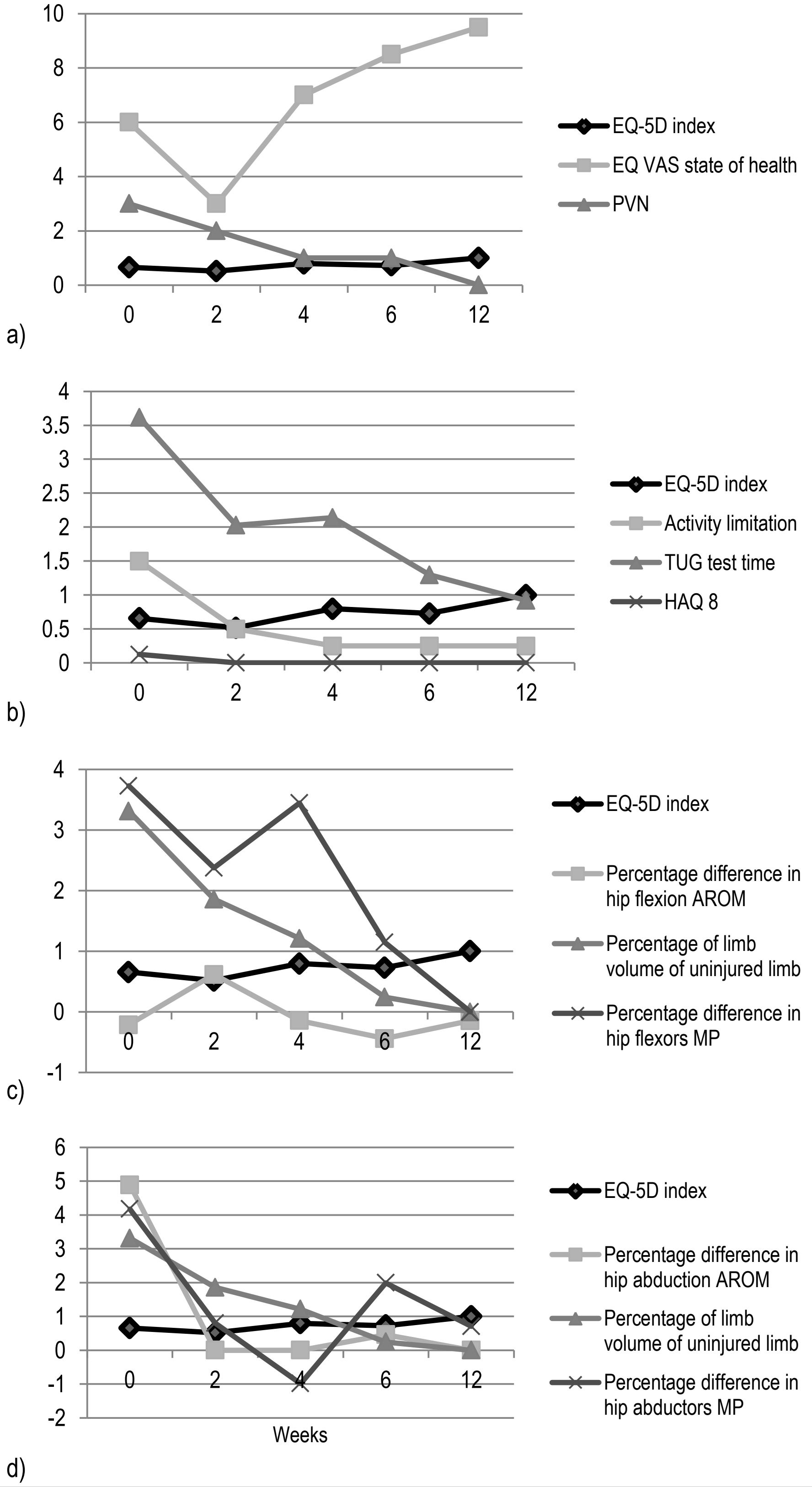
iii <u>EQ-5D, state of health, pain and activity limitation scores, TUG test time and hip function</u>



Key:

EQ-5D index (scores -0.594 – 1)

EQ VAS state of health (scores 0 - 100)

PVN (scores 0 – 10)

Activity limitation (scores 0 – 4)

HAQ 8 (scores 0 -3)

Note: An increase in the EQ-5D index and the EQ VAS reflects an improvement.

A decrease in the PVN score, TUG test time, activity limitations and HAQ-8 score indicates an improvement.

All values for EQ-5D VAS, TUG test and percentage differences for MP, AROM and volume are x 10

Figure 3-8 Participant Four: EQ-5D index and outcome variables of (a)EQ VAS state of health and pain scores (b)activity limitation score, HAQ 8 score and TUG test time and (c, d) hip function.

Figure 3-8 (a) demonstrates that by week 12, the participant reported that he had reached a state of full health. The EQ VAS state of health score had the same trend as the EQ-5D index. Notably, the participant reported relatively low pain levels throughout the study. All three variables improved simultaneously over the series in this participant. Figure 3-8 (b) demonstrates that the activity limitations score never reached zero which indicated that despite the improvement in function, the participant never returned to his pre-operative (complete independence) functional state. The TUG test time, activity limitations score and HAQ 8 improvements were consistent with improvements in the EQ-5D index. This suggests that a potential relationship between the variables may have existed.

Figure 3-8 (c) shows that each variable had improved over time which was consistent with the improvement of the EQ-5D index. A potential relationship appeared to be present between these variables and the HRQoL of this participant. An apparent relationship appeared to be present between percentage difference in hip abductor AROM, limb volume and the EQ-5D index (Figure 3-8 d). All these variables improved simultaneously. To a lesser extent, a potential relationship appeared to be present between the EQ-5D index and percentage difference of hip abductor MP as a general improvement was noted throughout the series.

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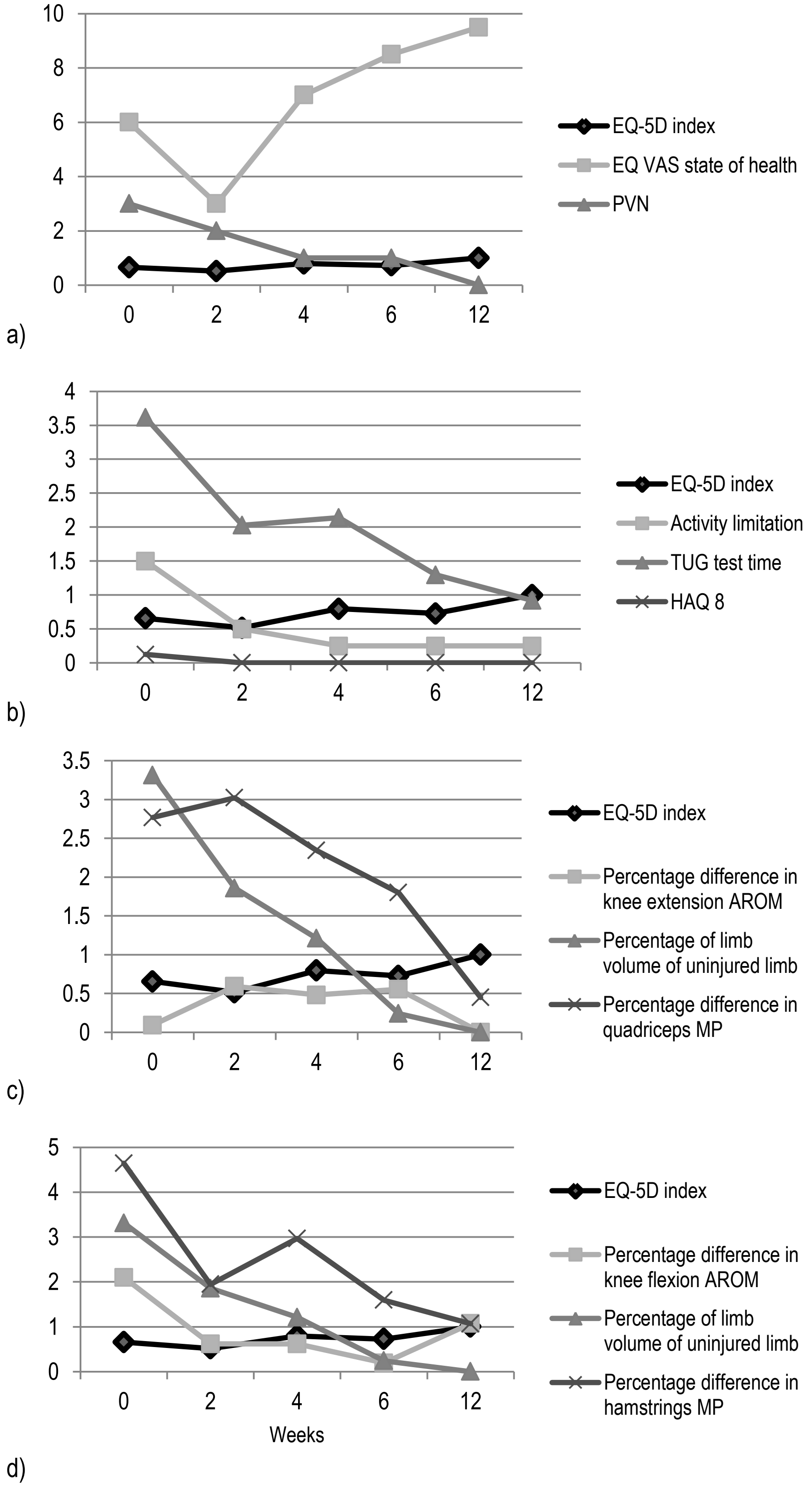
iv EQ-5D, state of health, pain and activity limitation scores, TUG test time and knee function



Key:

EQ-5D index (scores -0.594 – 1)

EQ VAS state of health (scores 0 - 100)

PVN (scores 0 – 10)

Activity limitation (scores 0 – 4)

HAQ 8 (scores 0 -3)

Note: An increase in the EQ-5D index and the EQ VAS reflects an improvement.

A decrease in the PVN score, TUG test time, activity limitations and HAQ-8 score indicates an improvement.

All values for EQ-5D VAS, TUG test and percentage differences for MP, AROM and volume are x 10

Figure 3-9 Participant Four: EQ-5D index and outcome variables of (a)EQ VAS state of health and pain scores (b)activity limitation score, HAQ 8 score and TUG test time and (c, d) knee function.

As shown in Figure 3-9 (c), all the variables improved over the series in relation to the EQ-5D index. Generally, the improvements in percentage differences in knee flexion AROM and hamstrings MP seemed to occur in a similar pattern to changes in limb volume and the EQ-5D index score over time (Figure 3-9 d) Further, the TUG test time and knee flexion AROM followed a similar trend.

v Physiotherapy intervention

During his hospital stay, three physiotherapy treatments were given to the participant on consecutive days. The treating physiotherapist had five years of experience. At discharge, he was issued with a home exercise programme and a referral letter to continue physiotherapy at the community health centre. The participant received two physiotherapy treatments on an outpatient basis in his community. The first treatment was between weeks two and four and the second between weeks six and twelve. Participant Four reported that the physiotherapist was unable to see him more often because of the long waiting list of patients. Details of the treatment given are unknown. The participant also reported that he was compliant with his home exercise programme.

vi Weight-bearing status

The participant remained NWB on his injured left leg from discharge until week two. At weeks four and six he was TWB. At week 12 the participant was FWB on the left leg.

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3.3.6 *Participant Five*

i Demographic information

Participant Five was a 32 year old man. He lived in Lower Cross Roads (an informal housing settlement) in the Cape Flats area of Cape Town. The participant lived with his cousin in a self-made hut with water and toilet facilities outside the hut. He was unmarried and unemployed but was seeking work. He had previously worked as a petrol attendant. The participant made use of public transport in the form of a mini bus taxi. His highest level of education was Grade 12. He had obtained no further formal education after completing Grade 12. He reported that he was a smoker. He had never experienced any form of serious illness (self, family or other).

ii Clinical information

Participant Five was involved in a MVA as a paedestrian. He was admitted at GSH via the trauma unit on the day of injury. He had sustained a short oblique fracture of the middle third of the left femur. The participant had surgery two days post admission. The delay in surgery was due to a lack of theatre time availability. The surgery was performed by a surgeon who had one year and nine months of experience. The length of surgical and anaesthetic time is unknown as the relevant form was not found in the participant's medical folder. A prograde IM nail was inserted via a trochanteric entry point. The participant had an eight day length of hospital stay. His objective clinical variable outcomes were measured on the day of discharge by the researcher. This participant returned for follow up evaluation sessions at weeks two, four and six. He was contacted telephonically in week 12. The participant reported that he had moved back to the Eastern Cape Province at that time and so did not arrive for his appointment. Thus he did not complete the series. At the time of discharge, the participant was ambulating with axillary crutches and was FWB on his left leg. He did not have a LLD.

The variable outcomes for Participant Five are shown in Table 3-5. A comprehensive table of all variable outcome values is found Appendix A 16.

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Table 3-5: Variable outcomes for Participant Five

Week	**0**	**2**	**4**	**6**
Questionnaires				
Pain (scores 0 - 10)	4	4	3	4
Stanford activity limitation (scores 0 - 4)	4	3.75	3	3.25
HAQ 8 (scores 0 - 3)	1	0.375	0.25	0
EQ-5D index (scores -0.594 – 1)	0.082	0.656	0.656	0.796
EQ-5D state of health	Worse	Better	Worse	Better
EQ VAS state of health (scores 0 - 100)	60	70	80	80
Muscle Power				
Percentage difference in hip flexors	32.86	-18.55	-22.96	6.33
Percentage difference in hip abductors	58.71	60.56	32.68	57.73
Percentage difference in quadriceps	72.12	63.24	51.90	35.97
Percentage difference in hamstrings	43.47	23.03	18.24	20.65
Limb Volume				
Percentage of limb volume of uninjured limb	-8.7	0.0	-3.8	-5.6
Range of Motion				
Percentage difference in hip flexion AROM	47.2	14.1	-7.7	-8.0
Percentage difference in hip abduction AROM	36.7	11.6	11.1	1.1
Percentage difference in knee flexion AROM	27.4	14.1	0.2	0.0
Percentage difference in knee extension AROM	10.0	5.6	5.2	0.0
TUG test time (seconds)	37.0	9.1	10.4	9.5
Leg length discrepancy (mm)	0.0	0.0	0.0	0.0

Pain scores “0” = no pain; “10” = severe pain
Stanford activity limitations scores “0” = no activity limitations; “4” = maximum activity limitation
HAQ 8 scores “0” = able to perform activity without difficulty; “3” = unable to perform activity
EQ-5D index scores “-0.594” = worst HRQoL; “1” = best HRQoL
EQ-5D VAS state of health scores “0” = worst imaginable state of health; “100” = best imaginable state of health
Negative values for MP and ROM indicate where the injured limb had better results than the uninjured limb.
Scores below zero for limb volume indicate that volume in the injured leg was less that the uninjured leg.
The MP, ROM and limb volume values are percentage differences between values of the affected and unaffected limbs.

Graphical presentation of the outcome variables are presented in the line graphs. They are presented in relation to hip function and knee function. The EQ-5D index is the primary outcome and is presented on each graph.

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iii EQ-5D, state of health, pain and activity limitation scores, TUG test time and hip function

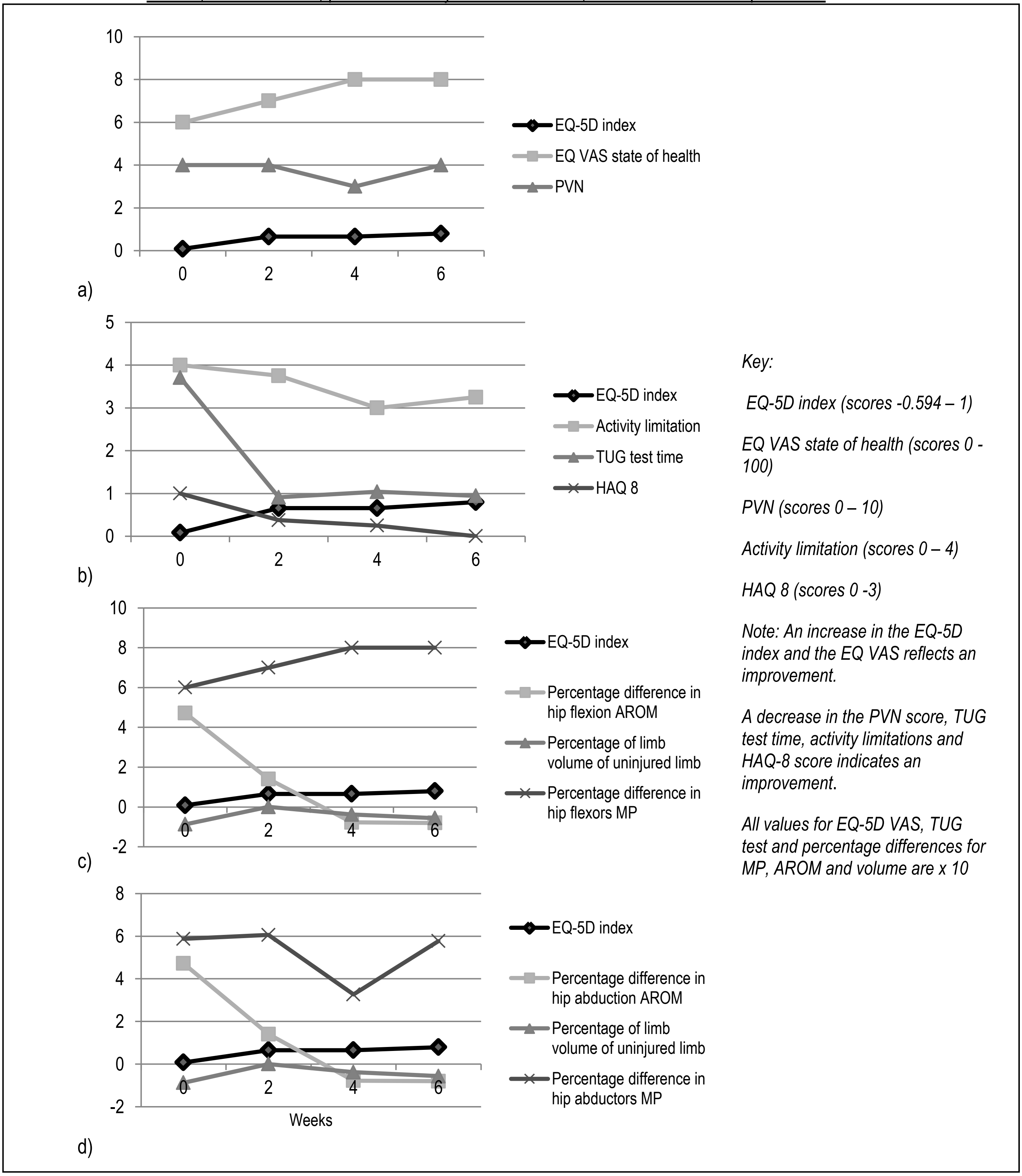

Figure 3-10 Participant Five: EQ-5D index and outcome variables of (a)EQ VAS state of health and pain scores (b)activity limitation score, HAQ 8 score and TUG test time and(c, d) hip function.

In Figure 3-10 (a), the EQ-5D index and EQ VAS scores improved concurrently which suggested an apparent relationship between these variables over time. The participant reported an improvement in his HRQoL and health state despite constant pain levels. Figure 3-10 (b) shows that the participant's functional ability was considerably affected by his injury. The HAQ-8 and TUG test time had the most substantial improvements in this participant. These variables improved in conjunction with the EQ-5D index score. Figure 3-10 (c) indicates that the hip flexor MP on the injured limb remained substantially weaker than the uninjured limb. Percentage difference in hip flexion AROM and limb volume appeared to be related to the EQ-5D index in that they all improved over the four weeks. However, the percentage difference in hip flexor MP for this participant followed an independent trend.

Percentage difference in hip abductor MP scores indicated a marked difference in hip abductor MP between the limbs (Figure 3-10 d). Hip abduction AROM, percentage difference in limb volume and the EQ-5D index scores all improved. The EQ-5D index did not appear to be influenced by the abductor MP in this participant. Further, it did not appear that limb volume affected hip abductor MP.

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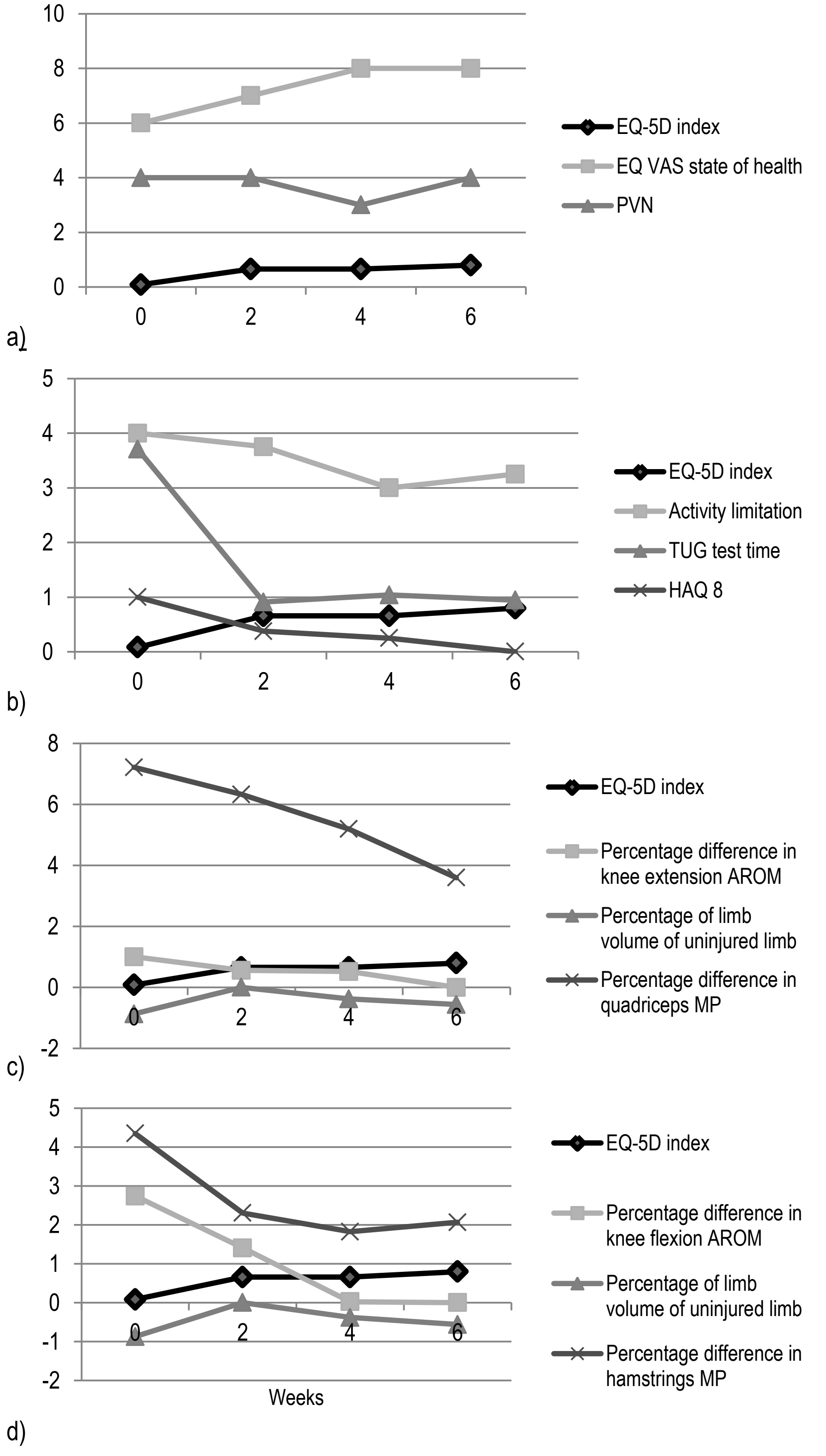
iv EQ-5D, state of health, pain and activity limitation scores, TUG test time and knee function



Key:

EQ-5D index (scores -0.594 – 1)

EQ VAS state of health (scores 0 - 100)

PVN (scores 0 – 10)

Activity limitation (scores 0 – 4)

HAQ 8 (scores 0 -3)

Note: An increase in the EQ-5D index and the EQ VAS reflects an improvement.

A decrease in the PVN score, TUG test time, activity limitations and HAQ-8 score indicates an improvement.

All values for EQ-5D VAS, TUG test and percentage differences for MP, AROM and volume are x 10

Figure 3-11 Participant Five: EQ-5D index and outcome variables of (a) EQ VAS state of health and pain scores (b)activity limitation score, HAQ 8 score and TUG test time and(c, d) knee function.

Figure 3-11 (c) shows that the EQ-5D index appeared to follow similar trends in improvement as the percentage differences of knee extension AROM and limb volume. The percentage difference in quadriceps MP also showed improvement over time but to a much lesser extent.

The percentage difference in knee flexion AROM was indicative of an improvement in knee flexion AROM (Figure 3-11 d). It appeared that a potential relationship existed between the EQ-5D index and knee flexion AROM as both followed a similar trend of improvement in this participant. The EQ-5D index appeared to be independent to changes of the percentage difference of hamstring MP in this participant. Notably, the TUG test time also improved as MP of the injured limb improved.

v Physiotherapy intervention

The participant had his physiotherapy delayed by two days. During his hospital stay, three physiotherapy treatments were given to the participant but not on consecutive days. No physiotherapy was given over the weekend. The treating physiotherapist had five years of experience. At discharge, he was issued with a home exercise programme and a referral letter to continue physiotherapy at the community health centre. The participant did not receive any further physiotherapy treatments after hospital discharge. He had not contacted the community health centre physiotherapist to make an appointment. He was concerned about transport costs to the community health centre as it was not within walking distance from his home. He reported that he was compliant with his home exercise programme.

vi Weight-bearing status

The participant remained FWB on his left leg from hospital discharge until his last assessment at week six.

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3.3.7 *Participant Six*

i Demographic information

Participant Six was a 24 year old man. He lived in Khayelitsha (a resource-poor residential area) in the Cape Flats area of Cape Town. The participant lived with his grandparents in a formal house with water and toilet facilities inside the house. He was unmarried. He was formally employed on a part-time basis by a non-governmental organization. The participant made use of his grandparents' car for transport purposes or walked as an alternative. His highest level of education was Grade 10. He had obtained no further formal education after completing Grade 10. He reported that he was a smoker. He had experienced a form of serious illness while caring for a family member.

ii Clinical information

Participant Six was involved in a MVA as a driver. He was admitted at GSH via the trauma unit on the day of injury. He had sustained a transverse fracture of the middle third of the left femur. The participant had surgery on the day of admission. The surgery was performed by a surgeon who had two years of experience. The length of surgical time was 65 minutes and anaesthetic time was 105 minutes. A prograde IM nail was inserted via a trochanteric entry point. The participant had a four day length of hospital stay. His objective clinical variable outcomes were measured on the day of discharge by the researcher. This participant returned for follow up evaluation sessions at weeks two, four, six and 12 thus completing the series. At the time of discharge from the hospital, the participant was ambulating with axillary crutches and was FWB on his injured left leg. He did not have a LLD.

The variable outcomes for Participant Six are shown Table 3-6 below. A comprehensive table of all variable outcome values is found in Appendix A 17.

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Table 3-6: Variable outcomes for Participant Six

Week	**0**	**2**	**4**	**6**	**12**
Questionnaires					
Pain (scores 0 - 10)	8	0	2	1	1
Stanford activity limitation (scores 0 - 4)	1	0.25	2.75	1.75	2.5
HAQ 8 (scores 0 - 3)	0.75	1	0.875	0.5	0.375
EQ-5D index (scores -0.594 – 1)	0.656	0.814	0.746	0.746	0.85
EQ-5D state of health	Much the same	Better	Much the same	Better	Better
EQ VAS state of health(scores 0 - 100)	70	40	90	94	95
Muscle Power					
Percentage difference in hip flexors	84.1	46.7	21.4	9.2	-41.5
Percentage difference in hip abductors	69.8	61.1	15.4	54.2	13.5
Percentage difference in quadriceps	74.6	54.1	54.9	22.8	12.1
Percentage difference in hamstrings	45.9	7.9	37.4	38.6	18.1
Limb Volume					
Percentage of limb volume of uninjured limb	49.1	13.9	12.3	25.2	20.9
Range of Motion					
Percentage difference in hip flexion AROM	77.9	30.0	-5.2	-2.9	-7.1
Percentage difference in hip abduction AROM	100.0	24.2	18.0	21.6	17.6
Percentage difference in knee flexion AROM	70.0	30.0	23.5	1.0	1.0
Percentage difference in knee extension AROM	16.3	16.7	5.6	5.6	0.0
TUG test time (seconds)	69.4	18.6	14.8	14.5	10.8
Leg length discrepancy (mm)	0.0	0.0	0.0	0.0	0.0

Pain scores “0” = no pain; “10” = severe pain
Stanford activity limitations scores “0” = no activity limitations; “4” = maximum activity limitation
HAQ 8 scores “0” = able to perform activity without difficulty; “3” = unable to perform activity
EQ-5D index scores “-0.594” = worst HRQoL; “1” = best HRQoL
EQ-5D VAS state of health scores “0” = worst imaginable state of health; “100” = best imaginable state of health
Negative values for MP and ROM indicate where the injured limb had better results than the uninjured limb.
Scores below zero for limb volume indicate that volume in the injured leg was less that the uninjured leg.
The MP, ROM and limb volume values are percentage differences between values of the affected and unaffected limbs.

Graphical presentation of the outcome variables are presented in the line graphs. They are presented in relation to hip function and knee function. The EQ-5D index is the primary outcome and is presented on each graph.

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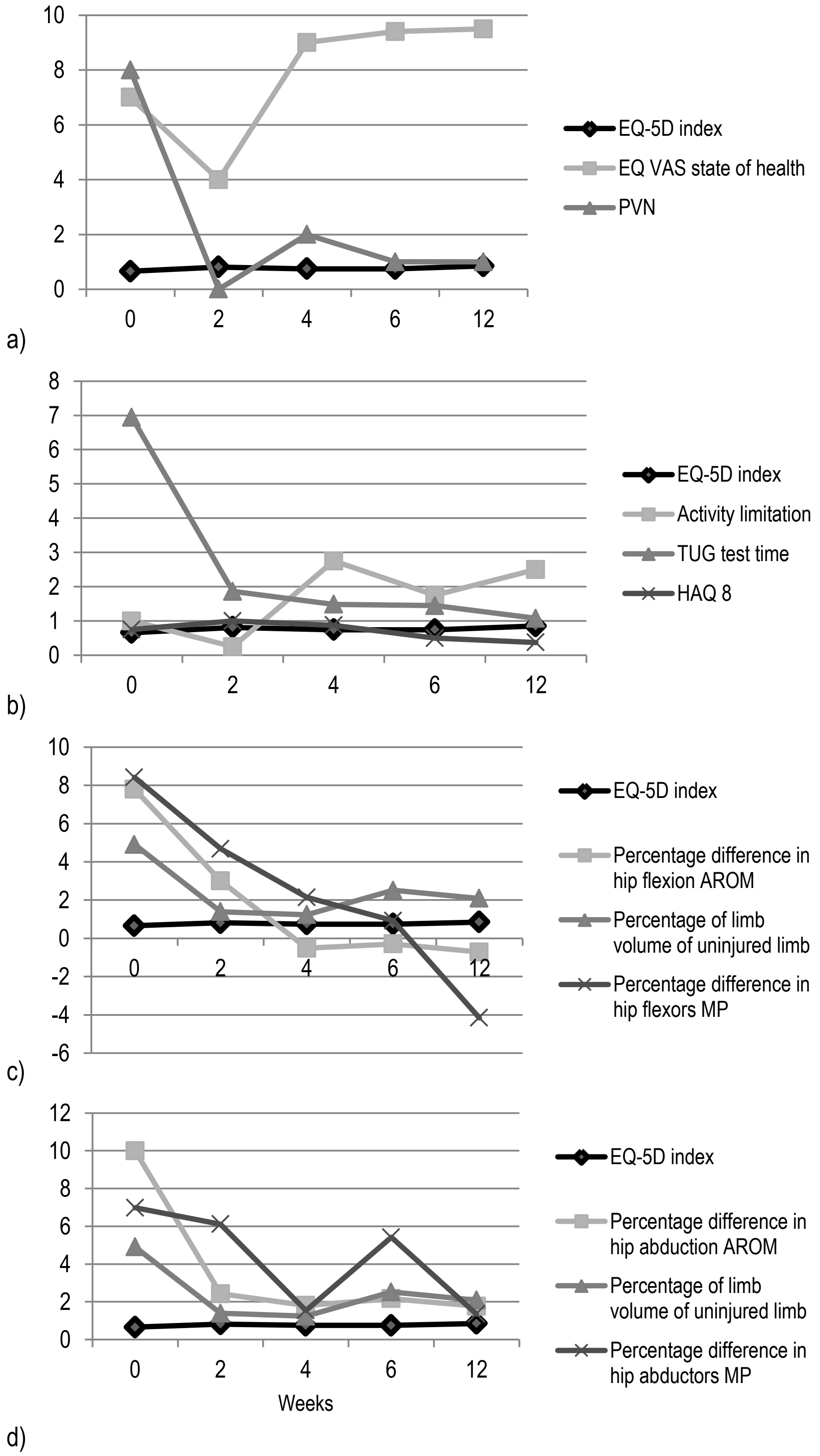
iii EQ-5D, state of health, pain and activity limitation scores, TUG test time and hip function



Key:

EQ-5D index (scores -0.594 – 1)

EQ VAS state of health (scores 0 - 100)

PVN (scores 0 – 10)

Activity limitation (scores 0 – 4)

HAQ 8 (scores 0 -3)

Note: An increase in the EQ-5D index and the EQ VAS reflects an improvement.

A decrease in the PVN score, TUG test time, activity limitations and HAQ-8 score indicates an improvement.

All values for EQ-5D VAS, TUG test and percentage differences for MP, AROM and volume are x 10

Figure 3-12 Participant Six: EQ-5D index and outcome variables of (a) EQ VAS state of health and pain scores (b)activity limitation score, HAQ 8 score and TUG test time and (c, d) hip function.

Figure 3-12 (a) shows that the EQ-5D index consistently increased over the 12 weeks indicating an improvement. Despite the improvement, the participant had not reached a state of full health regarding his HRQoL by the end of the series. An overall improvement in reported pain levels was noted but the participant still experienced pain by the end of the study period. A similar trend of improvement was noted between the EQ-5D index and the EQ VAS score from week four until week 12. By the end of week 12, the participant still had experienced substantial activity limitation (Figure 3-12 b). The TUG test score, the HAQ-8 score and the EQ-5D index appeared to be related in that they all indicate improvement over time. In this participant, the activity limitations score appeared unrelated to the other variables.

The percentage limb volume appeared to be unrelated to the EQ-5D index and the other variables (Figure 3-12 c). Figure 3-12 (d) shows that the EQ-5D index and the percentage difference in hip abduction AROM appeared to be related in that both these variables improved simultaneously. The percentage difference in hip abduction MP followed an independent trend. Percentage difference in limb volume did not appear to have a direct relation to these variable outcomes.

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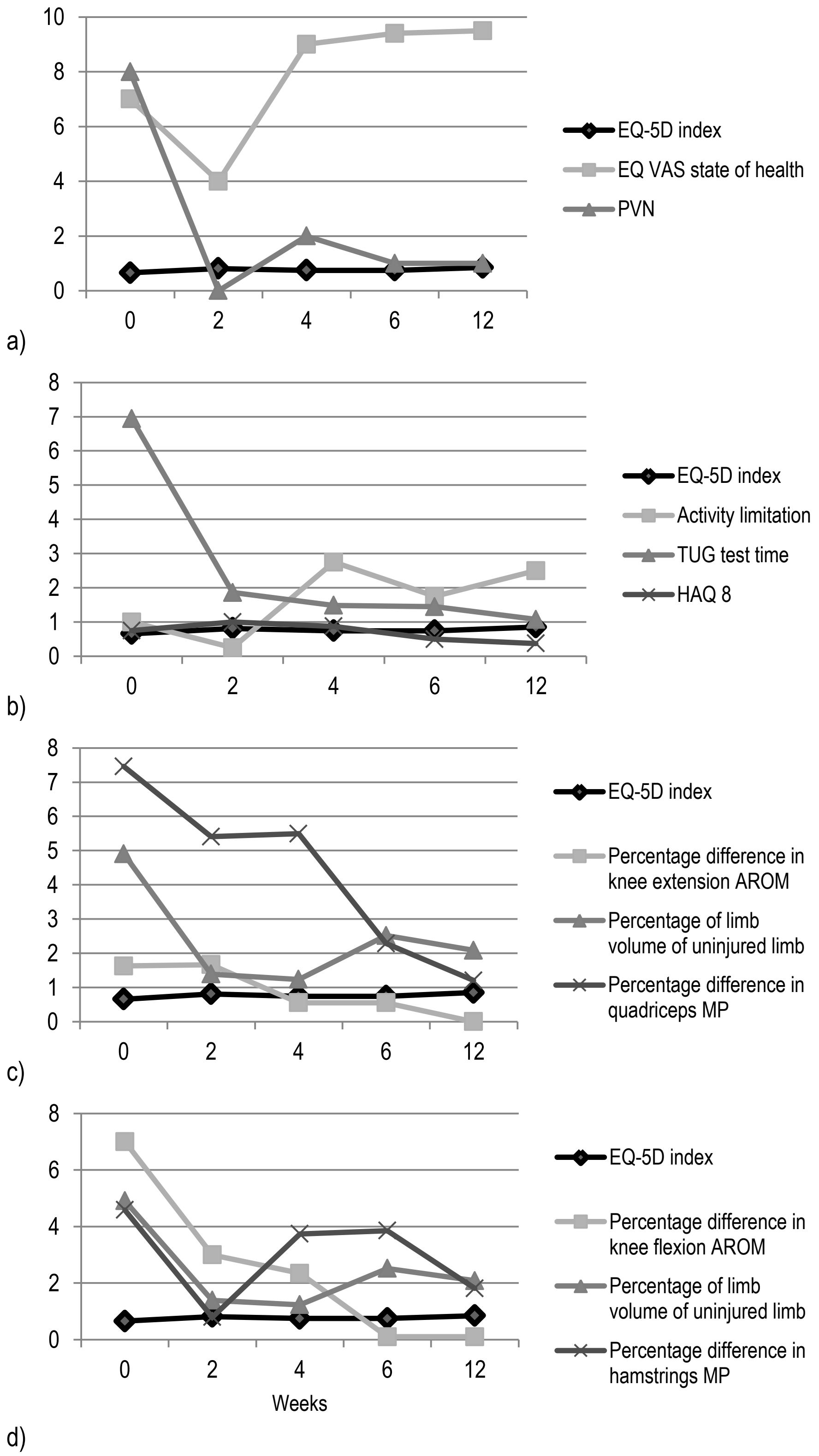
iv EQ-5D, state of health, pain and activity limitation scores, TUG test time and knee function



Key:

EQ-5D index (scores -0.594 – 1)

EQ VAS state of health (scores 0 - 100)

PVN (scores 0 – 10)

Activity limitation (scores 0 – 4)

HAQ 8 (scores 0 -3)

Note: An increase in the EQ-5D index and the EQ VAS reflects an improvement.

A decrease in the PVN score, TUG test time, activity limitations and HAQ-8 score indicates an improvement.

All values for EQ-5D VAS, TUG test and percentage differences for MP, AROM and volume are x 10

Figure 3-13 Participant Six: EQ-5D index and outcome variables of (a) EQ VAS state of health and pain scores (b)activity limitation score, HAQ 8 score and TUG test time and (c, d) knee function.

The percentage differences in knee extension AROM and quadriceps MP seemed independent of the percentage difference in limb volume. They instead appeared to be related to the EQ-5D index in that all three variables showed an improvement over the study period (Figure 3-13 c).

v Physiotherapy intervention

During his hospital stay, four physiotherapy treatments were given to the participant on consecutive days. The treating physiotherapist had two years of experience. At discharge, he was issued with a home exercise programme and a referral letter to continue physiotherapy at the community health centre. The participant reported that he did not receive any further physiotherapy treatments post discharge. He had not contacted the community health centre physiotherapist to make an appointment. He reported that he considered his attendance at the follow up sessions with the researcher to be his outpatient treatment. He had been compliant with his home exercise programme. Further, he reported that he had fallen at home in the street one day prior to his six week assessment. Between week six and 12, he had also sustained a superficial dog bite to the left lower leg (below the tibial tuberosity).He had not sought medical attention following either of these incidents.

vi Weight-bearing status

The participant was FWB on his injured left leg at discharge from the hospital and at week two. He was then PWB on the limb at week four and six and returned to FWB at week 12. The participant changed his WB status based on his own comfort.

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3.3.8 *Participant Seven*

i Demographic information

Participant Seven was an 18 year old man. He lived in Nyanga (an informal housing settlement) in the Cape Flats area of Cape Town. The participant lived with his older brother and his sister-in-law. The participant's sister-in-law accompanied him to each follow up assessment. They had an informal hut with water and toilet facilities outside the hut. He was unmarried and was unemployed. The participant made use of public transport in the form of a mini bus taxi. His highest level of education was Grade 7 (final year of primary school). He had obtained no further formal education after completing Grade 7. He reported that he was a smoker. He had experienced a form of serious illness while caring for a family member.

ii Clinical information

Participant Seven was involved in a MVA as a paedestrian. He was admitted at GSH via the trauma unit on the day of injury. He had sustained a comminuted fracture of the proximal third of the left femur. The participant had surgery on the day of admission. The surgery was performed by a surgeon who had two years of experience. The length of surgical time was 60 minutes and anaesthetic time was 115 minutes. A prograde IM nail was inserted via a trochanteric entry point. The participant had a four day length of hospital stay. His objective clinical variable outcomes were measured on the day of discharge by the researcher. This participant returned for follow up evaluation sessions at weeks two, four, six and 12 thus completing the series. At the time of discharge, the participant was ambulating with axillary crutches and was NWB on his left leg. He had a LLD of 10 mm.

The variable outcomes for Participant Seven are shown in Table 3-7. A comprehensive table of all variable outcome values is found Appendix A 18.

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Table 3-7: Variable outcomes for Participant Seven

Week	0	2	4	6	12
Questionnaires					
Pain (scores 0 - 10)	4	1	3	2	0
Stanford activity limitation (scores 0 - 4)	2.5	0.5	1	0.5	0
HAQ 8 (scores 0 - 3)	0.125	0	0.125	0	0
EQ-5D index (scores -0.594 - 1)	0.433	0.727	0.516	0.656	1
EQ-5D State of health	Better	Better	Better	Better	Better
EQ VAS State of health (scores 0 - 100)	50	40	70	90	100
Muscle Power					
Percentage difference in hip flexors	53.5	-37.6	9.2	-15.5	1.4
Percentage difference in hip abductors	68.6	33.5	-27.3	6.2	8.3
Percentage difference in quadriceps	69.3	38.8	22.9	16.9	17.3
Percentage difference in hamstrings	64.2	27.0	1.8	23.4	12.0
Limb Volume					
Percentage of limb volume of uninjured limb	4.6	5.4	-3.4	0.0	1.2
Range of Motion					
Percentage difference in hip flexion AROM	32.1	3.3	-28.9	-3.9	-0.3
Percentage difference in hip abduction AROM	67.8	12.2	0.0	-1.5	-1.1
Percentage difference in knee flexion AROM	7.6	3.3	0.0	-2.5	0.7
Percentage difference in knee extension AROM	15.4	0.0	0.0	0.0	0.0
TUG test time (seconds)	40.4	11.3	10.9	7.5	7.9
Leg length discrepancy (mm)	10.0	0.0	0.0	0.0	0.0

Pain scores “0” = no pain; “10” = severe pain
Stanford activity limitations scores “0” = no activity limitations; “4” = maximum activity limitation
HAQ 8 scores “0” = able to perform activity without difficulty; “3” = unable to perform activity
EQ-5D index scores “-0.594” = worst HRQoL; “1” = best HRQoL
EQ-5D VAS state of health scores “0” = worst imaginable state of health; “100” = best imaginable state of health
Negative values for MP and ROM indicate where the injured limb had better results than the uninjured limb.
Scores below zero for limb volume indicate that volume in the injured leg was less that the uninjured leg.
The MP, ROM and limb volume values are percentage differences between values of the affected and unaffected limbs.

Graphical presentation of the outcome variables are presented in the line graphs. They are presented in relation to hip function and knee function. The EQ-5D index is the primary outcome and is presented on each graph.

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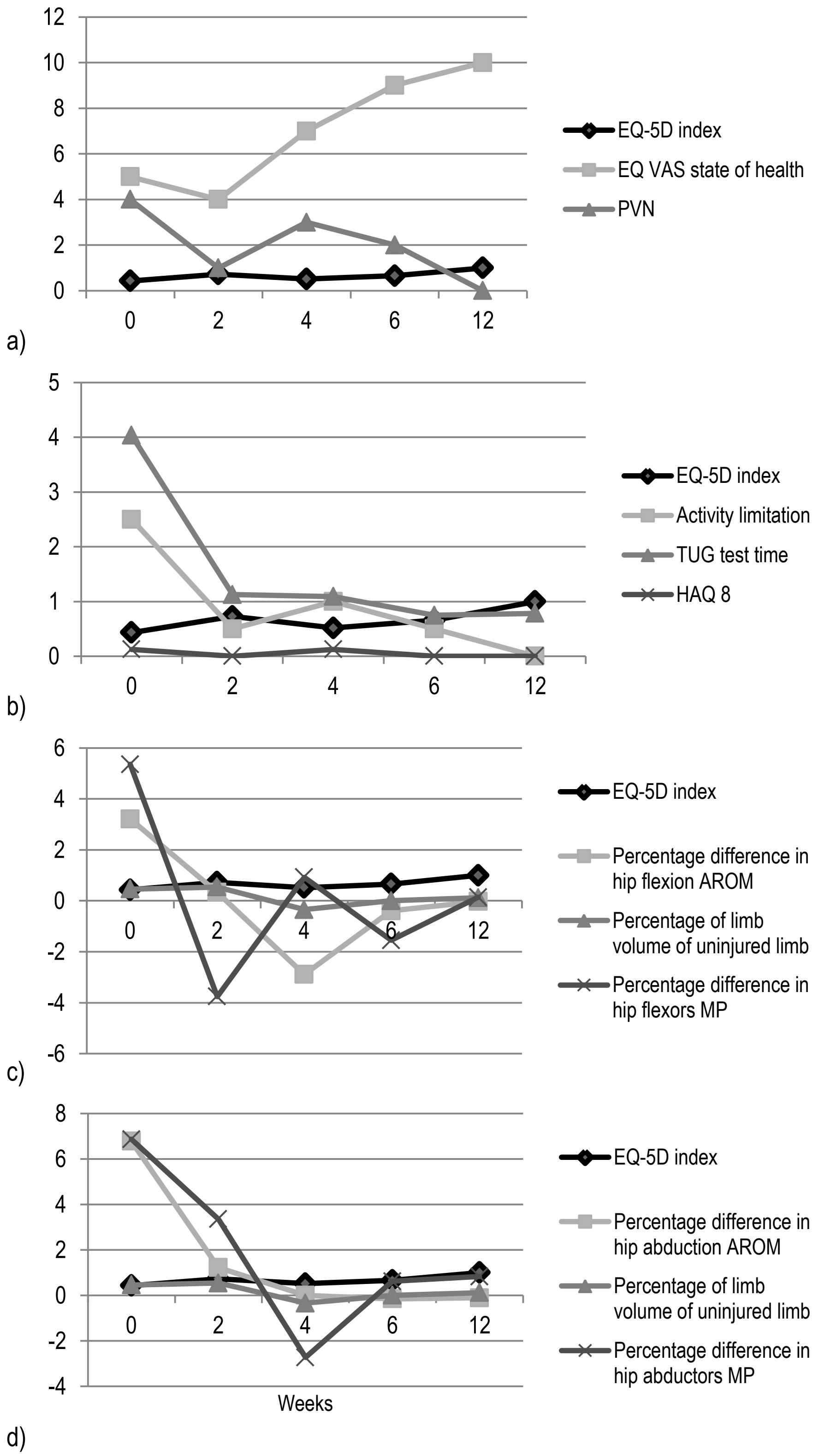
iii EQ-5D, state of health, pain and activity limitation scores, TUG test time and hip function



Key:

EQ-5D index (scores -0.594 – 1)

EQ VAS state of health (scores 0 - 100)

PVN (scores 0 – 10)

Activity limitation (scores 0 – 4)

HAQ 8 (scores 0 -3)

Note: An increase in the EQ-5D index and the EQ VAS reflects an improvement.

A decrease in the PVN score, TUG test time, activity limitations and HAQ-8 score indicates an improvement.

All values for EQ-5D VAS, TUG test and percentage differences for MP, AROM and volume are x 10

Figure 3-14 Participant Seven: EQ-5D index and outcome variables of (a) EQ VAS state of health and pain scores (b)activity limitation score, HAQ 8 score and TUG test time and (c, d) hip function.

Figure 3-14 (a) shows that the EQ-5D index score, EQ VAS state of health score and the PVN score appeared to be related from week four until week 12 as they all improved simultaneously during this period. Figure 3-14 (b) demonstrates that the participant walked approximately five times faster by the end of the study. The TUG test time, activity limitation and HAQ-8 score all improved over the 12 weeks as did the EQ-5D index. There was a potential relationship between all these variables.

The EQ-5D index and percentage differences in limb volume and hip flexion AROM appeared to all improve at similar time periods. The percentage difference in hip flexors MP also improved but appeared to be independent of the other variables (Figure 3-14 c). In Figure 3-14 (d), there only appeared to be a potential association between the EQ-5D index and the hip abduction AROM.

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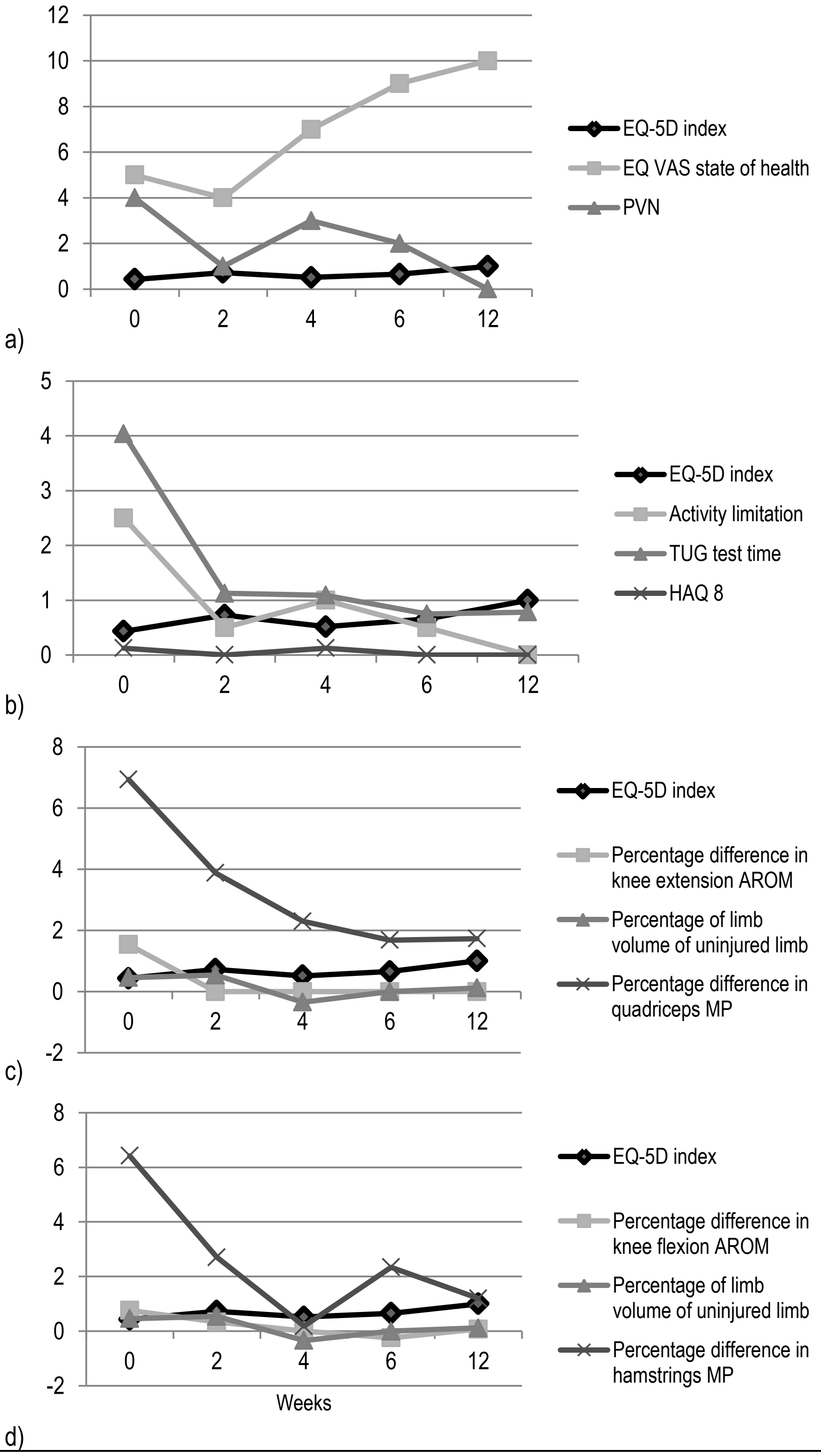
iv EQ-5D, state of health, pain and activity limitation scores, TUG test time and knee function



Key:

EQ-5D index (scores -0.594 – 1)

EQ VAS state of health (scores 0 - 100)

PVN (scores 0 – 10)

Activity limitation (scores 0 – 4)

HAQ 8 (scores 0 -3)

Note: An increase in the EQ-5D index and the EQ VAS reflects an improvement.

A decrease in the PVN score, TUG test time, activity limitations and HAQ-8 score indicates an improvement.

All values for EQ-5D VAS, TUG test and percentage differences for MP, AROM and volume are x 10

Figure 3-15 Participant Seven: EQ-5D index and outcome variables of (a) EQ VAS state of health and pain scores (b)activity limitation score, HAQ 8 score and TUG test time and (c, d) knee function.

The EQ-5D index and the percentage differences in knee extension AROM, quadriceps MP and limb volume all appeared to have improved over the study period (Figure 3-15 c). The line graph (Figure 3-15 d) demonstrates that the percentage difference in knee flexion AROM, limb volume and the EQ-5D index all appeared to have a gradual improvement over time.

v Physiotherapy intervention

During his hospital stay, two physiotherapy treatments were given to the participant on consecutive days. The treating physiotherapist had two years of experience. At discharge, he was issued with a home exercise programme and a referral letter to continue physiotherapy at the community health centre. The participant did not receive any further physiotherapy treatments post-discharge. He had not made an appointment with the physiotherapist at the community health centre. He reported that the community health centre was too far from where he lived and that he did not have money to pay for transport costs. He was also non-compliant with his home exercise programme.

vi Weight-bearing status

The participant was NWB on the left leg at hospital discharge. He progressed to PWB at week two and later to FWB at weeks four, six and 12.

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3.3.9 *Participant Eight*

i Demographic information

Participant Eight was a 35 year old man. He lived in Hanover Park (a low-cost housing area) in the Cape Flats area of Cape Town. This area is notorious for gang violence and crime[38]. The participant lived with his wife and two sons on the second floor of an apartment block. There was no elevator available. Water and toilet facilities were available inside the apartment. He was unemployed. The participant made use of public transport in the form of a bus or mini-bus taxi. His highest level of education was Grade 12. He had obtained no further formal education after completing Grade 12. He reported that he was a smoker. He had not experienced any form of serious illness (self, family or other).

ii Clinical information

Participant Eight was caught in the cross fire between gang members and sustained a GSW to his left thigh. He was admitted at GSH via the trauma unit on the day of injury. He had sustained a comminuted fracture of the distal third of the left femur.

The participant had surgery on the day of admission. The surgery was performed by a surgeon who had seven years of experience. The length of surgical time was 55 minutes and anaesthetic time was 90 minutes. A prograde IM nail was inserted via a trochanteric entry point. The participant had a five day length of hospital stay. His objective clinical variable outcomes were measured on the day of discharge by the researcher. This participant did not return for any follow up assessments despite numerous attempts to contact him telephonically. At the time of discharge, the participant was ambulating with axillary crutches and was NWB on his left leg. He did not have a LLD.

A table of all relevant data of the outcome variables (the impairments, activity limitations and participation restrictions) and HRQoL (primary outcome) are presented for this participant. The variable outcomes are shown in Table 3-8. Further details of variable outcomes values are found in Appendix A 19.

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Table 3-8: Variable outcomes for Participant Eight

Week	**0**
Questionnaires	
Pain (scores 0 - 10)	5
Stanford activity limitation (scores 0 - 4)	1.5
HAQ 8 (scores 0 - 3)	0.625
EQ-5D index (scores -0.594 – 1)	0.62
EQ-5D state of health	Worse
EQ VAS state of health (scores 0 - 100)	60
Muscle power	
Percentage difference in hip flexors	70.8
Percentage difference in hip abductors	28.2
Percentage difference in quadriceps	68.8
Percentage difference in hamstrings	36.1
Limb Volume	
Percentage of limb volume of uninjured limb	61.3
Range of Motion	
Percentage difference in hip flexion AROM	91.2
Percentage difference in hip abduction AROM	59.3
Percentage difference in knee flexion AROM	75.0
Percentage difference in knee extension AROM	8.2
TUG test time (seconds)	38.2
Leg length discrepancy (mm)	0.0

Pain scores "0" = no pain; "10" = severe pain
Stanford activity limitations scores "0" = no activity limitations; "4" = maximum activity limitation
HAQ 8 scores "0" = able to perform activity without difficulty; "3" = unable to perform activity
EQ-5D index scores "-0.594" = worst HRQoL; "1" = best HRQoL
EQ-5D VAS state of health scores "0" = worst imaginable state of health; "100" = best imaginable state of health
Negative values for MP and ROM indicate where the injured limb had better results than the uninjured limb.
Scores below zero for limb volume indicate that volume in the injured leg was less that the uninjured leg.
The MP, ROM and limb volume values are percentage differences between values of the affected and unaffected limbs.

At hospital discharge, the EQ-5D index was 0.62, the EQ VAS state of health was 60 and the PVN score was five. The activity limitations score was 1.5. The TUG test time was 38.2 seconds and the HAQ-8 was 0.625.

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Table 3-8 indicates that there were large differences in MP of the hip flexors and abductors, hip flexion and abduction AROM and limb volume of the injured limb as compared to the uninjured limb.

The percentage difference in knee extension AROM indicated that this variable was close to that of the uninjured limb (8% difference). The percentage differences in MP of quadriceps and hamstrings were high which indicated marked weakness in the injured limb.

The poor EQ-5D index may be related to the fact that all variables at this stage indicated poor function, minimal AROM and weak MP and marked differences in limb volume. The participant also reported a high pain level. No relationships between variables over time can be postulated due to a lack of data for this participant.

iii Physiotherapy intervention

During his hospital stay, three physiotherapy treatments were given to the participant on consecutive days. The treating physiotherapist had four years and six months of experience. At discharge, he was issued with a home exercise programme and a referral letter to continue physiotherapy at the community health centre. Further physiotherapy intervention following discharge is unknown.

iv Weight-bearing status

The participant was NWB on his left leg at discharge. No further information is known.

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3.3.10 *Summary of the results*

Figure 3-16 shows the participants that were lost to follow up during the study period.

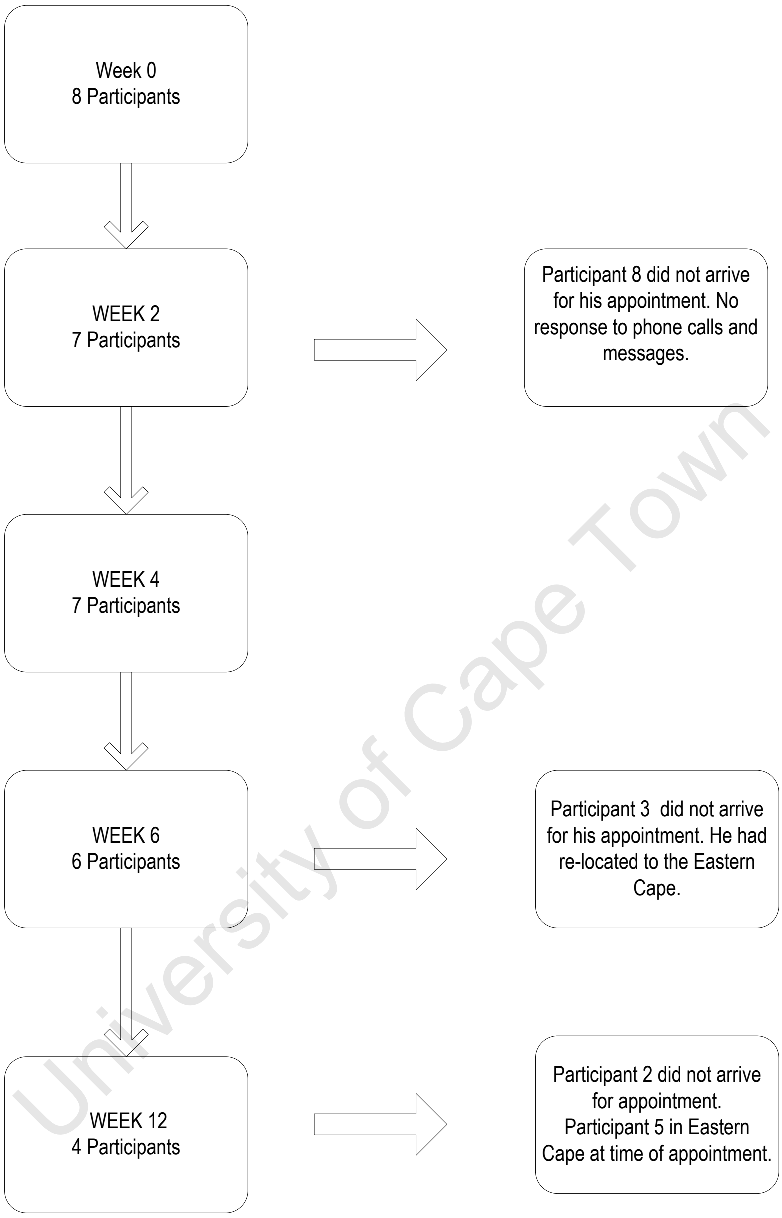

Figure 3-16: Process of how participants were lost to follow up in the clinical case series.

A summary of the outcome variables at discharge for the eight participants is presented in Table 3-9.

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Table 3-9: Summary of baseline variable outcomes of the eight participants for the clinical case series

Variable	Participants							
	1	2	3	4	5	6	7	8
Socio-demographic characteristics								
Age (years)	29	28	31	26	32	24	18	35
Education level	Grade 12	Grade 12	Grade 12	Grade 12	Grade 12	Grade 10	Grade 7	Grade 12
Employment status	Employed	Employed	Employed	Unemployed	Unemployed	Employed	Unemployed	Unemployed
Formal/informal housing	Informal	Formal	Informal	Informal	Informal	Formal	Informal	Formal
Clinical profile								
Mechanism of injury	GSW	GSW	GSW	MVA	MVA	MVA	MVA	GSW
Type of fracture pattern	Comminuted	Comminuted	Comminuted	Comminuted	Oblique	Transverse	Comminuted	Comminuted
Site of fracture	Distal third	Distal third	Proximal third	Middle third	Middle third	Middle third	Proximal third	Distal third
Surgery time (min)	80	65	85	55	Unknown	65	60	55
Anaesthetic time (min)	130	105	125	100	Unknown	105	115	90
Duration of hospital stay (days)	5	6	3	3	8	4	4	5
Physiotherapy management								
Delay of onset of physiotherapy treatment (days)	2	2	0	0	0	0	0	0
Number of inpatient physiotherapy treatments	3	3	3	3	3	4	2	3
Attended outpatient physiotherapy	No	No	No	Yes	No	No	No	Unknown
Compliance with home exercise programme	Yes	No	Yes	Yes	Yes	No	No	Unknown
HRQoL (Primary outcome)								
EQ-5D index score (-5.594 – 1)	0.725	0.189	-0.17	0.656	0.082	0.656	0.433	0.62
Impairments (at discharge)								
MP (hip flexors, hip abductors, quadriceps, hamstrings)	Decreased	Decreased	Decreased	Decreased	Decreased	Decreased	Decreased	Decreased
ROM (hip flexion & abduction; knee flexion & extension)	Decreased	Decreased	Decreased	Decreased	Decreased	Decreased	Decreased	Decreased
WB status	NWB	NWB	NWB	NWB	FWB	FWB	NWB	NWB
Oedema	Increased	Increased	Increased	Increased	Decreased	Increased	Increased	Increased
Leg length discrepancy (mm)	1.67	10	20	20	0	0	10	0
TUG test time (s)	35	25	30	36	37	69	40	38
Pain (PVN score 0 – 10)	8	4	5	3	4	8	4	5
Activity limitations (at discharge)								
HAQ-8 (0 – 3)	0.125	0.625	0.625	0.125	1	0.75	0.125	0.625
Participation restrictions (at discharge)								
Stanford Social/Role Activities Limitations score (0 – 4)	0.75	3.5	1.75	1.5	4	1	2.5	1.5

i Demographic information

All of the participants were young males with an average age of 27.8 years ± 5.7 (range 18 – 35 years). Only four of the participants were employed. Levels of education varied with only six participants having finished a grade 12 secondary school level. None of the participants had obtained any further education following secondary school. Seven participants resided in low income socio-economic areas. The remaining participant lived in a middle class residential area. The most common mode of transport used was a taxi.

ii HRQoL, pain and EQ VAS state of health

There appeared to be a relationship between pain and HRQoL. These variables improved over time in all the participants. The EQ VAS state of health also improved in a similar pattern to the HRQoL EQ-5D index measure indicating a potential relationship between these variables.

iii HRQoL, Stanford activity limitations, TUG test time and HAQ-8 Score

The HAQ-8 indicates the participant's self-reported disability. This measure improved markedly in all the participants over time. There were also similar improvements in the TUG test times and the activity limitation measures over the same time period for all participants. This indicated a potential positive relationship between these variables. The HRQoL measure improved as the HAQ-8, TUG test time and activity limitation scores improved. For this reason, it would appear that these variables may be positively related in participants with femoral fractures.

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iv HRQoL and hip function

Hip function in terms of hip AROM for abduction and flexion improved over time in all participants. This coincided with improvements in hip abductor and flexor MP. These two variables seem to be related in that AROM at the hip improved as MP improved. These variables also showed that hip abduction was more affected than hip flexion following IM nail insertion secondary to traumatic femoral shaft fractures. Hip abduction AROM and hip abductor MP did not always normalise to the same level as the uninjured limb in these cases. The volume of the injured limb also improved over time in the participants. It appeared to be that the oedema in the injured limb influenced MP negatively, which subsequently influenced AROM negatively. Improvement in all these variables followed a similar pattern over time. This indicates a potential relationship between these variables.

The HRQoL measure also showed improvement over time when compared to the percentage differences in hip AROM, MP and oedema. There may therefore be a positive relationship between HRQOL and hip function; and a negative relationship between HRQoL and limb oedema.

v HRQoL and knee function

Knee function in terms of AROM and MP of quadriceps and hamstrings also improved in all participants over time. Deficits in quadriceps MP remained in all participants at the final assessment, indicating that this had not returned to normal pre-injury levels when compared with the uninjured limb. Muscle power of hamstrings improved to a greater degree than the quadriceps. Further, knee flexion AROM improved more rapidly than knee extension AROM.

Knee function in terms of AROM and MP also improved as oedema levels decreased suggesting a potential relationship between knee function and limb volume. In addition, it appeared that both HRQoL and knee function improved over time suggesting a positive relationship between knee function and HRQoL. In summary, it appeared that the HRQoL measure was related to improvements in all variable outcomes over time.

3.4 Discussion

This clinical case series was the first attempt to describe HRQoL within the ICF framework in participants with femoral fractures. Summary statistics could not be performed due to the small sample size. Graphical analysis of the relevant clinical outcomes revealed trends that suggest that these variables may influence HRQoL. The nature of the sample is discussed first. This is followed by an overview discussion of the participants. Finally, clinical implications and recommendations for future studies are suggested and limitations of the study are presented.

3.4.1 *Sample*

The sample of eight participants does not reflect the number of patients that sustained traumatic femoral shaft fractures that were admitted to the traumatic orthopaedic wards at GSH during the data collection period. Many patients that had sustained this type of injury were excluded because of associated injuries. These injuries included traumatic brain injury; fractures of the spine, pelvis and other limbs; organ damage; and neural and vascular injury. This phenomenon of associated injuries has been reported by Ryan et al[43]. In a chart review study investigating the management of closed midshaft femoral fractures, it was found that the patients presenting at trauma centres were most often young, most frequently male and had associated injuries. The authors did not specify the type of associated injuries[43].

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The participants in the current study were all young males. This sample reflects the findings of Singer et al[41] where young males below the age of 35 years were found to be more likely to sustain fractures compared to females. Further, femoral fractures are more commonly reported in young males[41]. Similar results were observed in an epidemiological study[42].Young people were reported to sustain more long bone fractures as a result of trauma compared to older individuals. These long bone fractures were more frequent amongst young males[42].

The mechanisms of injury were evenly split between GSW and MVA. Both of these mechanisms have been reported to be causative factors for femoral fractures globally[20-21, 162]. In each participant that sustained a GSW, the incidence was related to interpersonal violence. The consequence of interpersonal violence and road accidents in South Africa is not a new concept in terms of mortality[16, 19, 44]. Morbidity following femoral fractures in South Africa has only been explored by Gross et al[28] This study also found MVA and GSW to be the highest causative factors of traumatic femoral fractures[28]. Further, morbidity following these fractures persisted at one year following injury[28]. This study indicated that femoral shaft fractures have long term effects that continue beyond the normal physiological healing time of the bone and soft tissue. Further, it appears that the morbidity following femoral fractures is not only determined by medical management at a biomedical level but rather by health care that incorporates a holistic management plan. This management plan should be founded on the ICF framework that addresses biomedical, activity and participation factors as well as environmental factors which may affect morbidity. Unfortunately the authors did not specify or investigate the reason for the self-reported disability in the South African sample[28].

3.4.2 *Overview of participants*

The following section will discuss the role of specific variable outcomes on the HRQoL in the eight participants in the clinical case series. Only four of the eight participants had attended all of the follow up evaluation sessions.

i Socio-economic factors

All of the participants were from low-income residential areas with poor infrastructure. All of the participants except Participant Two were reliant on the informal minibus taxi system for transport. Only half of the sample were employed. However, participants that had attended all the follow up sessions (n = 4) reported improvements in their HRQoL over the study period. This was despite some of them still experiencing pain and having deficits in MP, AROM and altered WB status. This finding is consistent with a previous study in which South Africans were found to have lower expectations in terms of recovery following femoral fractures as compared to their European counterparts[28].

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ii Level of education

None of the participants in the current series had any formal education following secondary school. However, previous studies established that socio-economic grouping, and not education, primarily influenced HRQoL in a South African setting [88]. Within a South African context, socio-economic grouping will determine living conditions and area of residence. People in the low-income group live in impoverished areas with minimal access to basic amenities. These poor living conditions will affect an individual's health at a biomedical level as disease is common in these areas because of overcrowding and poor hygiene issues. Further, these living conditions will also impact on disability by imposing environmental barriers in terms of the ICF principles[32]. These factors would subsequently affect the HRQoL of the individual. The nature of the sample of the current study was determined by the areas which are serviced by GSH. All of the participants were from low-income residential areas.

iii Mechanism of injury

No obvious differences or pattern of relationships were observed in terms of HRQoL outcomes regarding the mechanism of injury. Participants who had sustained GSW (half of the sample) tended to WB much later in the series compared to those who sustained their injuries via MVA. This finding however, was not consistent throughout the series and did not appear to influence HRQoL.

The high cost associated with GSW has previously been investigated[45]. The high incidence of femoral fractures admitted at GSH has considerable financial costs for the hospital. According to Pendleton[46], these costs could have been alleviated by decreasing the time delay to surgery and physiotherapy. Participants One and Five both had their surgery delayed by two days due to a lack of theatre availability. In addition, participants Two and Five had their physiotherapy treatment postponed over weekends, as no physiotherapy services are available to orthopaedic patients at GSH over weekends. The weekend physiotherapy service is limited by budget constraints and personnel shortages. This potentially highlights the lack of adequate service delivery within the hospital (personal communication with Lionel Naidoo; Assistant Director of the Department of Physiotherapy, GSH). The delay to surgery and physiotherapy resulted in the hospital stay of these participants being unnecessarily prolonged[46].

iv Physiotherapy treatment

Holden and Daniele[55] investigated the influence of a seven-day and five-day physiotherapy coverage programme on the length of hospital stay in patients with acute orthopaedic disorders. There were no differences in functional outcomes between the five-day and seven-day treatment groups because patients in both groups received the same number of treatment sessions.

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These results implied that by providing a consecutive seven day physiotherapy service without increasing the number of physiotherapy treatments, the length of hospital stay will not be altered. The authors suggested that by increasing the number of physiotherapists, the number of treatments could then be increased and subsequently reduce length of hospital stay[55].

Thomas[57] demonstrated the effect of increasing the number of treatments to decrease length of hospital stay, with a fast-track clinical pathway for patient rehabilitation following hip and knee arthroplasties. Although this clinical trial series did not provide treatments over the weekends, the patients did receive pre-operative therapy as well as bi-daily post-operative treatment. The increase in the number of treatment sessions helped to decrease the length of hospital stay of these orthopaedic patients[57]. This fast track clinical pathway cannot, however, be applied at GSH in the traumatic orthopaedic wards for several reasons. Firstly, pre-operative treatment is not possible as these patients usually receive surgery on the day of admission. This means that the opportunity to prepare patients mentally and physically for surgery and rehabilitation is not possible as is the case with elective surgery. Secondly, bi-daily treatments are not possible due to staff shortages and an unpredictable patient load on a daily basis. Treatment of orthopaedic patients over weekends is not practiced at GSH as previously mentioned, because budget constraints do not allow for this expense. Furthermore, the current compliment of staff is not sufficient to manage the added workload of bi-daily treatments (personal communication Lionel Naidoo, Assistant Director of Physiotherapy, GSH). The result of these constraints means that patients with femoral fractures will have a prolonged hospital stay if they receive their surgery over a weekend, as the rehabilitation therapy will only begin on the Monday. This leads to increased hospital expenditure and rising costs of health care. These health care costs may be alleviated by allowing these patients to receive physiotherapy over the weekend. This disruption in physiotherapy treatment was evident in participants Two and Five who spent a longer time in hospital. On-going physiotherapy on an outpatient basis has been advocated to limit the impairments caused by femoral shaft fractures[6]. A major concern in this case series was the lack of post-hospital physiotherapy despite all patients being referred for physiotherapy on discharge. Only Participant Four received physiotherapy on an outpatient basis. Although he had only had two treatments, he showed a greater improvement in his outcome variables as compared to the other participants who had had no physiotherapy. This study highlighted concerns regarding the post-hospital physiotherapy services in the community.

In this study, Participant Four reported that the community physiotherapist was unable to provide him with more frequent treatment sessions due to long waiting lists of patients. Participants Five and Seven did not attend physiotherapy due to concerns about the cost of transport to the community health centre. They were both unemployed and the community health centre was not within walking distance from their homes.

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Participants One, Two, Three and Six felt that because they were coming for their follow up sessions with the researcher (who was a physiotherapist); this was to be their rehabilitation treatment. The misunderstanding could firstly be attributed to communication problems. English was not the first language of any of the participants and this could have been a barrier to coherent communication. The discharge instructions were also only provided in English. This may have affected their adherence due to poor understanding and comprehension because of a language barrier. In addition, non-adherence with fracture management could have been the reason for non-attendance with post-discharge physiotherapy rehabilitation.

The physiotherapists who had treated the participants had varied amounts of experience. This did not appear to affect the outcome of the participants. This finding may be associated with the structured rehabilitation protocol that is used at GSH for patients with fractured femurs during the acute hospital stay (Appendix A 11). This protocol promotes early AROM of the affected hip and knee and early mobilisation out of bed (day one post-surgery). The influence of the years of experience of the physiotherapist cannot be ascertained in this clinical case series. Further research regarding the influence of years of experience of the physiotherapist on treatment outcomes is warranted.

v <u>Experience of orthopaedic surgeon</u>

The orthopaedic surgeons also had varied levels of experience. Most of the surgeons were fairly inexperienced, with less than five years of practice. They completed the surgery in similar time frames. These findings are similar to those of Gross et al[28]. South African surgeons had operated unsupervised and had less experience compared to orthopaedic surgeons in the EU[28]. This phenomenon can be explained in terms of the amount of exposure to IM nailing surgery that SA surgeons are required to perform. At GSH, an average of 250 femoral IM nail surgeries is performed each year. This equates to a mean of 40 surgeries per junior orthopaedic registrar per year. The local surgeons are thus exposed to this type of surgery very often, which may improve their skill with the insertion of IM nails. For this reason, SA surgeons have more experience in the number IM nail surgeries performed (personal communication with Dr Sithombo Maqungo; Head of Department of Traumatic Orthopaedics at GSH).

vi <u>Surgical management of femoral fractures</u>

At GSH, the orthopaedic practice of treatment for fractured femurs is IM nail fixation, which is the internationally accepted gold standard[1-2, 20]. With the exception of Participant Eight whose post-discharge variable outcomes are unknown, the use of IM nails in these participants had been successful. Each participant was encouraged to mobilise immediately (day one post-surgery) as reported in the literature[1]. All of the IM nails used at GSH are inserted via a trochanteric entry point.

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Association between post-surgical pain, self-efficacy and HRQoL

Trochanteric entry points have been reported to cause pain over the trochanteric area[14]. In this sample, the pain levels of the participants decreased markedly over the study period. However, some of the participants reported improvement in their HRQoL despite pain. The improvement in HRQoL while participants were experiencing pain, suggests that the participants had developed coping skills to manage pain. This was associated with increased levels of self-reported SE and improvements in HRQoL. This inverse relationship between increased levels of SE, HRQoL and decreased level of disability has been demonstrated in literature in patients with chronic pain[89] and musculoskeletal pain[95]. Borsbo et al[89] explained that pain intensity and the spreading of pain caused lower SE beliefs, which resulted in a higher level of disability. However, individuals who had high SE beliefs were able to manage their pain by developing coping strategies that could be adapted to transform difficult environments into benign environments[89]. This concept seems to be applicable in the current case study series. Most of these participants were from informal settlements where the physical environment posed difficulty in their activity limitations and participation. Their strong SE beliefs may have allowed them to persist in their ADLs despite being faced with obstacles in their environment[94] and while experiencing sub-acute pain post-fracture. Therefore, despite impairments and activity limitations, the participants still reported an increase in their HRQoL. The concept of improving SE should be applied in the rehabilitation of patientsl[89] with femoral fractures as activity limitation and participation restrictions appear to be the biggest obstacles for these patients post-hospital discharge. Further, despite having similar injuries and the same surgical management, inter-individual variation in recovery was noted in the current sample regarding pain and HRQoL. This variation in recovery may be attributed to the different levels of SE demonstrated by the participants.

vii Muscle power

Weakness of the hip abductor muscles had also been reported following trochanteric entry approaches to IM nailing[14, 62]. In this sample, except for Participant Three, all of the other participants had deficits in hip abductor MP compared to their opposite limb. This weakness often causes a Trendelenburg gait pattern[14]. This gait pattern may be associated with abnormalities in the stance phase of the affected leg[52] because the weakened muscle is unable to stabilise the pelvis sufficiently. The presence of a Trendelenburg gait pattern in the participants was not observed. This was because the TUG test had to be performed using the same assistive device each time[72] for comparative reasons. The participants were therefore not assessed without their crutches to observe the presence of a Trendelenburg gait pattern.

Quadriceps MP has also been reported to persist up to one year post femoral fracture[2, 14, 54]. This soft tissue pathology has been postulated to be related to the high energy and traumatic nature of the mechanism of injury[53].

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All of the participants in this study therefore suffered soft tissue damage due to the GSW or the direct trauma of the MVA. In each participant, quadriceps MP remained weaker than the opposite leg compared to their last follow up assessment. This was irrespective of adherence with the home exercise programme. Notably, Participant Four had less than a 5% difference in quadriceps MP between his limbs. This participant had attended physiotherapy on an outpatient basis and was keen to do his exercises. Paterno and Archdeacon[53] reported that inadequate rehabilitation following femoral fractures resulted in MP deficits. Participant Four demonstrated that further physiotherapy and exercise training following hospital discharge appeared to be beneficial to restoring MP. This participant was a cyclist prior to his injury. His previous exposure to exercise may have provided him with the insight regarding the beneficial effects of exercise on muscle strengthening and joint ROM. This may have contributed to his recovery. It seems intuitive that his previous level of fitness and familiarity with regular exercise may have assisted him in his early recovery.

Quadriceps MP deficits following femoral fractures has also been attributed to its position along the shaft and the pattern of fracture[61]. This also appeared to be the trend for the present study. The participants with fractures in the proximal third (Participants Three and Seven) and middle third (Participants Four, Five and Six) of the femur had greater improvements in their quadriceps MP than those participants who had sustained fractures in the distal third of the femur (Participants One, Two and Eight).

viii Range of motion

Five of the participants (One, Three, Four, Six and Eight) had a deficit in AROM of knee flexion at their last assessment. These deficits occurred with associated deficits in hamstring MP. Participants One and Three had deficits in the hip flexion AROM which appeared related to the weak hip flexor muscles. Participant Six had a deficit in hip abduction AROM that appeared related to the weak abductors. For the other participants, the converse seemed true in that AROM improved as MP improved. This relationship between hip and knee AROM and MP has been demonstrated previously following femoral fractures[6, 14]. Bain et al[14] found a trend between abduction weakness and abduction stiffness in patients with IM nails following femoral fractures and in closed femoral shortening. The authors postulated that the gluteal muscle splitting with the insertion of the IM nail may be responsible for the muscle weakness and associated loss of abduction AROM post-surgery. They advised on abduction exercise post-surgery to improve MP and AROM[14].

At certain times during the study, the injured limbs of some participants had improved objective outcome variables compared to the uninjured limb in terms of MP and AROM. This may have been a consequence of participants being made aware of their results after each contact session, which could have motivated them to place emphasis on improving the injured limb.

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Subsequently, this may have resulted in the uninjured limb being neglected in terms of exercise. This theory has not been investigated in orthopaedic literature. Further investigation is required.

ix Oedema

In the majority of participants (excepting Participants Three and Five), the percentage difference in limb volume was highest at hospital discharge indicating the presence of oedema. This corresponded with reports of high pain scores as well as high percentage differences in hip and knee AROM. These findings are similar to those of Kristensen et al[63] who reported that oedema is common post-surgery following fractured femurs, causing pain, discomfort and joint stiffness, with a negative association between knee extension MP and thigh oedema. In the current study, the highest percentage difference in oedema between the injured and uninjured limb was recorded at hospital discharge for most of the participants. Participant Eight had the highest percentage difference of 61.31% at hospital discharge. According to Kazmi et al[58], a percentage difference in oedema of 17.2% is regarded as considerable in influencing MP and ROM. Except for Participants Three and Seven, the rest of the participants all had a percentage difference in oedema above the 17.2% mark. This indicates that the oedema was quite severe at hospital discharge. This oedema may have played a profound role in the limitations in ROM and MP of the injured limb[58].

x Leg length discrepancy

Five participants had a LLD at hospital discharge. However, by the end of their respective assessment follow ups, only Participant One had a LLD of five millimetres. His LLD was below 10 mm which has been proposed as being a post-operative complication of femoral fractures which affect gait[24]. An explanation for these variations in LLD may be related to the measurement procedure. The TMM of measurement for LLD relies on surface measurement[122]. This allowed for errors in measurement in the early weeks of assessment as thigh and calf oedema would influence the measurements. The oedema in the thigh and calf increased the girth of the limb, which may have subsequently influenced surface measurements taken on the limb for the measurement of LLD.

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xi Weight-bearing status

All participants varied their WB status at different stages of assessment. The WB status seemed to have been guided by comfort and necessity rather than on instruction of the orthopaedic surgeon. The most notable benefits of early WB were seen in Participant Seven. Despite having a comminuted fracture, he began WB as early as week two. Subsequently, he presented with improvements in all MP, AROM, PROM and limb volume measurements and his TUG test time. The participant suffered no complications secondary to this early WB. Similar results following early WB with IM nailing have been reported in the literature[65-66].

Participant Seven lived in an informal settlement. It seems that early WB may have allowed him to cope with more ease within his environment, which may have been related to the early improvements in activity limitation. The other participants who were living in similar circumstances and who were still NWB had poorer participation scores at the same assessment period. As suggested by Arazi et al[66], it seems that WB following IM nailing is safe, promotes healing, and the ability to walk. These are important factors to limit participation restrictions and disability for those living in environments with poor infrastructure. As discussed earlier, only four of the participants were formally employed. During their early recuperation period, none were able to return to work as the work required standing and walking. Of the four participants that completed the entire study, only Participant One returned to work towards the end of the study period. He reported that he had requested a change to his previous position at work to a position which required less walking. Arazi et al[65] suggested that complications related to femoral fractures may cause the loss of ability to work. Gross et al[28] also documented that patients in the EU and SA sample reported that their femoral fracture had a negative impact on their working capacity one year after the initial injury. In a case study of a manual labourer who sustained a midshaft femoral fracture presented by Paterno et al[52], the patient returned to work after a prolonged rehabilitation period. The authors reported that despite intensive rehabilitation that consisted of twice daily treatments as an inpatient until day three post-surgery when he was discharged from hospital, the patient still had to employ coping strategies for high level tasks at his workplace. The patient then continued to attend outpatient physiotherapy two to three times per week for a total of 30 visits before returning to work[52]. In a South African setting, this amount of rehabilitation is not possible due to staff shortages at hospital level and poor adherence with outpatient physiotherapy. This lack of rehabilitation following femoral fractures may negatively influence a patient's chances of returning to work[52].

In South Africa, social grants are issued by the Department of Social welfare if a person is evaluated to be unable to work due to a disability. Temporary social grants are available for those patients whose disability will last for six to 12 months. Referral for a social grant is based on the findings of a medical doctor[36]. Many patients with femoral fractures who may experience disability because of environmental factors will not qualify for a social grant because the average bone healing period following IM nailing is less than six months. Further, as explained by Jelsma et al[36], the referral for a social grant is made by a medical doctor based on impairments at a biomedical (physical) level. This means that activity limitations and participation factors causing disability according to ICF principles are not considered[36].

The lack of rehabilitation is evident in that not all outcome variables of the participants had returned to pre-injury levels at 12 weeks. Paterno and Archdeacon[53] observed that inadequate post-operative rehabilitation following femoral fractures lead to deficits in MP, which negatively affect ADL. Earlier studies also emphasised the importance of post-operative rehabilitation[6, 14, 54].

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These authors highlighted strengthening of the quadriceps[6, 54] and hip abductor muscles[14]. Bain et al[14] reported that exercise of the hip abductor muscles will assist in improving the endurance of these muscles, which are susceptible to fatigue pain following IM nailing. The elimination of fatigue pain would limit the resultant limp and Trendelenburg gait pattern which are surgical complications associated with the IM nail[14]. Kapp et al[54] investigated the musculoskeletal deficits after femoral shaft fractures managed with IM nails. The authors reported that despite the early stabilisation and mobility that is provided by IM nailing, this intervention does not suffice to guarantee symmetrical quadriceps strength. They hypothesise that greater effort is needed to rehabilitate the quadriceps muscles following femoral shaft fractures[54]. Further, in the landmark study by Winquist et al[6] in which 520 cases of patients with IM nailing were investigated, it was confirmed that post-operative rehabilitation of the quadriceps contributed greatly to the patients' improvement. Physiotherapy was also advocated for three months following the fracture to improve quadriceps muscle control and subsequently knee ROM[6]. Literature thus provides substantial evidence to suggest that adequate rehabilitation following femoral fracture is essential to ensure a favourable outcome for patients following IM nailing of the femur[6, 52, 54].

The right to access to health services for all South Africans is part of the constitution of South Africa (Constitution of South Africa, Chapter 2, Section 27)[163]. This includes emergency care and rehabilitation services. At GSH, a shortage of physiotherapists and increasing pressure on bed availability limits the amount of inpatient physiotherapy treatments that each patient receives (personal communication Lionel Naidoo, Assistant Director of Physiotherapy, GSH). Furthermore, as previously discussed, due to budget constraints, these patients are not prioritised to receive treatments over weekends limiting progress.

In the community, physiotherapy services are only available at specified community health centres. These physiotherapists are often those who are newly qualified and completing their community service training. This means that a sole, minimally experienced physiotherapist, often in a poorly resourced clinic, may be responsible for treating patients from several impoverished communities. Ramklass[164] reported on the issues raised by community services physiotherapists working in these communities. The therapists reported that they did not have sufficient practical skills to treat patients when there is a lack of physiotherapy equipment. Further, these therapists felt that the university physiotherapy curriculum that they had been taught did not emphasise the holistic approach to patient care. Community service physiotherapists were thus not adequately prepared for the work in the community health centre as stipulated by the WHO ICF model. This poses a problem for patients such as those presented in this study when attending these clinics, as their health needs require a management approach beyond the biomedical level.

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These limitations are conducive to poor rehabilitation service delivery when patients do access the services; however many patients often do not have the available resources (for example, finances and access to transport) to attend the clinic[99].

xii Adherence to treatment

Adherence to treatment is a factor that influences poor outcomes[99]. A qualitative study by Kagee et al[99] found that health literacy, social support and financial implications affected adherence to treatment at primary health care clinics. Health literacy is related to educational level. Educational levels are poor in low-income South African communities[99]. This implies that health literacy was most likely low among the patients in the current clinical study as seven of them were from low-income communities. They would be expected to have a lack of understanding regarding the consequences and long term effects of non-adherence to treatment[99]. However, in the current study, seven of the eight participants had reached secondary level of education which may have influenced adherence.

Social support from family, neighbours and health care workers also improves adherence[99]. Participant Seven was adherent to his follow up sessions with the researcher because of the social support from his sister-in-law. A lack of social support was evident for Participant Three who lived alone in an informal settlement, and Participant Five who was alone at home during the day while his cousin was at work. Both of these participants returned home to the Eastern Cape to live with their families before completing the study. It may be suggested that a lack of social support as a consequence of living in the Western Cape affected their adherence. However, Participant Four also lived alone but had very good adherence. Most notably, Participant Four had very strong SE beliefs compared to Participants Three and Five. It would appear that SE and motivation may potentially play a role in adherence in the patients' lives.

Socio-economic factors may also contribute to poor adherence[99]. Poverty affects adherence as financial resources are not available for travel costs to the clinic. Time spent travelling to the clinic and waiting to be seen by a clinician causes the patient to stay out of work, which results in a loss of income[99]. In the current study, only half of the sample was employed and seven of the eight participants lived in impoverished communities. Financial constraints may therefore have been a major factor associated with travel costs. This may have affected adherence to treatment. Participant Eight was unemployed and had a spouse and children to support. It would therefore seem logical to propose that financial difficulties may have been his reason for non-adherence.

Sumartojo[98] used the term "*adherence*" as an alternative to the term "*compliance*" as the author felt it reflected the active role of the patient in the management of treatment. It was postulated that adherence to treatment requires a behavioural change by the patient.

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However, most patients have difficulty to maintain motivation to make these changes over long periods of time. Maintenance of this motivation is particularly difficult when patients are stressed by difficulties such as substance abuse, poverty and homelessness[98].

Non-adherence was a major limiting factor in this study. Four of the eight consenting participants failed to complete the series despite phone calls to remind participants of their appointments and the provision of an allowance to cover transport costs. The issue of poor adherence with follow up attendance after femoral fractures in a local setting has previously been reported by Gross et al[28].

3.4.3 *Summary of the discussion*

The results of this study cannot be generalised to the larger population because of the small sample. The study highlighted the impairments associated with IM nailing of femoral fractures and the issue of non-adherence with rehabilitation post-hospital discharge. These factors have major clinical implications.

3.4.4 *Clinical implications and recommendations*

The case study had useful clinical implications for management of femoral fractures at GSH as well as for general practice. At the institutional level, IM nailing appears to be the most appropriate surgical fixation allowing for early mobilisation and WB. South African orthopaedic surgeons are well trained and experienced to perform this type of surgery. The literature and the results of this study support the role of physiotherapy rehabilitation programmes which emphasise early WB within pain limits, MP strengthening and ROM. These programmes should particularly (but not exclusively) target the AROM of hip abduction and knee flexion as well as strengthening of the hip abductors and quadriceps. In addition, these programmes should emphasise education and practical execution of tasks that will assist the patients with issues regarding self- care and preparation for the home environment in terms of ADL. Differences in inter-individual recovery patterns were noted in the case series. This indicates the need for physiotherapy rehabilitation to be patient-centred i.e. physiotherapy treatment should be modelled on the ICF framework to assist the patients to adapt ADL's to their current function within their home and work environments in the acute stage. This will assist in curbing activity limitation in the early stages of recovery. Patients should also be made aware of the possible complications following surgery.

Further, physiotherapy treatment should include education regarding the importance of treatment adherence and the consequences in terms of morbidity because of non-adherence[99]. This may be achieved by improving social support from clinical staff and enhancing health education regarding the benefits of adherence.

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A physiotherapy screening clinic could also be incorporated into the outpatient orthopaedic clinic to reassess patients with each visit and provide feedback regarding the progression and/or regression of objective signs to encourage adherence. Feedback and education have being shown to be good motivators to continue with lifestyle changes to improve health conditions in patients[99,97].

Financial barriers to adherence due to transport costs may be overcome by making community health centres more accessible by providing a hospital transport service and decreasing the waiting time to see the clinicians. Social grants should be based on the assessment of a multidisciplinary team which evaluates all aspects of the patient's health and not only the impairment.

Future research would be strengthened by exploring qualitative aspects surrounding HRQoL following femoral fractures to provide more insight into the morbidity for those living in impoverished conditions.
These fractures are also due to high energy trauma that may influence the psychological aspects of the patient's health and may be more clearly reflected in a qualitative report of HRQoL.

This case series was able to identify the HRQoL for eight participants following traumatic femoral fracture and has highlighted some of the factors which may have influenced outcome in HRQoL. However, the study did have its limitations which will now be discussed further.

3.4.5 *Limitations*

This study was limited by the small sample size. Participants were only recruited from the traumatic orthopaedic wards at GSH. Those patients with femoral fractures that were discharged from the hospital via the trauma and emergency unit were not included. Only participants that were able to converse in English and Afrikaans were included as the researcher was not conversant in isiXhosa (the other most commonly spoken language in the region). This further limited the population that was included. Only GSH was used to recruit participants. This hospital admits patients from specified areas in the Cape Town metropole as demarcated by the Western Cape Department of Health. This limited the population of the sample to low-income areas. For this reason, the data cannot be generalised. A more diverse population would have been sourced by including other Cape Town based institutions and private health facilities. In addition, the current series investigated pain in the first 12 weeks post-surgery. A longer follow-up period after the injury would give more perspective to the persistent trochanteric hip pain reported in the literature, as this is often a long term complication following the trochanteric approach[2, 14]. However, the current study period indicated that the variables of pain, SE and HRQoL appear to have an interdependent relationship. X-rays at the end of the 12 week study period would also have provided greater insight into the healing phase of the fracture.

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The different variable outcomes related to HRQoL could have been influenced by the healing phase of the fracture. In line with international practice of limiting exposure to radiation, the orthopaedic practice at GSH only allows X-rays to be taken if clinical evidence dictates the need for radiographic investigation. The current results are thus based on clinical evidence of healing.

Information about participants' adherence with their orthopaedic follow ups was not recorded. This was because the research follow up sessions were booked on the same day as the orthopaedic follow up appointment sessions to alleviate transport costs for the participants. For this reason, it was assumed that if participants did not attend the research evaluation session, they had not attended the follow up appointment with the orthopaedic surgeon. This assumption may have been presumptuous because it assumed that the participants placed equal importance on the orthopaedic and research follow up appointments. The participants may have chosen to attend the orthopaedic clinic and not the research evaluation session. The current results thus only reflect adherence (or non-adherence) with the research follow up sessions and cannot reflect the adherence of the participants with their orthopaedic follow up appointments.

The participants were followed up for 12 weeks. The results of the study are thus only applicable to these eight participants for the first 12 weeks following surgery. Longer follow up at six months and one year would have provided further information regarding the presence of long term functional deficits and its effects on HRQoL as described by Gross et al[28] and Harris et al[48]. The 12 week follow up time was chosen for the current study as this is the average time to consolidation of the femur following IM nailing[11].The short term effects of HRQoL were thus evaluated in this study to investigate the influence of physical (biomedical), psychological and environmental factors on clinical outcome. Studies with longer follow up time frames may have improved adherence by conducting follow up sessions in the community.

In the current case series, the use of functional outcome measures proved beneficial in terms of evaluating the impact of injury and rehabilitation on the level of activity limitations and participation restrictions in patients following femoral fractures. The measurement of the functional outcomes required the use of a variety of instruments. These instruments had positive and negative factors associated with their use. The following section will discuss the instrumentation used in the study as well as their limitations and benefits.

The Frustrum method for measurement of limb oedema provided information on limb volume similar to previous studies[58]. In this case series, as oedema decreased the percentage difference in limb volume of the injured limb was less than the uninjured limb. This volume was affected by oedema but also by muscle bulk. The method makes use of surface measurements at specific points, making it susceptible to changes based on the girth of the limb.

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In instances where the injured limb had less volume than the uninjured limb, it can be theorised that this was due to muscle wasting. This is verified in the corresponding MP measurements for the specific time periods. The Frustrum method must therefore be used in conjunction with other objective tests to ascertain reasons for change in girth. The test is sensitive to detect volume changes but cannot be used to determine the reasons for change.

The use of the TMM to measure LLD had its shortcomings in this case series. The method makes use of surface measurements to determine LLD[10]. In this sample, the girth of the limb secondary to oedema affected the measurement obtained with the TMM. For this reason, participants had an apparent LLD at the beginning of the study when there was marked limb oedema. This LLD was eliminated once the girth of the limbs was equalised. In this case series, the TMM appeared to only be reliable and valid in the absence of limb oedema.

The TUG test was sensitive to evaluate change in the functional mobility of the participants over time. It was easy to perform, required minimal set up time and was not complicated for the participants to understand. The test allowed for the use of assistive devices[72] making it appropriate for patients with femoral fractures in the acute stage. At week 12, participants were already FWB and walking without their crutches. Despite this, they were required to use crutches to perform the TUG test at week 12 to standardise the testing procedure. This could have impeded their actual functional mobility as the crutches were a hindrance at this stage of their healing.

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Chapter 4: Chart review study

4.1 Introduction

The clinical case series highlighted the numerous issues related to the management of patients who have sustained traumatic femoral shaft fractures at GSH. A major issue was the poor follow up and poor adherence of these patients. Further, femoral fractures are common injuries associated with significant morbidity and increased costs of care[46]. The clinical case series highlighted the importance of understanding activity limitations and participation restrictions following traumatic femoral fractures. In addition, the results also emphasised how clinical care and rehabilitation may influence outcomes. However, due to a small sample size, no definitive conclusions may be drawn from the clinical case series. Accordingly, a chart review study was undertaken with the aim to describe the factors contributing to clinical outcome following traumatic femoral shaft fractures in patients admitted to the traumatic orthopaedic wards at GSH.

The specific objectives of this study are described in Section 1.3.4, page 4.

4.2 Methodology

Ethical approval was obtained from the UCT Faculty of Health Sciences Human Research Ethics Committee (HREC REF: 051/2012) and from the Groote Schuur Hospital (GSH) management (Appendix A 36).

4.2.1 *Study design and sample*

A descriptive retrospective audit of patients' folders was conducted. All the folders of patients admitted to GSH Traumatic Orthopaedic wards during the period of March 2007 and March 2011 that met the inclusion criteria were included in the study. Sample size was not calculated as the entire population (all folders) was included in the sample. Statistics for femoral fractures for GSH were available only until March 2011 at the time that the research was conducted.

i <u>Inclusion criteria</u>

Folders of patients who were between the ages of 18 and 45 years on admission and who had been admitted for management of an isolated traumatic femoral shaft fracture using a pro-grade IM nail. The inclusion criteria were based on those of the clinical case study series and have been described in Section 3.2.1i, page 43. Language preferences were irrelevant for the chart review.

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ii Exclusion criteria

Folders of patients who had co-morbidities that affected bone healing (e.g. bony pathologies, diabetes, previous ipsilateral knee injuries or fractures, cancer) were excluded. If patients had mobilised using MAD prior to hospital admission, or if they had sustained neurological damage to the affected leg (whether pre- or post-surgery), their folders were excluded from the retrospective review.

4.2.2 *Procedure*

A list of all patients who had been admitted to GSH with femoral shaft fractures from 1st March 2007 to 31st March 2011 was obtained from the hospital's Department of Statistics. This list was then used to obtain the relevant folders from the Medical Records department at the hospital. All folders were scrutinised according to the inclusion and exclusion criteria. Folders that fulfilled the inclusion criteria were analysed during a two month period from March 2012 to May 2012. All folders were assessed on site in the Medical Records Department of GSH.

4.2.3 *Measurement instruments*

A self-designed data collection sheet (Appendix A 37) and the revised WHODAS II instrument (Appendix A 38) were used to gather data. The information contained in the data collection sheet was considered in relation to the relevance of data to outcomes following femoral fractures. It was divided into two domains, namely; demographic data and medical history data. The demographic data contained information regarding gender, age and employment status of the patient.

The medical history data included: date of admission and discharge, source of referral to GSH, mechanism of injury[6], site of fracture[61], type of fracture pattern[61], type of surgical approach[49], length of hospital stay[46], duration of surgery and anaesthesia[28], qualification of the individual who performed the initial physiotherapy assessment, number of physiotherapy treatment sessions[52], date of the first outpatient department (OPD) appointment and the date of discharge from OPD, number of OPD visits[52], known co-morbidities[43], adherence to fracture management[28], reason for loss of adherence and referral route if the patient was not followed up at GSH.

The WHODAS II is not commonly used to assess disability from medical folders. Therefore, for this study a revised version of the WHODAS II was used to determine the level of disability of patients based on information contained in the medical folders. The instrument consists of five domains. Part I is an evaluation of the patient's demographic information. This includes variables of gender, age, education and employment.

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Part II evaluates the patient's level of mobility in terms of ease of walking, use of a MAD, distance the patient is able to walk and ability to stand up from sitting down. Part III evaluates the level of disability regarding self-care. This contains information concerning the ability of the patient to wash and dry his/her body, dressing and feeding and the ability to toilet. Part IV evaluates life activities in terms of how the patient is able to cope with household errands. Part V evaluates participation in society.

Parts II, III, VI and V are scored from "*1*" to "*6*" according to a ranking system. A score of "*1"* denotes that the patient experiences no disability in the given task. A score of "*2*" indicates mild disability, where the patient is able to complete the task independently but experiences slight difficulty. Moderate disability is denoted by a score of "*3".* The patient is able to perform the task independently but it requires increased effort. A scoring of "*4*" is given when the patient has severe disability. The patient has much difficulty in completing the task and may require help to do so. If the patient is unable to perform the task, a score of "*5*" is given. In the event that insufficient information regarding disability was documented in the folder, a score of "*6*" is noted. Each part of the revised WHODAS II is measured at three time frames, namely; at hospital admission, at discharge from hospital and at OPD follow up.

4.2.4 *Reliability and validity study*

A process of cross-checking was used to ensure relevant data was being obtained from the medical folders. Two researchers collected the specified data from 10 folders and their results were compared to ensure consistency. Intra-rater reliability was considered. During data collection, a random sample of 10 folders previously reviewed with the data collection sheets by the researcher, was re-checked. Intra-rater reliability was analysed by calculating the percentage of agreement and confidence intervals.

The validity of the revised WHODAS II instrument was considered in relation to the relevance of the data to outcome of femoral shaft fractures. Content validity of this revised version of the WHODAS II form was established using the following procedure. The instrument was used to retrieve information from the medical folders of the eight participants from the clinical case series (Chapter 3). This information was then compared to the data gained from the questionnaires that these patients had completed during the clinical case series regarding their wellbeing and function (Stanford HAQ 8-Item Disability Index, the EQ-5D, and the Stanford Social/Role Activities Limitations Scale). Statistical agreement between the revised WHODAS II data obtained from the folder and the information from the questionnaires was explored to determine the validity of using the revised WHODAS II instrument to gather information from patient records. A validity coefficient of 0.60 was regarded as acceptable[165]. The revised WHODAS II was only used in an unpublished undergraduate physiotherapy student thesis[152], in which it was piloted. For this reason there are no norms for validity testing.

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4.2.5 *Data management*

Data were entered electronically into a spread sheet using drop down menus with specific available options. All data were saved in an electronic password protected spread sheet on the researcher's personal laptop. Only the researcher and her supervisors had access to the spread sheet.

4.2.6 *Statistical analyses*

Data were entered into Microsoft Excel 2007 (Microsoft Corporation, Redmond, USA) and analysed using Statistica software (StatSoft, Inc. 2004, STATISTICA, Data Analysis Software System, version 8.0, www.statsoft.com). Descriptive statistics were used to summarise the information obtained from the data collection sheets. Results are presented as means ±standard deviation and as frequencies for categorical data. The distribution of data were analysed using the Kolmogorov-Smirnoff and Lilliefors tests for normality. The data were not normally distributed and consequently non-parametric analyses were conducted. The primary outcome measure was level of disability as recorded on the revised WHODAS II. Data were grouped according to revised WHODAS II outcomes to explore differences in variables using the Mann-Whitney U test. Variables included gender, mechanisms of injury, source of referral, educational level and employment status. Secondary groupings of data using gender, site of fracture, mechanism of injury and qualification of the physiotherapist were conducted. The Spearman's test was used to determine correlations for non-parametric data. The Pearson's Chi-squared test was used to determine differences for categorical data of the revised WHODAS II.

4.2.7 *Ethical considerations*

The use of the folders for research purposes did not interfere with the management of the patients if they were being re-admitted to hospital or seen at the outpatient clinics. Once data had been collected from the folders, they were returned to the Medical Records department immediately. The confidentiality of all patients and medical professions was maintained throughout the study through the use of coding. Only variables required for the study were extracted from the folders. Data collection occurred using the researcher's personal laptop. The laptop had a password to enter the spread sheet. Only the researcher had access to the laptop. All data were saved on a password protected external hard-drive for back-up purposes. Following the conclusion of the study, information gathered on the personal laptop will be stored in an electronic, password protected format for a period of five years. After this period the information will then be deleted to ensure that it is not available to any other party.

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i Benefits

As this was a retrospective record review, there were no direct benefits to participants in this study. There is much literature regarding rehabilitation following femoral fractures of the femur. However, to the knowledge of the researcher, only one study has thus far been conducted regarding this medical condition in South Africa[28]. The results of the present study will highlight the degree of disability following traumatic femoral shaft fractures, the causes of these fractures (e.g. GSW) and the impact on society in South Africa. Subsequently, it may inform health care practitioners of possible shortcomings in the medical care and rehabilitation services for these patients, and provide insight as to whether the South African health care system is on par with evidence-based guidelines.

ii Risks

The only risk to the participants were the loss of confidentiality, or loss of continuity of medical care should a patient folder have been lost. This occurrence was limited as all folders were assessed on the premises of GSH to eliminate any chances of folders being lost. In addition, the GSH electronic folder tracking system could have been used to document the location of the folders at all times. This ensured that the folder could be retrieved in the event that a patient was re-admitted to hospital. In addition, measures to protect anonymity and confidentiality were described in Section 4.2.5, page 118.

4.3 Results

In this section, the results of the chart review are presented. The sampling process is first described followed by the results of the reliability and validity study. Socio-demographic and clinical characteristics of the sample are then presented. Finally, the results of the revised WHODAS II outcomes are described.

Data were collected on 16 days between 20th March 2012 and 28th May 2012. Data collection was delayed due to the availability of folders as provided by the Medical Records Department at GSH. The Department of Statistics identified 690 folders according to their records. A manual check of statistics as provided by the Department of Physiotherapy was also employed, and a cross check between these statistics and those provided by the Department of Statistics identified a further 117 folders for analysis. A total of 807 folders were therefore identified for analysis. A total of 583 folders were issued by Medical Records with another 37 folders being made available on microfiche. Unfortunately, 224 folders were not located by the Medical Records department. Upon analysis of the available folders, only 165 folders were included for the chart review when assessed according to the inclusion criteria. Figure 4-1 describes the elimination process.

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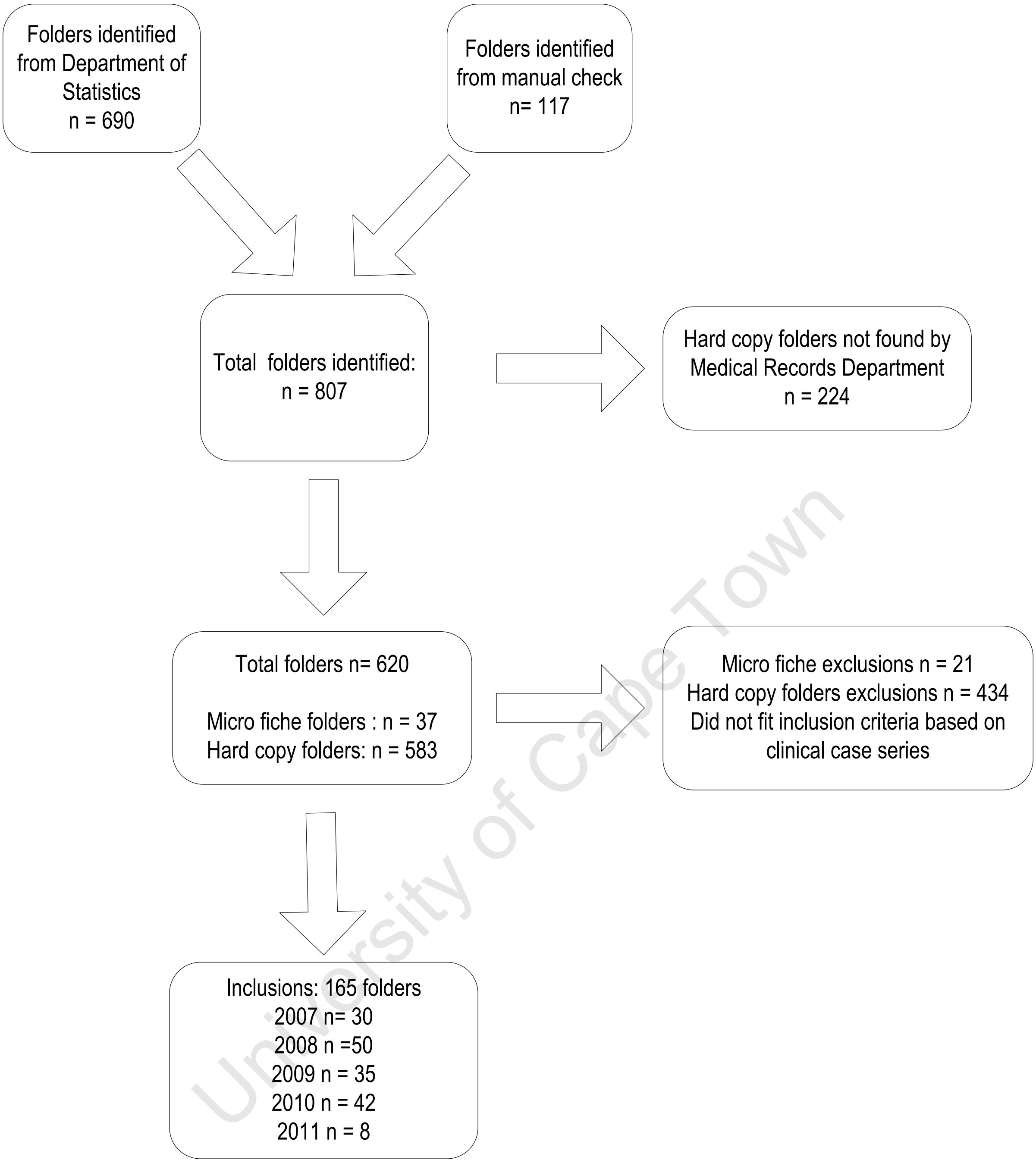

Figure 4-1: Sampling process of the chart review study.

4.3.1 *Reliability and validity study*

The process of cross-checking of folders between two researchers was conducted in a pilot study of the data sheet using 10 folders. There was 95.8% agreement (95% confidence interval 93.66 – 97.24) between results. Intra-rater reliability was established.

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A random sample of 10 folders that had been previously reviewed with the data collection sheet by the researcher was re-checked. Intra-rater reliability was found to be 100% (95% confidence interval 99.24–100). All data collected for reliability testing were included in the data analysis of the study. Following the validation process, the WHODAS II instrument was revised to exclude "*life activities*" and "*participation*" as statistical agreement for these two domains was found to be poor i.e. a validity coefficient below 0.60.

4.3.2 *Socio-demographic characteristics*

i <u>Gender and age</u>

Of the sample, 81% were male (n = 134). At the time of fracture, the mean age was 26.8 years (± 6.37, range 18 – 44 years). Figure 4-2 illustrates the distribution of ages between males and females. There was no significant difference in ages between males and females (U = 1971.0; p = 0.66).

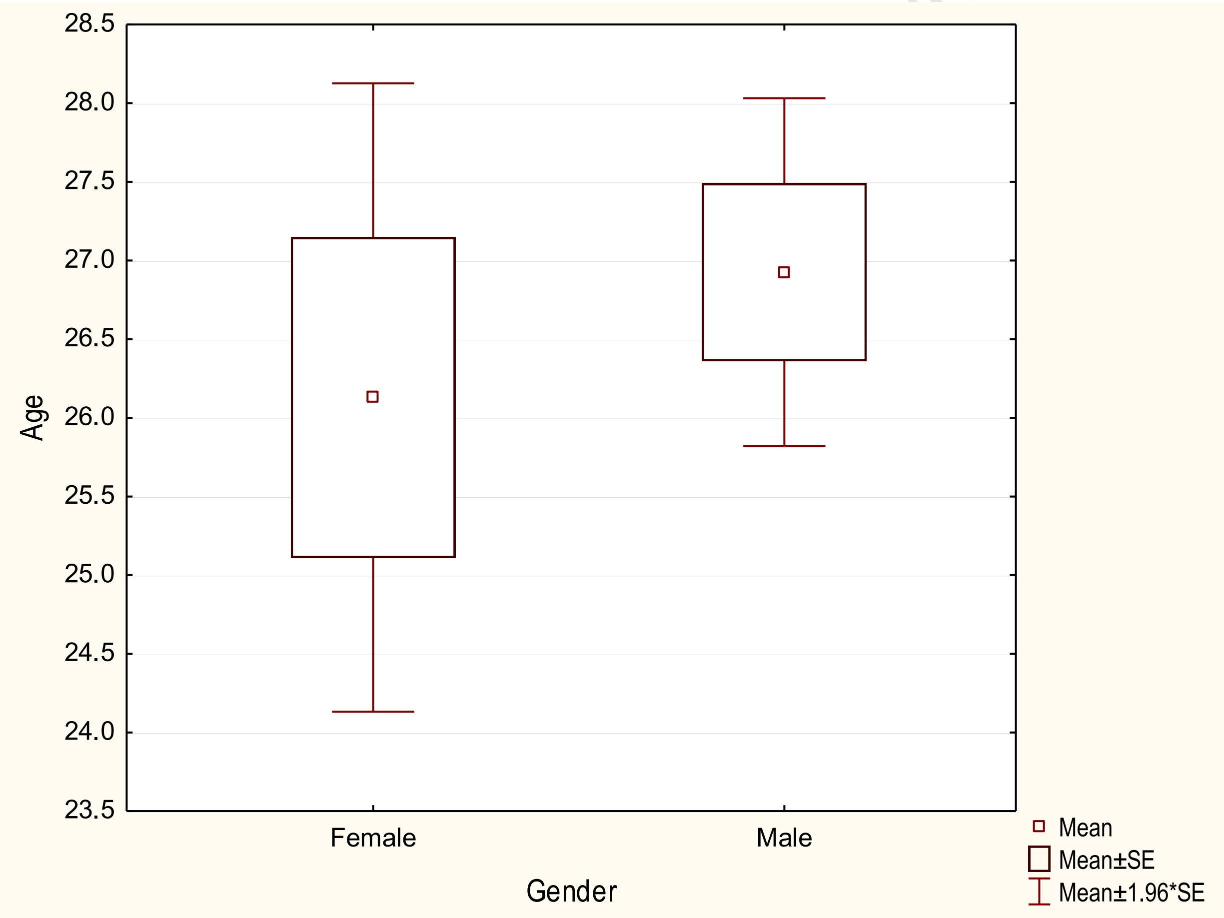

Figure 4-2: Differences in mean age between males and females in the chart review study

ii <u>Employment status</u>

There was an equal distribution regarding employment status between males and females (Table 4-1:). Only 14 of the sample were identified as students.

Table 4-1: Distribution in employment status according to gender for the chart review study

Gender	Student	Unemployed	Employed	Unknown
Female	4	16	11	0
Male	10	59	63	2
Totals	14	75	74	2

4.3.3 *Clinical characteristics*

The clinical characteristics of the sample are presented by a description of the source of referral to GSH. The co-morbidities of the sample are then described. This is followed by a description of the mechanisms of injury and types of fracture patterns. Finally, inpatient care and length of hospital stay are presented as well as characteristics relating to outpatient care and adherence with fracture management.

i Source of referral to GSH

The majority of cases were referred from the Trauma Unit (n = 77) followed by Community Health Centre referral (n = 64) and Secondary Hospital referral (n = 24). Significantly more of the GSW cases were referred from the community health centres, whereas most of the MVA cases were referred directly from the trauma unit (χ^2 = 17.59; df = 4; $p < 0.01$) (Table 4-2).

Table 4-2: Distribution of source of referral to GSH according to mechanism of injury for the chart review study

Source of referral to GSH	MVA	GSW	Other
Community Health Centre	20	33	11
Trauma Unit	44	21	12
Secondary Hospital	7	16	1
Totals	71	70	24

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ii Co-morbidities

These co-morbidities were unrelated to the patient's hospital admission with the femoral fracture. They were pre-existing conditions. Only a small percentage (15.15%) of the sample had co-morbidities. These consisted of surgical conditions (n = 1), previous orthopaedic-related injuries (n = 4) and medical conditions (n = 12). Previous injuries relating to trauma accounted for 4.8% (n = 8) of all co-morbidities.

iii Mechanisms of Injury

The majority of the fractures sustained were secondary to MVA (n = 71; 43%) followed by GSW (n = 70; 42.4%) as indicated in Figure 4-3. Other mechanisms of injury included falls, sport and work injuries and assaults.

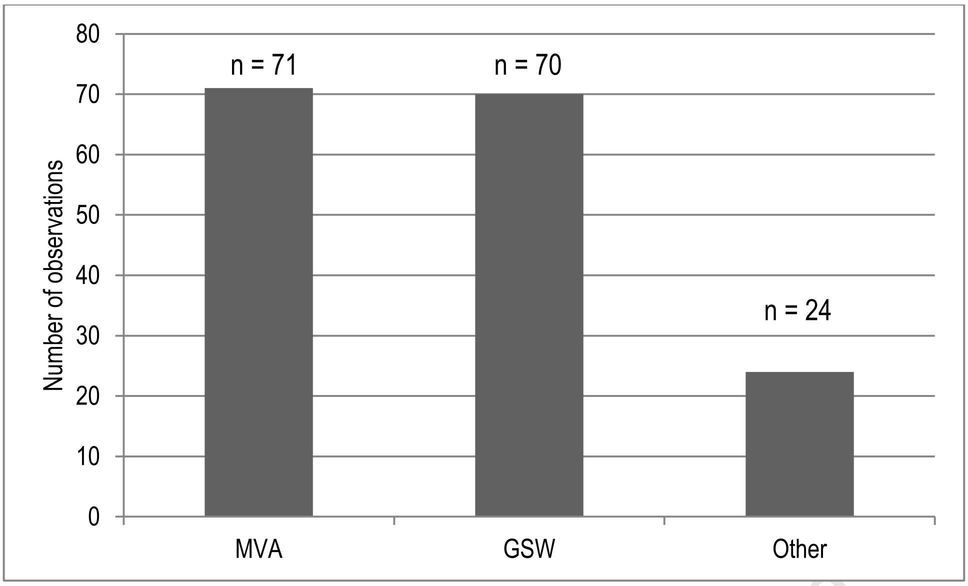

Figure 4-3: Distribution of mechanisms of injury in the chart review study

There was a significant difference in mechanism of injury when explored by gender ($\chi^2 = 28.90$; df = 7; $p < 0.01$). Females mainly sustained fractures as a result of MVA's whereas males mainly sustained fractures secondary to GSW (Table 4-3).

Table 4-3: Distribution of mechanism of injury according to gender for the chart review study

Gender	**MVA paedestrian**	**GSW**	**MVA (other)**	**Assault**	**Fall**	**Sport injury**	**Work injury**
Female	11	2	13	0	5	0	0
Male	26	68	21	7	9	2	1
Totals	37	70	34	7	14	2	1

Socio-demographic characteristics of patients were also analysed according to differences between GSW and non-GSW fractures. These differences that were considered included gender, source of referral, fracture patterns, length of hospital stay and inpatient care and adherence to fracture management.

Significantly more of the GSW were referred from the community health centres compared with non-GSW fractures ($\chi^2 = 15.19$; df = 2; $p < 0.01$). Further GSW mainly resulted in comminuted fractures ($\chi^2 = 82.91$; df = 4 and $p < 0.01$) compared to other fracture patterns. There were no significant differences between patients who had sustained fractures secondary to GSW and those with non-GSW fractures regarding duration of surgery (U = 2677.0; p = 0.77) and the number of OPD visits (U= 2709.5; p = 0.09). The differences between these two groups regarding the number of inpatient physiotherapy treatment sessions received approached significance (U=2744.0; p = 0.05).

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The length of hospital stay was significantly longer in the GSW patients ($U = 2458.5$; $p < 0.01$) compared to non-GSW patients.There was a significant difference in adherence to fracture management between GSW and non-GSW groups ($\chi^2 = 5.95$; df = 1 and $p = 0.014$). Patients with GSW fractures had worse adherence to fracture management compared to patients with non-GSW fractures.

iv Fracture patterns

There was an equal distribution of fractures in the right (48.47%, n = 80) and left (51.51%, n = 85) legs. The most common fracture patterns are presented in Table 4-4. Comminuted fracture patterns accounted for the majority of the fractures, followed by transverse type fractures.

Table 4-4: Distribution of fracture patterns for the chart review study

Type of fracture pattern	Count	Percent
Transverse	40	24.2
Comminuted	77	46.7
Spiral	12	7.3
Oblique	19	11.5
Segmental	3	1.8
Missing	14	8.5

There was a significant difference in mechanism of injury and the type of fracture pattern ($\chi^2 = 97.79$; df = 8; $p<0.01$). Transverse type fractures were mainly secondary to MVA, whereas comminuted fractures were mainly caused by GSW (Table 4-5).

Table 4-5: Distribution of mechanism of injury according to fracture patterns for the chart review study

Mechanism of injury	Transverse	Comminuted	Spiral	Oblique	Segmental
MVA	32	12	3	10	3
GSW	0	62	3	3	0
Other	8	3	6	6	0
Totals	40	77	12	19	3

The majority of the fractures were sustained in the middle third of the shaft of the femur (55.8%, n = 92) followed by the proximal third of the femur (24.8%, n = 41) and distal third (17.6%, n = 29). Data regarding site of the fracture along the femoral shaft were missing from three (1.8%) of the folders.

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v Length of stay and inpatient care

The average length of stay in hospital was 6.3 ± 2.5 days (range 2 – 16 days). The mean duration of surgery and anaesthesia times are shown in Table 4-6.

Table 4-6: Length of time of surgery and anaesthesia for the chart review study

	N	Mean	Minimum	Maximum	Std.Dev.
Duration of surgery (min)	149	67.2	15.0†	210.0	29.2
Duration of anaesthesia (min)	138	108.0	30.0	260.0	34.5

The majority of the sample were treated by final year physiotherapy students (n = 61) and physiotherapists (n= 54) during the inpatient stay, followed by physiotherapy assistants (n = 45) and community service physiotherapists (n = 4). One patient had not received any physiotherapy. The average number of physiotherapy sessions was 4 ± 2 (range 0 –12).

vi Outpatient care and adherence with fracture management

The mean number of orthopaedic OPD appointments was 2 ± 2 (range 0 – 7). Most of the sample (63.63%) were non-adherent with outpatient follow up management and had not returned for their follow up outpatient department appointments. There was a significant difference between gender and adherence to fracture management ($\chi^2 = 5.63$, df = 1; $p = 0.01$) (Figure 4-4). Males were less adherent compared to females.

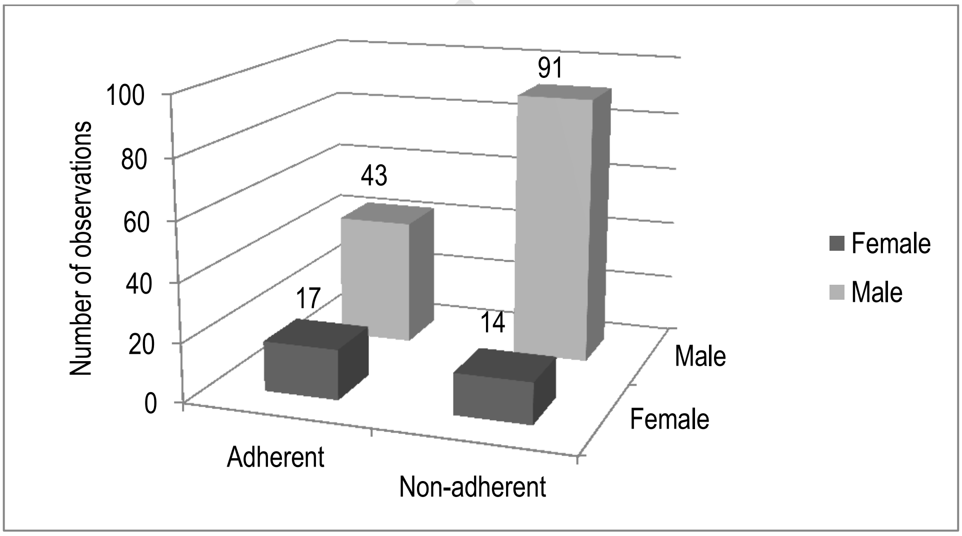

Figure 4-4: Distribution of adherence to fracture management according to gender

Only 36.36% of the sample were discharged by the surgeon from OPD. The rest of the sample had not attended the OPD clinic and had defaulted on follow up treatment.

† Given the low value, this data was double-checked to ensure that it was recorded correctly.

There were no significant differences between the qualification of the therapist that treated the patients and their adherence with treatment ($\chi^2 = 6.19$; df = 3, p = 0.10) (Table 4-7).

Table 4-7: Adherence with treatment versus qualification of physiotherapist for the chart review study

Qualification of physiotherapist	**Adherent**	**Non -adherent**
Physiotherapy assistant	17	28
Physiotherapist	26	28
4th year physiotherapy students	16	45
Community service physiotherapist	1	3
Totals	60	104

There was no difference between adherence with fracture follow-up and employment status (χ^2= 3.09; df = 3 and p = 0.37) (Table 4-8).

Table 4-8: Distribution of adherence to treatment according to employment status for the chart review study

Employment status	**Adherent**	**Non- adherent**
Student	4	10
Unemployed	23	52
Employed	32	42
Unknown	1	1
Totals	60	105

4.3.4 *Revised WHODAS II outcomes and disability*

The revised WHODAS II was used to obtain scores of the WHODAS II score for mobility Part II, ("*does the patient struggle to walk independently?*") and for self- care Part III ("*is the patient able to wash and dry his/her entire body?*"). The frequency distributions of scores obtained using the revised WHODAS II at hospital discharge and at OPD discharge are presented in the tables below (Table 4-9, Table 4-10, Table 4-11 and Table 4-12). The explanation for the interpretation of each category is found in Section 4.2.3, page 116.

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Table 4-9: Distribution of revised WHODAS Part II "mobility" scores at hospital discharge for the chart review study

Category	Count	Percent
Able to walk with crutches and negotiate stairs (2)	125	75.8
Able to walk with crutches/walking frame but unable to negotiate stairs (3)	38	23.0
Cannot do (5)	1	0.6
Not enough information (6)	1	0.6
Missing	0	0.0

Table 4-10: Distribution of revised WHODAS Part II "mobility" scores at OPD discharge for the chart review study

Category	Count	Percent
None (1)	44	26.7
Able to walk with crutches and negotiate stairs (2)	21	12.7
Not enough information (6)	100	60.6
Missing	0	0.0

Table 4-11: Distribution of revised WHODAS Part III "self-care" scores at hospital discharge for the chart review study

Category	Count	Percent
Able to walk with crutches and negotiate stairs (2)	125	75.8
Able to walk with crutches/walking frame but unable to negotiate stairs (3)	38	23.0
Cannot do (5)	1	0.6
Not enough information (6)	1	0.6
Missing	0	0.0

Table 4-12: Distribution of revised WHODAS Part III "self-care" scores at OPD discharge for the chart review study

Category	Count	Percent
None (1)	44	26.7
Able to walk with crutches and negotiate stairs (2)	21	12.7
Not enough information (6)	100	60.6
Missing	0	0.0

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Unfortunately, 60.6% of the folders did not have enough information at discharge from OPD for part II and part III of the revised WHODAS II outcome measure to obtain scores for "*Disability*" and "*Function*". For this reason, analysis of disability at OPD discharge based on this outcome measure was limited.

There were no significant differences in gender distribution according to revised WHODAS II mobility scores at hospital discharge (n = 165), or OPD discharge (n = 65). There were no significant differences in revised WHODAS II mobility scores at hospital discharge or at OPD discharge when analysed according to site of injury along the femoral shaft (n = 63).

There were no significant differences in revised WHODAS II mobility scores at hospital discharge and OPD discharge when analysed according to mechanism of injury(n = 65).There were also no significant differences in revised WHODAS II mobility scores at hospital discharge (n = 164) or at OPD discharge when analysed according to the qualification of the treating physiotherapist. Spearman's correlations were used to explore for relationships between revised WHODASII outcomes for mobility (part II) and self-care (part III) between patients with GSW and those with non-GSW fractures. There were no significant correlations between any of the variables explored for either outcome at hospital discharge or OPD discharge respectively.

4.3.5 *Summary of the results*

The majority of the sample were male (n = 134). The mean age of the sample was 26.8 years at the time of fracture. There was an equal distribution regarding employment status between males and females. The main source of referral of patients to GSH was via the Trauma Unit (n = 77) followed by Community Health Centre referral (n = 64) and Secondary Hospital referral (n = 24). Significantly more of the GSW cases were referred from the community health centres. The majority of the fractures sustained were secondary to MVA (n = 71) followed by GSW (n = 70). Females mainly sustained fractures as a result of MVA's. Males mainly sustained fractures secondary to GSW. In addition, GSW's mainly resulted in comminuted fractures. Comminuted fracture patterns accounted for the majority of the fractures. The majority of the fractures were sustained in the middle third of the shaft of the femur. The length of hospital stay was significantly longer in the GSW patients compared to non-GSW patients. Adherence to fracture management was a major issue. There was a significant difference in adherence to fracture management (p = 0.014) in that patients with GSW fractures were less adherent compared to patients with non-GSW fractures. Further, males were less adherent compared to the females (p = 0.01). Only 36.36% of the sample was discharged by the surgeon from OPD. The rest of the sample had defaulted on follow up treatment. Analysis of disability at OPD discharge based on the revised WHODAS II outcome measure was limited. This was because 60.6% of the folders did not have enough information at discharge from OPD for part II and part III of the revised WHODAS II outcome measure to obtain scores for "*Disability*" and "*Function*".

4.4 Discussion

The aim of the chart review study was to describe the characteristics that may contribute to functional outcome and disability following traumatic femoral shaft fractures in patients admitted to the traumatic orthopaedic wards at GSH.

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This chart review study is the first attempt to use the revised version of the WHODAS II instrument to describe the level of disability based on information in the folders of patients who had sustained traumatic femoral fractures.

Socio-demographic and clinical attributes of the sample will first be discussed. This will be followed by a discussion on the applicability of the revised WHODAS II to assess disability and participation from information in the medical chart. A discussion of whether the revised WHODAS II is associated with gender, employment status, education, source of referral, mechanisms of injury, fracture pattern, the length of hospital stay and inpatient care and outpatient care including adherence with fracture management, is presented.

Finally, limitations of the study are presented. Recommendations for future studies are proposed and clinical implications of the study are highlighted.

4.4.1 *Socio-demographic characteristics of the sample*

i Gender and age

Most markedly, the majority of the sample was male and consisted of young people (Section 4.3.2i, page 121). Femoral fractures were more common in males than in females. These findings reiterate those of Singer et al[41] who found that males below the age of 35 years were more likely to sustain diaphyseal femoral fractures. Later studies by Ryan et al[43] and Gross et al[28] also found a similar results concerning the high incidence of femoral shaft fractures in young adults, particularly males. Gross et al[28],determined that the South African sample group had an average age of 33 years. Ryan et al[43] also showed that the average age of participants was 33 years. This indicates that although the current study sample had a similar gender representation as previous studies, they were much younger than those previously reported. This may be representative of the younger Western Cape population (Census 2011, Statistics South Africa)[166] that attends at GSH. Further, this younger age group is typically associated with interpersonal violence and homocides[19, 28].

ii Employment status

Employment status of this sample was equally distributed between employed and unemployed. These results are similar to that of the clinical case series (Section 3.4.2i, page 101) in which only 50% of the sample was employed. Results regarding employment were insignificant in relation to the functional outcomes. Employment status does influence the socio-economic status of an individual. Jelsma and Ferguson[88] found that in a South African setting, socio-economic status was a determinant of HRQoL. Lower income groups had poorer reported HRQoL measures[88]. Based on this finding, it may be postulated that half of the current sample would experience low measures of HRQoL because of unemployment.

4.4.2 *Clinical characteristics*

i Source of referral

Most of the sample was referred to the orthopaedic department via the trauma unit at GSH. This indicates that the injuries were sufficiently traumatic in nature to warrant immediate referral to the trauma unit. The second most common source of referral was via the community health centres. In this current study, MVA's were mostly referred via the trauma unit and GSW's were mostly referred to GSH from the community health centres. This result may suggest that these violent GSW injuries were triaged in the community health centres prior to referral to the hospital. The high number of GSW injuries reflects the high incidence of interpersonal violence in the low-income Cape Flats communities[16, 19]. Norman et al[19] attributes this high level of interpersonal violence to rapid urbanisation and socioeconomic disparities[19]. Goosen et al[16] cited similar findings in that violence against the background of poverty and rapid urbanisation has caused an increased burden of disease[16].

Secondary hospital referrals were the third most common source of referral. The burden of MVA and GSW on secondary hospitals has been highlighted by an earlier pilot study[44] conducted at GF Jooste Hospital in the Cape Flats, in which firearms were used in 15.3 % of violent attacks. Motor vehicle (traffic) accidents accounted for a third of all injuries that were recorded[44].

ii Co-morbidities

There were minimal co-morbidities in this sample. This finding is similar to previous studies by Gross et al[28] and Ryan et al[43] that showed co-morbidities were uncommon in younger patients following femoral shaft fractures.

iii Mechanism of injury

Significantly, MVA and GSW were the most common mechanisms of injury. GSW were more common in males, whereas females mainly sustained femoral fractures as a result of MVA. These mechanisms of injury have also been found to be the most common cause of femoral fractures in previous international studies[21, 24, 28, 43, 48]. Harris et al[48] identified that road traffic accidents were the causative mechanism of injury in 81% of the cases[48]. Zirkle[23] has reported that road traffic accidents are becoming an increasingly common cause of fractures in the low- to middle-income countries. This is a concern for orthopaedic surgeons in these countries as this increases the burden on the health services[23]. Gunshot wounds, often associated with interpersonal violence, are also causing a burden on health services in South Africa[19, 45]. Similarly, Norberg et al[45] reported that GSW were mainly sustained by young males.

The costs incurred by MVA's and GSW's often reach beyond the health care system and into the greater economy. These injuries affect young people and thus results in time off from work.

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In South Africa, patients with femoral fractures have reported a negative impact on their working capacity at one year following the original injury[28]. Based on the results of the current study, only half of the sample were found to be employed at the time of injury. The result of the femoral fracture may thus negatively influence this employed group resulting in possible further unemployment and time off from work to recover from the fracture. This may have a negative impact on the economy. However, with effective treatment of these long bone fractures, disability could be limited subsequently decreasing the burden on the patient and their families and in the long term reducing the negative effect on society[23].

The most marked difference between the GSW and non-GSW cases was in the distribution between genders. Male patients had mainly sustained fractures secondary to GSW. Patients with fractures sustained via GSW were mostly referred from the community health centres as compared to patients with non-GSW fractures. This bears testimony to the gang violence amongst young adult males in the poorer communities along the Cape Flats[38].

iv <u>Fracture patterns</u>

The fractures sustained via GSW were mainly comminuted type fractures. Fractures sustained by non-GSW had more transverse and oblique type fracture patterns. The results of this chart review indicated a significant relationship between the mechanism of injury and type of fracture pattern. Most of the fractures with a comminuted fracture pattern were significantly associated with GSW. Transverse type fractures were associated with MVA. The association between mechanism of injury and type of fracture pattern is compatible when the types of forces resulting in the fracture are considered[11].

The consequence of comminuted fractures is that these patients have to be NWB on the injured limb until physiological bone union has occurred. This influences the gait pattern and may cause considerable difficulty with mobility and subsequently activity limitation and participation restrictions. Most of the patients in the chart review were from low- and middle-income communities where accessibility to transport and clinics is often problematic. The comminuted fracture pattern may thus cause considerable disability to these patients in light of environmental factors. This concept of disability caused by internal (personal) and external (environmental) factors has been previously emphasised[30]. Some of the environmental factors described in the literature include the physical environment, access to transportation, access to medical services and community resources, health of the economy and social attitudes[30]. Physical environment and access to transport remains a problem in informal and low-income communities along the Cape Flats that have limited infrastructure due to rapid growth of these communities. Despite the attempt at transformation of the health system into an integrated comprehensive service, failures in leadership and the consequence of poor management have caused poor access to medical services[37].

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This has created further environmental barriers that may contribute to patients' activity limitations and participation restrictions. For this reason, it may be proposed that the 77 patients who sustained comminuted fractures would experience considerable disability based on environmental factors during the acute stages of healing. Unfortunately, this information regarding disability and activity limitations was not documented in the patients' folders.

The most common site of injury along the femur was the middle third of the shaft, followed by the proximal third and lastly the distal third. Mira et al[61] reported that patients with proximal and middle third femoral fractures had better functional outcomes compared to patients with fractures in the distal third of the shaft. However, the results of that study cannot be generalised as it included patients who had femoral fractures managed with conservative management using splints as well as patients managed with surgery. Further, the surgical management did not only include fixation with an IM nail. The findings of the clinical case series indicated that patients with fractures in the proximal and middle third of the femur had better functional outcomes at 12 weeks post-surgery (Section 3.4.2vii, page 105). Based on this information, most of the current sample in the chart review should have then experienced better functional outcomes because of the site of fracture. However, data relating to these functional outcomes were not documented in the medical records due to poor adherence with fracture follow-up management.

v Length of stay and inpatient care

The length of hospital stay was statistically significant when comparing patients with GSW and non-GSW cases. Patients with GSW's had a longer length of hospital stay. It seems intuitive that patients with GSW-induced fractures would have a longer length of stay. In civilian settings, low velocity GSW injuries are a common occurrence. These injuries are associated with lacerations and crushing of the soft tissue. There is associated vascular injury as well[162]. The subsequent tissue injury and blood loss will detrimentally influence the patients' recovery. This may have been the reason for a longer hospital stay of the patients with GSW.

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There were no other major differences between the two groups. Both groups had a similar time of surgery and a similar number of physiotherapy treatment sessions. Due to a lack of information in the medical folders, the revised WHODAS II was unable to detect any differences in disability levels between the groups. Information regarding the qualification of the orthopaedic surgeons was not available in patients' medical charts. It is the practice at GSH that IM nails are inserted by the junior orthopaedic residents who provide emergency orthopaedic services for the trauma unit (section 3.4.2vi, page 104). A previous study found that South African surgeons had less years of experience than their international counterparts and operated without supervision in regard to IM nailing of the femur. Despite this lack of experience and supervision, there were fewer post-operative complications in the South African sample[28].

The average length of hospital stay was 6.3 days. This was longer than the average length of stay for patients in the clinical case series (4.75 days). Factors that influence and prolong hospital stay following femoral fractures have been previously reported in the literature[46]. These factors included time to surgery, time for physiotherapy evaluation and radiology delays[46]. Some of these factors were identified in the clinical case series discussion (Section 3.4.2iii, page 102). The factors which affected the length of hospital stay in the chart review were unfortunately not captured from the medical folders.

The qualification of the physiotherapist that attended to the patients did not influence the functional outcome. This may be due to the fact that isolated femoral shaft fractures are an uncomplicated diagnosis that is easily managed by both experienced and inexperienced therapists. In addition, rehabilitation protocols have been developed making it easier to treat these patients by following a set treatment programme, which will improve functional outcomes[52-53]. GSH has its own rehabilitation protocol for patients with femoral fractures based on the findings in literature[6, 14, 52] (Appendix A 11). Further, the qualification of the attending physiotherapist did not influence the rate of adherence of patients with their follow up appointments in their fracture management.

vi Outpatient care and adherence with fracture management

Adherence with fracture management was poor in both the GSW and non-GSW cases. Significantly, the GSW cases were more inclined to be non-adherent with the follow up fracture management. Interestingly, certain patients who had sustained GSW's were escorted by the South African Police Service to a correctional facility immediately at discharge from the hospital. Mode of discharge was not part of the data collection sheet, and therefore these discharge data were not recorded. This may have added a further dimension to the issues of adherence, as these patients did not return for their follow up appointments. This may be attributed to the fact that these patients have to appear in court after hospital discharge. They are then often released on bail due to the overburdened criminal justice system in South Africa. These patients subsequently default on their treatment once they are released on bail. The few that remain in custody are sent to various correctional facilities across the province. These patients are then followed up at the nearest hospital facility indicated (personal communication with a head nursing professional in charge of the health care clinic at Goodwood correctional facility in Cape Town). However, this requires further follow up as no reliable data are available.

4.4.3 *Revised WHODAS II outcomes and disability*

The traumatic nature of femoral fractures has associated functional impairments. These impairments frequently result in disability[52]. In this chart review, an attempt was made to measure the level of disability based on information in the medical folder using the revised WHODAS II instrument. The chart review highlighted that disability could not be determined from the medical charts using the revised WHODAS II.

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This was due to two reasons. Firstly, insufficient information was available in the medical charts. Secondly, the majority of the sample was lost to follow up because of non-adherence with treatment.

The original WHODAS II was designed to evaluate levels of disability as reported by patients and their care-givers[148-149]. The questionnaire is usually self-administered. In the present study, a revised version of the WHODAS II was used to obtain information from patient records regarding disability. The revised WHODAS II may not have been sensitive to evaluate disability based on the information in the medical folders. The use of the revised WHODAS II in the current study highlighted important shortcomings in documentation protocols of health care professionals at GSH. The medical notes reflected a biomedical approach with emphasis on health at a biological level. The physiotherapists were the only profession that captured some information regarding social circumstances and functioning.

The rehabilitative practice of health care has adopted an ICF-based approach that incorporates the impairment, activity limitation and participation restriction into the management of patients[30]. This concept is generally accepted by rehabilitation therapists at GSH (personal communication with Lionel Naidoo, Assistant Director of Department of Physiotherapy, GSH). However, this is not reflected in the documentation of medical records at GSH. During the data collection process, it was observed that information regarding function was mainly documented by the physiotherapist and to a much lesser extent by surgeons and nurses. Although physiotherapists and the surgeons (to a lesser degree) placed some emphasis on activity limitations, factors of participation were not recorded. For this reason, Part IV and V of the revised WHODAS II could not be included in the analysis during the validation process of the questionnaire, as the data were not available. Consequently, the WHODAS II was unable to detect any statistically significant associations due to missing data. Further, there were no significant associations between the revised WHODAS II (part II) scores and gender, mechanism of injury, site of injury along the shaft and qualification of the physiotherapist at hospital discharge and at the OPD follow up.

It is possible that disability levels in these patients are independent of these factors (gender, mechanism and site of injury and the qualification of the physiotherapist). The disabilities experienced may be due to other factors in these patients' lives such as physical and financial resources as well as low levels of self-efficacy. A previous South African study has shown that financial factors due to a lack of employment and environmental factors (poor uneven roads, lack of basic amenities) influenced patients activity limitations and participation and subsequently their level of disability[32]. However, this study was conducted on a specific cohort of patients who had rheumatoid arthritis. The results can thus not be generalised[32]. Most of the current sample were from low-income areas with poor resources. It may be that the environmental factors rather than medical factors would influence levels of disability.

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In addition, as previously discussed, poor socio-economic factors associated with unemployment also influence disability and HRQoL outcome measures[88]. Half of the current sample were unemployed at the time of injury. However, due to a lack of data, these theories are inconclusive.

A second reason for the lack of information for the WHODAS II instrument was due to non-adherence. Poor adherence with follow up after femoral fractures has previously been reported in South Africa[28]. The current sample had very poor adherence with their fracture follow up management, with only 36.6% returning for follow up at the OPD orthopaedic clinic. This phenomenon of non-adherence has been reported in developing countries where only a 30% follow up was recorded in orthopaedic patients[23]. In the current study, male patients were less adherent than their female counterparts. Factors affecting adherence have been attributed to health literacy, social support and financial implications[99]. Kagee et al[99] suggested that health literacy is often associated with educational level. Unfortunately, the levels of education of patients were not often recorded in patients' folders. Only five folders had the level of education documented. This further highlights the lack of information in the medical charts. Kagee et al[99] also postulated that educational levels of patients who reside in low-income areas are most likely low. Based on this finding, it may be hypothesised that the poor levels of adherence observed in the chart review study may be related to poor health literacy levels, as many of the patients were from low-income settlements. This low-income status may subsequently also impact on the financial implications associated with transport costs as it relates to non-adherence[99].Employment status may therefore also influence adherence associated with financial issues. However, statistical analyses indicated that employment status did not influence adherence in the current sample. In addition, social support structures may have played a role in influencing adherence[99]. Unfortunately information relating to social support was not recorded from the folders.

4.4.4 *Limitations*

A sample size of only 165 folders was included from a possible 807 folders. The small sample size was due to multiple factors. Many folders were not located at the time of the study. These folders were lost between the ward and the outpatient clinic. Many of the folders had also been coded with the incorrect ICD codes resulting in folders not being made available for review. Further, in some of the folders that were coded correctly, the patients had other associated orthopaedic injuries which led to these folders being excluded based on the inclusion criteria. The study results can therefore only be interpreted based on the current sample and should not be generalised to all patients with femoral fractures that were admitted at GSH during the study period investigated.

A second major limitation was the poor adherence rate of the patients, which resulted in a lack of information in the patients folders.

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The folders contained information regarding the inpatient stay but not regarding the OPD status of the patients due to the poor adherence with follow-up. This was exacerbated by inadequate documentation by the health care professionals. This resulted in folders that were available for patients that had attended outpatient follow-up not always having sufficient information. Further, as mentioned above, the information was also mainly based on the biomedical model of health care and lacked information concerning activity limitations and participation. This limited the use of the revised WHODAS II questionnaire. The suburbs in which the patients lived were not recorded. This would have indicated which suburbs were affected by violence, adding further insight to the results. Although many of the patients admitted to GSH are from low-income communities, some of these patients may have come from more affluent residential areas. No definitive conclusions regarding environmental factors and socio-economic factors which are known to influence disability can therefore be made based on the areas in which the patients lived.

4.4.5 *Clinical implications and recommendations*

This study has shown that the use of the ICF framework should be incorporated into treatment as well as medical record keeping. This will allow health professionals to focus their interventions at a holistic level rather than the current, limited biomedical level. A standardised assessment form could be introduced into each orthopaedic folder to encourage the health professionals to document the patient's level of disability, impairment, activity limitations and participation restrictions at different stages of the recuperation process. Factors that influence each domain could then be recorded on the assessment form. This information could then be used to plan appropriate interventions by the multi-disciplinary team to promote a favourable outcome for patients.

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Education about the importance of adherence with follow up should be emphasised as part of the inpatient medical management. This information should be reinforced by all the health professionals that manage the patient during the inpatient hospital stay.

For future studies, additional information from X-rays and other radiological investigations should be included in a chart review study. This would provide more insightful information regarding classification of fractures and healing time frames. Non-adherence with follow up management was a major limitation. This study confirms that further knowledge regarding the factors associated with poor adherence is required. Further knowledge regarding interventions to improve adherence is also required in future research[98].

Chapter 5: Conclusion

Traumatic fractures of the shaft of the femur are common injuries in younger adults[28, 41-42]. The injury is often sustained following high energy trauma[20] such as sport injuries, MVA, work-related injuries[14] and GSW[21, 162]. South African literature reports the mortality associated with the high burden of trauma as it relates to violence and road traffic accidents[16, 39, 45] but fails to indicate the resultant morbidity on HRQoL.

Groote Schuur Hospital is a tertiary health care centre which provides a major trauma centre for Cape Town and the Western Cape Province. A total of 1 474 patients were admitted to the hospital with femoral fractures during March 2007 until March 2011 (GSH Department of Statistics). Most of the femoral shaft fractures were managed with IM nailing, which is the gold standard of management for these types of fractures[1, 54]. The use of IM nailing does however result in functional impairment despite good union of the bone[2]. These impairments include: a loss in MP of the affected hip abductors[14] and quadriceps[54], loss of ROM in the affected limb[61], excessive oedema[63] and leg length discrepancies[48] as well as alterations in the weight bearing status[65]. These impairments may cause disability in these patients.

There is little evidence that describes the extent of disability in patients with traumatic femoral fractures. The information relating to femoral fractures has focussed on the physical impairments[6, 54, 61] and anecdotal perceptions of activity limitations[14, 52] and participation restrictions[28]. The focus of this study was to provide evidence of the functional limitations and the extent of disability associated with femoral fractures in a local setting. Anecdotally, patients with femoral fractures that are treated at GSH are often from poverty-stricken communities that have limited infrastructure and poor access to basic amenities. The physical environment coupled with functional impairments may therefore compound their level of disability following injury. The consequence of the injury, its impairments as well as the poor social structure may subsequently influence the patient's HRQoL. Therefore, the aim of the first part of this thesis was to document the health-related outcomes in patients that sustained traumatic fractures of the shaft of the femur. The second aim of the thesis was to describe the factors contributing to clinical outcome following traumatic femoral shaft fractures in patients admitted to the traumatic orthopaedic wards at GSH. The evidence provided in this thesis, allowed the specific objectives listed in Section1.3.2, page 3 to be answered as follows:

> *"To determine the HRQoL, pain scores, activity limitations and SE of patients who sustained traumatic femoral shaft fractures at discharge from hospital, and at two weeks, four weeks, six weeks and 12 weeks post-surgery".*

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Only four of the eight participants completed the full study. This was due to attrition. The current study indicated that there was a consistent increase in the HRQoL and SE levels, an improvement in activity limitations scores as well as a decrease in pain scores at the specified time frames post-surgery in seven of the eight participants. No results were reported for the eighth participant as he had not returned after hospital discharge. These improvements in HRQoL measurements appeared to be related to the measures of SE, pain and activity limitations.

> *"To determine the functional outcome variables (ROM, MP, swelling, WB status and LLD) in patients who have sustained traumatic femoral shaft fractures at two weeks, four weeks, six weeks and 12 weeks post-surgery."*

The results of the clinical case series indicated that all the participants had functional impairments that were a consequence of the surgery and the injury. The affected hip abductors and quadriceps appeared markedly weaker than the unaffected leg at hospital discharge. Oedema and loss of ROM of the hip and knee were also worst at hospital discharge. Oedema, MP and ROM showed a substantial improvement in the seven participants over time. However, MP had not returned to pre-morbid levels as compared to the uninjured limb by the 12 week follow up. Participants varied their WB status according to their comfort levels and not according to prescription during the 12 week period. There was an apparent LLD in some of the participants at hospital discharge. This was found to be due to limitations of measurement method and did not represent a true LLD. The measure of HRQoL appeared to be inter-related to the functional impairment variables. In summary, it was found that HRQoL improved as MP, ROM and WB improved. Similarly, HRQoL also showed improvement as oedema in the affected limb decreased. The results suggest that a potential relationship may exist between HRQoL and improvement in the functional impairment variables.

> *"To determine whether there were differences between the mechanism of injury (GSW versus non-GSW) and functional outcome variables of pain scores, activity limitations and SE and HRQoL".*

The only notable difference was that participants with fractures sustained by GSW appeared to have slightly higher oedema measurements at hospital discharge. No other differences were noted in outcome variables and pain scores, activity limitations, SE and HRQoL related to mechanism of injury in the eight participants. All participants improved over time irrespective of the mechanism of injury. Inter-individual variation in recovery patterns was noted. This was due to contextual factors as defined by the ICF framework. This included personal factors such as family support, self-motivation and financial issues. Environmental factors entailed issues related to distance from the clinics. This highlighted the need for an individual approach to patient management.

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The results of the clinical case series indicated that HRQoL improved over time from hospital discharge until 12 weeks post-surgery. This improvement appeared to be related to improved levels of SE, an associated decrease in pain and improvement in activity limitations and participation restrictions. Further, improvements in the functional impairments (MP, ROM, oedema, LLD and WB status) may also be positively related to improvement in HRQoL in this study sample.

In the chart review study, the results provided insight to answer the specific objectives listed in Section 1.3.4, page 4:

> *"To describe the socio-demographic and clinical attributes of patients that sustained an isolated traumatic femoral shaft fracture".*

The socio-demographic results indicated that South African patients that sustained femoral fractures had similar attributes with regards to gender and age, compared to international findings[28, 43]. Male patients sustained femoral fractures more often than female patients. The average age of the sample was found to be slighter younger than previously reported[28]. Only half of the sample were employed which reflects the high rate of unemployment among young adults in the communities of the Cape Flats[38].

The clinical attributes of the sample were also similar to previous findings[28, 43]. There were minimal co-morbidities and the most common mechanisms of injury were MVA and GSW. These findings reinforce the notion that trauma-related injuries have become a burden to the South African disease profile[17]. Patients with GSW fractures were also found to have a significantly longer length of hospital stay. This indicated that the rise in trauma-related injuries related to GSW's may have had a significant financial impact on the hospital as a longer length of hospital stay is often related to increased hospital costs[46]. Further, in the current sample there was also poor adherence with follow up fracture management. Poor follow up rates has been documented in South Africa[28] and Africa[23]. Patients may not return for follow up if they feel physically fit[23, 28]. However, this study was unable to determine underlying reasons for the poor adherence with follow up fracture management, and further investigation is required.

> *"To investigate if the level of disability could be determined from the patients' folder history using the revised World Health Organisation Disability Assessment Schedule Version II (WHODAS II)".*

Unfortunately, the level of disability of patients could not be determined from information in the medical folder using the revised WHODAS II. The documentation consisted of medical parameters based on findings at a biomedical level rather than activity limitation and participation restrictions according to the ICF framework.

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Further, this lack of information was compounded by the poor adherence with fracture management. Most of the sample (64 %) were non-adherent with their outpatient follow up appointments.

> *"To investigate whether revised WHODAS II scores were associated with variables of gender, employment status, education, source of referral, mechanism of injury, fracture patterns, length of hospital stay, inpatient care, and outpatient care including adherence with fracture management".*

This objective could not be answered through the findings of the chart review. The associations between the revised WHODAS II and the various variables could not be determined due to insufficient information available in the medical folder. The paucity of information was due to poor documentation of function as stipulated by the ICF framework and was compounded by non-adherence with follow up fracture management.

In conclusion, based on the findings of clinical case series and the chart review study, and data from previous studies, an ICF framework for patients with traumatic femoral shaft fractures in South Africa is presented in Figure 5-1.

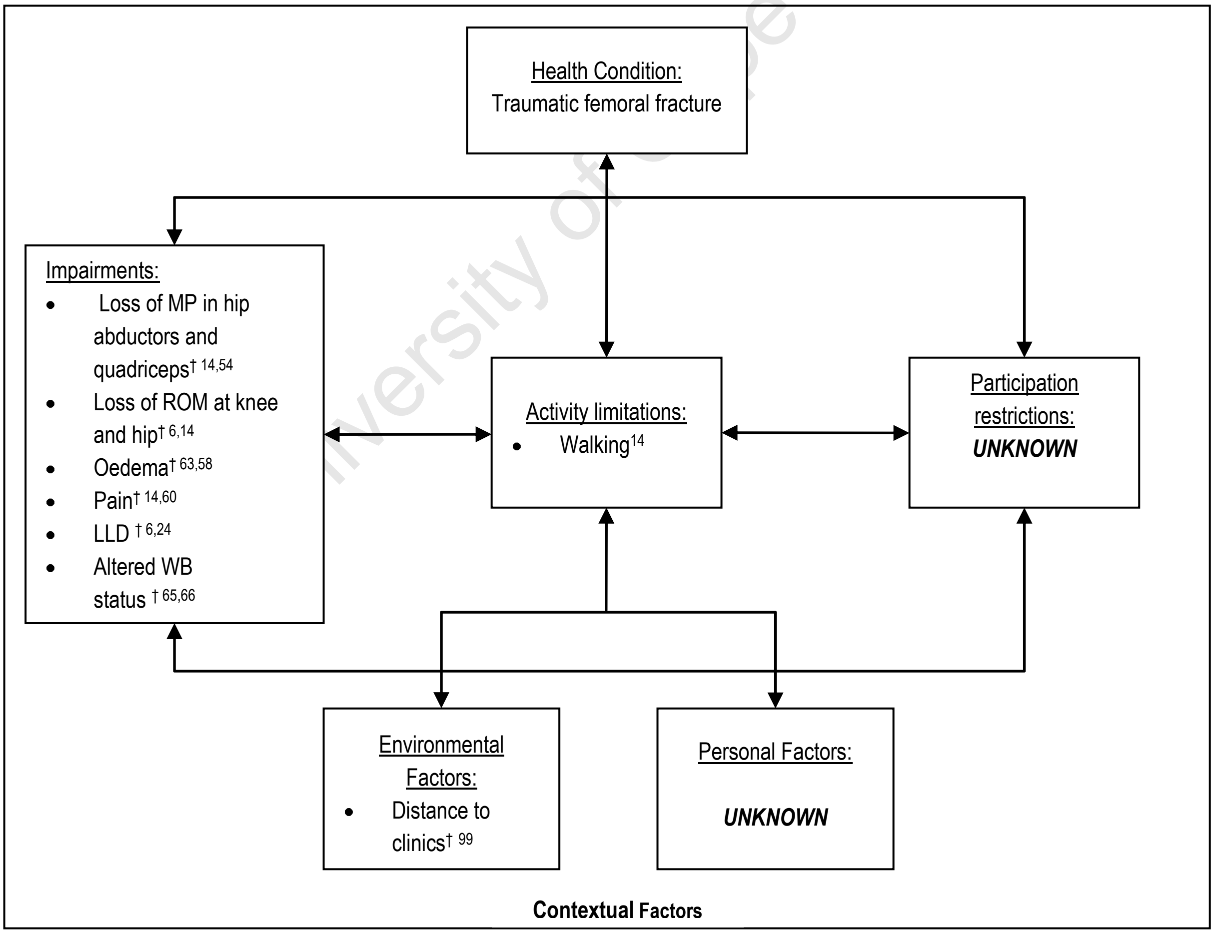

Figure 5-1: Modified ICF model for patients with femoral fractures in South Africa
Note: The symbol "†" indicates the findings of the current study.

The impairments following femoral fractures have been extensively described[6, 14, 48, 54, 58]. These impairments have also been identified in the current study sample. In contrast, literature has provided limited evidence of the activity limitations[14, 52] and participation restrictions associated with traumatic femoral fractures. These concepts are clinically relevant for holistic care of the patient.

The findings of the current studies highlighted that local medical professionals are using a predominantly biomedical model of care in the management of patients with femoral fractures. However, a shift in the health care paradigm towards a patient-centred approach within the ICF framework is essential for holistic patient management[9]. This holistic management plan allows the patient to be treated beyond the level of the impairment[30]. This kind of management is essential to enhance the quality of care, as it is allows fracture management to be more applicable to the individual's social context[29]. This will ensure that interventions are relevant for the each individual, which may also facilitate improved adherence with fracture management. The absence of a patient-centred approach within the ICF framework is concerning, and may lead to sub-optimal care following traumatic femoral fractures. A holistic approach grounded within the ICF framework is needed to minimise the disability associated with the impairments, activity limitations and participation restrictions following traumatic femoral shaft fractures. This holistic approach will ensure contextually relevant health care that will address diverse health and rehabilitation needs of South African patients.

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Appendices

Appendix A 1: Ethics approval letters for clinical case series.

UNIVERSITY OF CAPE TOWN

Health Sciences Faculty
Faculty of Health Sciences Research Ethics Committee
Room E52-24 Groote Schuur Hospital Old Main Building
Observatory 7925
Telephone [021] 406 6338 • **Facsimile** [021] 406 6411
e-mail: sumayah.ariefdien@uct.ac.za

15 October 2010

HREC REF: 357/2010

Miss R Siebritz
c/o Ms R Parker
School of Health & Rehabilitation Sciences
Division of communications Sciences and Disorders
F 45 OMB

Dear Mss Siebritz

PROJECT TITLE: PREDICTORS OF HEALTH RELATED QUALITY OF LIFE IN PATIENTS WITH FEMORAL SHAFT FRACTURES

Thank you for your response to our letter dated 27 September 2010.

It is a pleasure to inform you that the Ethics Committee has **formally approved** the above-mentioned study.

Approval is granted for one year till the 30 October 2011.

Please submit a progress form, using the standardised Annual Report Form (FHS016), if the study continues beyond the approval period. Please submit a Standard Closure form (FHS010)if the study is completed within the approval period.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please quote the REC. REF in all your correspondence.

Yours sincerely

PROFESSOR M BLOCKMAN
CHAIRPERSON, HSF HUMAN ETHICS

Federal Wide Assurance Number: FWA00001637.

sAriefdien

Institutional Review Board (IRB) number: IRB00001938

This serves to confirm that the University of Cape Town Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical Research Council (MRC-SA), Food and Drug Administration (FDA-USA), International Convention on Harmonisation Good Clinical Practice (ICH GCP) and Declaration of Helsinki guidelines.

The Research Ethics Committee granting this approval is in compliance with the ICH Harmonised Tripartite Guidelines E6: Note for Guidance on Good Clinical Practice (CPMP/ICH/135/95) and FDA Code Federal Regulation Part 50, 56 and 312.

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Appendix A 2: Description of hip and knee ROM measurements.

Hip Flexion: The participant was positioned in supine with a single standard pillow under the head. The pelvis was checked to ensure a neutral position. A marker was used to identify the greater trochanter. The stationary arm of the goniometer was aligned with the trunk and the moving arm was aligned with the lateral malleolus (Figure A 1). The patient was instructed to bend the leg upwards towards his chest as far as he was able to move. The patient was allowed to bend the knee to limit the stretch of the hamstrings during the movement. When the patient stopped moving, this measurement was recorded as the active ROM. The researcher then assisted the participant to flex the hip further until the participant requested to stop the movement. This measurement was recorded as the active assisted ROM. Finally, the researcher flexed the hip as far as possible passively until the participant requested the movement to be stopped. This was noted to be the passive ROM. Each measurement was recorded three times.

Figure A 1: Measurement of hip flexion for clinical case series.

Hip abduction: The participant remained in the supine position with the pelvis and the legs in neutral and a single pillow under his head. The anterior superior iliac spine (ASIS) was marked as the reference point (Figure A 2). The stationery arm of the goniometer was aligned with the trunk and the mobile arm was aligned with the middle toe. The patient was instructed to move his leg outwards (sideways) as far as possible keeping the knee straight and the toes pointing upwards towards the ceiling. This was recorded as the active ROM. The researcher then assisted the participant to move the leg further outwards. This was recorded as the active assisted ROM. Finally, the researcher moved the leg as far as possible outwards to the side until the participant requested the movement to be stopped or a resistance to movement was felt. This was recorded as the passive ROM.

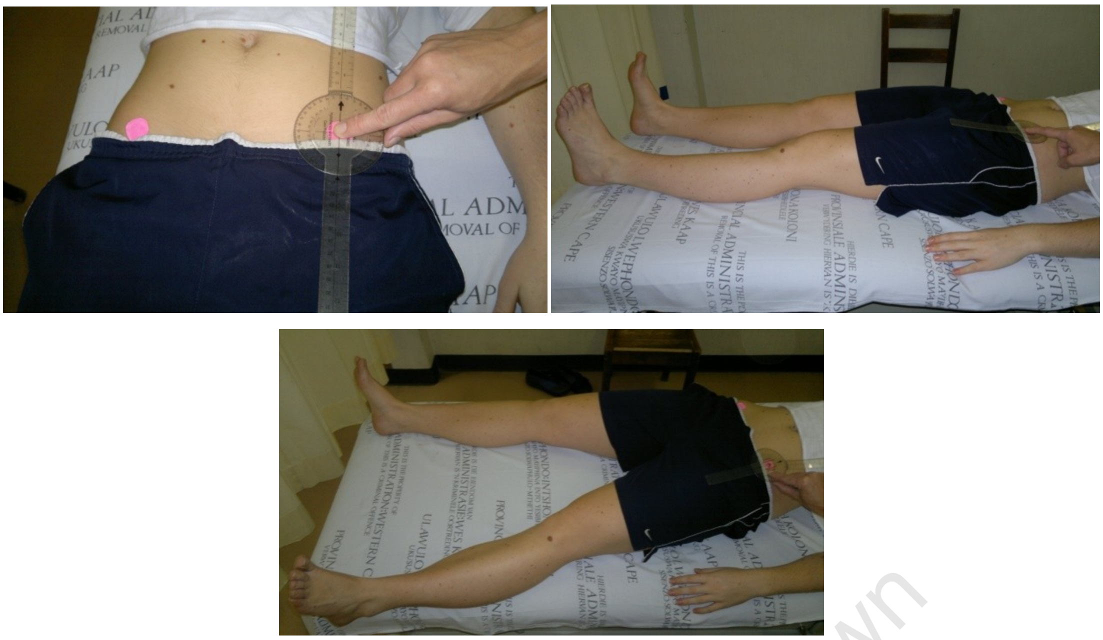

Figure A 2: Measurement of hip abduction for clinical case series.

<u>Knee flexion:</u> The participant remained supine as before. The lateral condyle of the femur was marked as the reference point (Figure A 3). The stationary arm of the goniometer was kept aligned with the greater trochanter and the mobile arm was aligned with the lateral malleolus. The patient was instructed to bend the knee up towards the chest as far as possible whilst keeping the foot supported on the bed. Once the patient was unable to move further, this was recorded as the active ROM. The researcher then assisted the participant to move further. This was recorded as the active assisted ROM. Once the participant could bend no further, the researcher moved the knee further passively until the participant requested the movement to be stopped or resistance to the movement was felt. This was recorded as the passive ROM.

Figure A 3: Measurement of knee flexion for clinical case series.

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Knee extension: This was measured with the patient sitting upright over the edge of the bed with both knees flexed and the thighs fully supported. The bed was elevated so that the feet were not touching the floor. Knee extension was measured in terms of a quadriceps lag i.e. the difference between the active and passive ROM of knee extension. The lateral femoral condyle was marked as the reference point (Figure A 4). The stationary goniometer arm was aligned with the greater trochanter and the mobile arm with the lateral malleolus. The participant was asked to straighten his knee as far as possible bringing his toes up towards the ceiling without lifting the thigh off the bed. The active ROM was measured when the participant stopped moving. The researcher then assisted the participant with the movement as necessary until the participant requested that the movement be stopped. This was recorded as the active assisted ROM. The researcher then continued moving the knee passively until resistance to movement stopped further progress or when the participant requested to stop. This was recorded as the passive ROM.

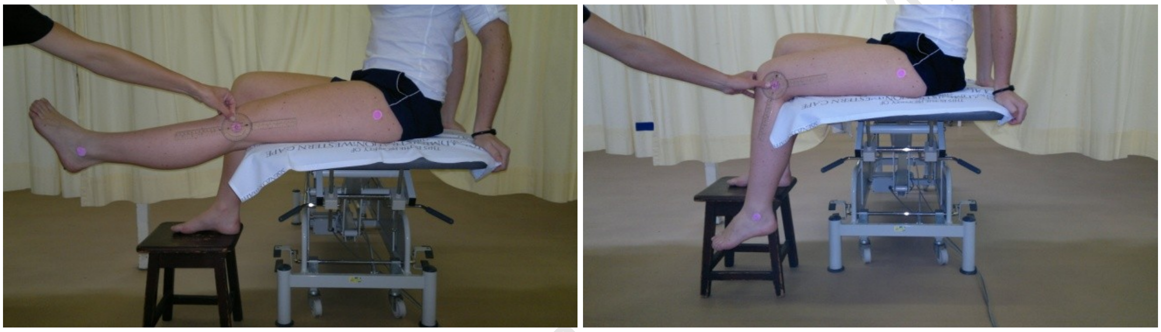

Figure A 4: Measurement of knee extension for the clinical case series.

Ankle Dorsiflexion: The participant was positioned in supine with a single pillow under their head. The ankle was held in a plantargrade position. The lateral malleolus was used as the reference point (Figure A 5). The stationary arm of the goniometer was aligned with the greater trochanter and the mobile arm with the lateral border of the fifth metatarsal. The participant was instructed to pull the ankle upwards towards the head as far as possible. When the participant stopped, this was recorded as the active ROM. The researcher then assisted the participant to move further until she/he requested the movement be stopped. This was recorded as the active assisted ROM. The researcher then moved the ankle passively until resistance to movement limited further range or until the participant requested the movement to be stopped. This was recorded as the passive ROM.

Figure A 5: Measurement of ankle dorsiflexion for the clinical case series.

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Appendix A 3: The Medical Research Council Scale for muscle power[161].

Grade	Response
0	No movement
1	Flicker of contraction
2	Active movement with gravity eliminated
3	Active movement against gravity
4	Active movement against resistance but not full strength
5	Normal power

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Appendix A 4: Description of MP measurements for the clinical case series.

Hip Flexors: The participant was positioned in supine with a single pillow under his head. The leg was positioned in the middle range of participants' available hip flexion ROM. The participant was instructed to push as hard as possible against the dynamometer on the command of the researcher. The dynamometer was positioned on the distal part of the thigh just above the knee joint.

Hip abductors: The participant remained positioned in supine as above. The participant's leg was placed in the mid-range of the available abduction ROM. The dynamometer was place laterally on the leg above the lateral malleolus. On command, the participant was asked to push the leg as hard as possible sideways against the dynamometer.

Knee extensors: The participant was positioned in upright sitting over the edge of the bed with both thighs fully supported on the bed. The bed was raised so that the feet were not in contact with the floor. The dynamometer was positioned anteriorly on the distal part of the leg just above the level of the malleoli. The participant's leg was positioned in mid-range of the available knee extension. The researcher instructed the participant to push as hard as possible against the dynamometer as if to try to straighten the knee. The instruction included caution to keep the thigh on the bed during the exercise.

Knee flexors: The participant remained seated over the edge of bed as described above. The dynamometer was now positioned posteriorly on the distal part of the leg just above the level of the malleoli. The tested leg was placed in the mid-range of the available knee flexion ROM. The participant was instructed push against the dynamometer as hard as possible by bending the knee. The instruction included caution to keep the trunk in a neutral, upright position.

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Appendix A 5: Record of physiotherapy interventions for the clinical case series.

Inpatient record:

QUALIFICATION OF PHYSIOTHERAPIST	
YEARS OF EXPERIENCE OF PHYSIOTHERAPIST	
NUMBER OF PHYSIOTHERAPY INTERVENTIONS	
REFERRAL LETTER ISSUED YES / NO	
HOME PROGRAMME ISSUED YES / NO	

Outpatient record:

QUALIFICATION OF PHYSIOTHERAPIST	
YEARS OF EXPERIENCE OF PHYSIOTHERAPIST	
NUMBER OF PHYSIOTHERAPY INTERVENTIONS	
COMMUNITY / PRIVATE PRACTICE	
HOME PROGRAMME ISSUED YES / NO	

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Appendix A 6: Informed consent sheet and study outline for clinical case series.

Dear Participant

Thank you for volunteering your time. Kindly read the attached information sheet before signing this form.

This research will assist physiotherapists in understanding which factors affect health related quality of life in individuals who have sustained femur fractures. All your personal information recorded will remain anonymous and confidential.

Participation in this research study is completely voluntarily. You have the right to withdraw from the study at any stage. In the event that you should choose to withdraw your participation, no penalties will be incurred.

If you choose to participate in the study, this will have no added benefit on your physiotherapy treatment. Your treatment will remain unchanged whether or not you participate in the study. In the event that you may withdraw from the study, your treatment will remain unaffected.

All the information that you will provide will be treated confidentially. Your identity will not be printed in any of the data publications.

Your physiotherapist will inform you about the times allocated for your normal physiotherapy treatment sessions. She will also inform you regarding the time when the research session will be scheduled. These two sessions will be scheduled at different times during the day.

You are encouraged to contact the Investigator, Ruth Siebritz, or the research supervisor, Romy Parker (021-4066571), should you require any additional information regarding the research or your rights as a participant.

My contact details are as follows:

Physiotherapy Department
E54 Old Main Building
Groote Schuur Hospital
Observatory
Tel: 021 404 4410 or 021 404 4412

University of Cape Town

OUTLINE OF STUDY: INFORMATION SHEET

STUDY REGARDING HEALTH- RELATED QUALITY OF LIFE IN INDIVIDUALS WITH FEMUR FRACTURES

AIM OF THE STUDY

I am a postgraduate physiotherapy student from the University of Cape Town. I am investigating which factors affect your quality of life following the injury to your leg. I want to answer questions such as: To what extent are people who have sustained broken thigh bones affected by the injury? What are the possible reasons contributing to this? Do the effects of the injury affect your quality of life? I would like to interview people like you who have broken thigh bones, to answer these questions. I am specifically interested in investigating these types of injuries. This research will assist physiotherapists in understanding which factors affect health related quality of life in individuals who have sustained femur fractures. This study has been given Ethical Approval by the UCT Faculty of Health Sciences Human Research Ethics Committee (HREC REF: 357/2010)

WHAT YOU WILL BE ASKED TO DO

Consent Form

After your operation, you will be approached by the researcher to discuss the study. You will be required to complete a consent form if you choose to partake in the study. You will be asked to provide your basic personal information. All this information will be kept strictly anonymous and confidential. It will not be kept in your hospital folder where other health professionals may have access to it. Only myself as the researcher and my supervisor will be able to see the information.

Questionnaires

On the day that you are discharged from hospital, you will be asked to complete four (4) questionnaires which will ask you how you are coping with your injury in day to day activities. Each questionnaire is different and requires that you tick the most appropriate answer according to how you are feeling, how much pain you are having and how you are managing with your injury.

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You will also be asked to perform the movements and muscle tests of the legs described below.

Range of motion tests

These tests will check how much you are able to move your hip and knee joints. A small plastic instrument called a goniometer will be used to measure the range of movement.

Hip flexion: This will check how high you are able to bend your hip upwards. You will lie on your back in the bed and bend your hip up by sliding your foot along the bed. The goniometer will be held on the outside of your thigh to check how high you can bend.

Hip abduction: This will check how far you are able to move your leg sideways. You will lie on your back in the bed and be asked to move your whole leg sideways away from the body. The goniometer will be held on the top of the thigh to measure how far you can move the leg sideways.

Knee extension: This will measure how much you can straighten the knee. Sitting upright over the edge of the bed with your hips and knees bent, you will be asked to straighten the knee as much as you can. The goniometer will be held on the side of your knee to measure how much you are able to move.

Knee flexion: This will check how much you are able to bend your knee. You will have to lay in bed on your back/on your side and bend the knee as far as you can. The goniometer will be held against the outside of your knee to measure the movement.

Ankle Dorsiflexion: This will measure how much ankle movement you have. You can lie on your back in the bed and pull your foot upwards towards your head. The goniometer will be held against your ankle bone on the outside of the foot to measure how much movement you have.

Each of the above tests will be measured three (3) times on both the left and right legs.

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Muscle power

This test will determine how strong the muscles are in your injured leg. Four muscles will be tested namely the hip flexors (which bend your hip), the hip abductors (which moves your leg sideways), your knee extensors (which straighten your knee) and your knee flexors (which bend your knee). Where possible, these tests will be done at the same time as the range of motion tests to minimise your discomfort.

To test the hip flexors: You will have to lie on your back in the bed and bend your hip up by sliding your foot up along the bed. You will be asked to use the muscle to hold the leg in this position. A small electronic device called a dynamometer will be held against the leg being tested. This device will measure how strong the muscle is.

To test the hip abductors: You will again lie on your back in the bed. The dynamometer device will be held against the outside of your leg above the ankle. You will be asked to move your leg sideways away from your body and hold it in that position.

To measure the knee extensors: You will sit upright over the edge of the bed with your hips and knees bent. The dynamometer device will be held against your leg above your ankle. You will be asked to straighten your knee and hold the position.

To measure the knee flexors: You will sit upright over the edge of the bed with your hips and knees bent. The dynamometer device will be held at the back of your leg above the ankle joint. You will be asked to bend the knee and hold the position.

Each test will be repeated 3 times on the right and left legs. The repetition may cause fatigue in your leg and cause you to experience some pain and/or discomfort. Time to recover between each repetition will be allowed so that this discomfort may be avoided.

Leg length discrepancy measurements

This test will measure if your legs are the same length. You will be asked to lie on your back with the legs straight next to each other. A tape measure will be used to measure the legs from the top of the hip bone to the inside of your ankle. Three (3) measurements will be taken on the left and on the right leg.

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Swelling measurements

This test checks how much swelling is present in your thigh and calf area of your leg. A tape measure will be used to measure the distance around your upper and lower thigh and the distance around your upper and lower calf areas. The distance between these points will also be measured using the tape measure. This will be measured while you are lying on your back in the bed.

Timed Up and Go Test

This test will determine the time taken for you to stand up from sitting on a chair using your crutches, and then walking to a line 3 metres in front of the chair, turning around and then returning to the seated position. You will be allowed an opportunity to practice this task before it is timed.

You will be required to return for follow up assessments with the researcher at the Outpatient Physiotherapy department at E54 Old Main Building at 2 weeks, 4 weeks, 6 weeks and 12 weeks after your discharge from the hospital. The follow up assessments will be made to coincide with your doctor's check-up so that you are not inconvenienced. At each assessment session, the procedure of answering questionnaires and performing movement and muscle tests described above will be repeated.

Each assessment session will be approximately 1 hour. This is a long time but it is important that all the information is gathered to determine the extent of the problems that you face because of your injury.

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THE RISKS INVOLVED

There is no risk to your health or medical care if you partake in the study. If you refuse to partake in the study, or choose to withdraw at a later stage, you will not be penalised for this in any way. All the measurements will be taken by the researcher who is a qualified physiotherapist working in the orthopaedic department of Groote Schuur Hospital.

There are no risks associated with the completion of the questionnaires. However, should you become distressed whilst completing the questionnaires, you will be referred to a psychologist or a social worker.

Range of movement tests to check how much your hip and knee can move, will be carefully performed to avoid pain and discomfort. You will be allowed to rest during the testing procedure. The muscle power tests will require that you apply your best effort during testing. Occasionally this muscle power may be tested against a resistance. This may cause you to feel muscle soreness and tiredness and may be painful. The resistance applied will only be as much as you can tolerate.

There are no risks involved when the length and swelling of your legs are measured.

There is a risk of losing your balance and falling when performing the "Timed up and Go" test, particularly when you use your crutches. To avoid this, you will first be taught how to stand up and walk using the crutches and then be allowed to practice the test. The physiotherapist will hold onto you by using a safety belt. You will only be asked to walk 3 metres forward and then turn around and come back to sit on the chair. During the actual test, the physiotherapist will be close by you in case you lose your balance.

THE BENEFITS INVOLVED

Your participation will assist us as medical professionals to understand the consequence of your injury. During the study, should you have any post-surgery complications, you will be immediately referred to the Orthopaedic Doctor. Also, should you be experiencing any major problems with your daily activities after discharge from the hospital, you may be referred to a social worker who can assist you.

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Questions or Concerns:

If there are any questions or concerns regarding the study, please feel free to use the contact numbers provided below. All enquiries will be kept confidential.

Ruth Siebritz	Tel: 021-404 4410/2
	E-mail: ruth.siebritz@pgwc.gov.za
Romy Parker	Tel: 021-406 6571
	E-mail:romy.parker@uct.ac.za
Theresa Burgess	Tel: 021-406 6171
	E-mail:theresa.burgess@uct.ac.za
Professor Marc Blockman	Tel: 021- 406 6492
	Chairperson
	Health Science Faculty
	Human Research Ethics Committee
	E-mail: marc.blockman@uct.ac.za

University of Cape Town

Please note that UCT does offer a no-fault insurance that will cover all participants in the event that something may go wrong. This insurance will provide prompt payment of compensation for any trial-related injury according to the Association of the British Pharmaceutical Industry (ABPI) guidelines (1991). These guidelines recommend that UCT, without any legal commitment, should compensate you without you having to prove that UCT is at fault. An injury is considered trial-related if, and to the extent that, it is caused by study activities. You must notify the study investigators immediately of any injuries during the trial, whether they are research-related or other related complications. UCT reserves the right not to provide compensation if, and to the extent that, your injury came about because you chose not to follow the instructions that you were given while taking part in the study. Your right in law to claim compensation for injury where you prove negligence is not affected.

I, ________________________________ (name and surname) acknowledge that I have read and understand the above information and I am willing to participate in the study. I have had an opportunity to ask questions, and all my concerns have been addressed. I understand that I can withdraw from the study at any time without prejudice. Furthermore, I agree to attend the follow up contact assessments to complete the relevant questionnaires and to take part in the study.

Participant____________________ Date____________

Witness ___________________ Date____________

University of Cape Town

Appendix A 7: Demographic questionnaire for clinical case series.

For contact purposes

NAME AND SURNAME	
ADDRESS	
TELEPHONE NUMBER	
LANGUAGE PREFERENCE	

University of Cape Town

For research purposes

DATE OF BIRTH (AGE)					
AREA OF RESIDENCE					
HABITUAL MODE OF TRANSPORT	WALK	BUS	TAXI	TRAIN	CAR
OCCUPATION		SEDENTARY	MANUAL	MIXED	
	STANDING				
	WALKING				

Appendix A 8: Medical folder details for the clinical case series.

<table>
<tr><td>MALE / FEMALE</td><td colspan="2"></td></tr>
<tr><td>DATE OF INJURY</td><td colspan="2"></td></tr>
<tr><td>MECHANISM OF INJURY</td><td colspan="2"></td></tr>
<tr><td>DATE OF ADMISSION</td><td colspan="2"></td></tr>
<tr><td>TYPE AND LOCATION OF FRACTURE
(L / R LEG)</td><td colspan="2"></td></tr>
<tr><td>DATE OF SURGERY</td><td colspan="2"></td></tr>
<tr><td rowspan="2">DURATION OF SURGERY AND ANAESTHETIC</td><td>TIME: SURGERY</td><td>TIME: ANAESTHETIC</td></tr>
<tr><td></td><td></td></tr>
<tr><td>TYPE OF SURGICAL APPROACH</td><td colspan="2"></td></tr>
<tr><td>SURGEON’S CODE AND QUALIFICATION</td><td colspan="2"></td></tr>
<tr><td>DATE OF DISCHARGE FROM HOSPITAL</td><td colspan="2"></td></tr>
</table>

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Appendix A 9: Questionnaires used to assess pain, activity limitations, SE and HRQoL.

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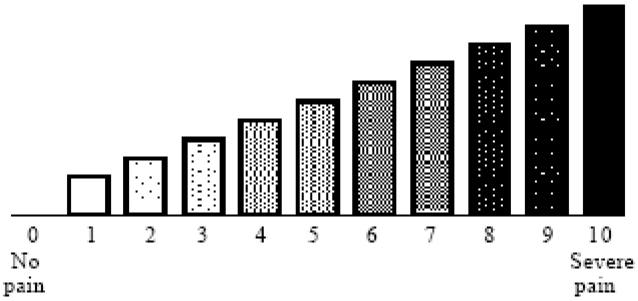
Pain Visual Numeric

We are interested in learning whether or not you are affected by PAIN. Please circle the number below that describes your pain in the past 2 weeks:



Scoring

The score is the number circled or histogram marked. Scores range from 0 to 10, with the higher score indicating more pain. If two consecutive numbers are circled, score the higher (more pain) number, if two non-consecutive numbers are circled, do not score.

Characteristics

Tested on 122 subjects.

No. of Items	Observed Range	Mean	Standard Deviation	Internal Consistency Reliability	Test-Retest Reliability
1	0-10	4.36	3.03	—	NA

Source of Psychometric Data

English language participants in the Stanford/El Paso Border Diabetes Project. Unpublished.

Comments

This scale is a modified version of the visual analog scale. We found that this scale is easier for subjects to use, resulting in less missing and unclear responses. The scale above is that used for our Internet studies, with color and shading used. We have used these anchor phrases and a variation,

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Social/Role Activities Limitations

During the **past 4 weeks**, how much... *(Circle one)*

	Not at all	Slightly	Moderately	Quite a bit	Almost totally
1. Has your health interfered with your normal social activities with family, friends, neighbors or groups?	0	1	2	3	4
2. Has your health interfered with your hobbies or recreational activities?	0	1	2	3	4
3. Has your health interfered with your household chores?	0	1	2	3	4
4. Has your health interfered with your errands and shopping?	0	1	2	3	4

Scoring

The score of each item is the number circled. If two consecutive numbers are circle for a single item, score the higher number (more limitation). If two non-consecutive numbers are circled, do not score the item. The score of the scale is the mean of the four items. If more than one item is missing, do not score the scale. The higher score indicates greater activities limitations.

Source of Psychometric Data

Stanford Chronic Disease Self-Management Study. Psychometrics reported in: Lorig K, Stewart A, Ritter P, González V, Laurent D, & Lynch J, *Outcome Measures for Health Education and other Health Care Interventions*. Thousand Oaks CA: Sage Publications, 1996, pp.25,52-53.

Characteristics

Tested on 1,130 subjects with chronic disease. N=51 for test-retest.

No. of Items	Observed Range	Mean	Standard Deviation	Internal Consistency Reliability	Test-Retest Reliability
4	0-4	1.70	1.11	.91	.68

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Stanford HAQ 8-Item Disability Scale

Please check (✓) the **one** best answer for your abilities.

At this moment, are you able to:	Without ANY difficulty	With SOME difficulty	With MUCH difficulty	UNABLE to do
1. Dress yourself, including tying shoelaces and doing buttons?	❑	❑	❑	❑
2. Get in and out of bed?	❑	❑	❑	❑
3. Lift a full cup or glass to your mouth?	❑	❑	❑	❑
4. Walk outdoors on flat ground?	❑	❑	❑	❑
5. Wash and dry your entire body?	❑	❑	❑	❑
6. Bend down to pick up clothing from the floor?	❑	❑	❑	❑
7. Turn faucets on and off?	❑	❑	❑	❑
8. Get in and out of a car?	❑	❑	❑	❑

Scoring

Score the number circled for each item. If more than one consecutive number is circled for one item, code the higher number (more difficulty). If responses are not consecutive, code as blank. The disability index is the mean of the eight items. If more than 2 items are blank, do not score the index.

Characteristics

Tested on 611 subjects with chronic disease.

No. of Items	Observed Range	Mean	Standard Deviation	Internal Consistency Reliability	Test-Retest Reliability
1	0-1.88	0.384	0.409	.85	NA

EQ - 5D

Health Questionnaire

South African English version

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By placing a tick in one box in each group below, please indicate which statements best describe your own state of health TODAY.

Mobility

I have no problems in walking about ❑

I have some problems in walking about ❑

I am confined to bed ❑

Self-Care

I have no problems with self-care ❑

I have some problems washing or dressing myself ❑

I am unable to wash or dress myself ❑

Usual Activities (e.g. work, study, housework, family or leisure activities)

I have no problems with performing my usual activities ❑

I have some problems with performing my usual activities ❑

I am unable to perform my usual activities ❑

Pain/Discomfort

I have no pain or discomfort ❑

I have moderate pain or discomfort ❑

I have extreme pain or discomfort ❑

Anxiety/Depression

I am not anxious or depressed ❑

I am moderately anxious or depressed ❑

I am extremely anxious or depressed ❑

Compared with my general level of health over the past 12 months, my state of health today is:

Better ❑ please tick

Much the same ❑ ONE

Worse ❑ BOX

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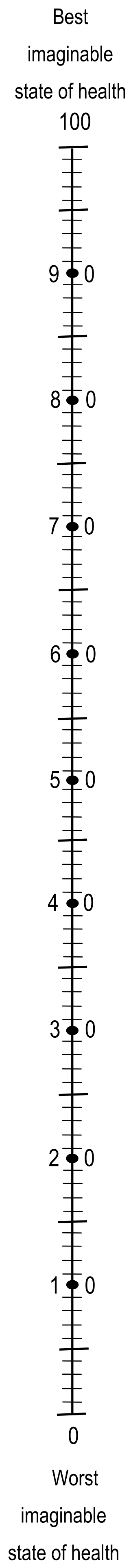
To help people say how good or bad their state of health is, we have drawn a scale on which the best state you can imagine is marked 100 and the worst state you can imagine is marked 0.

We would like you to indicate on this scale, in your opinion, how good or bad your own health is today. Please do this by drawing a line from the box below to whichever point on the scale indicates how good or bad your state of health is today.



Your own state of health today

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Because all replies are anonymous, it will help us to understand your answers better if we have a little background data from everyone, as covered in the following questions.

		Yes	No	
1.	Have you experienced serious illness?			please tick appropriate boxes
	yourself	❑	❑	
	in your family	❑	❑	
	while caring for others	❑	❑	

2. What is your age in years? ___________

		Male	Female	
3.	Are you male or female?	❑	❑	please tick appropriate box

4.	I smoke	❑	please tick appropriate box
	I used to smoke	❑	
	I have never smoked	❑	

		Yes	No	
5.	Do you now, or did you ever, work in health services or social welfare?	❑	❑	please tick appropriate box

If so, in what capacity? ....

6. Which of the following best describes your main activity? (please tick appropriate box)

- self employed ❑
- in formal employment ❑
- retired ❑
- homemaker/domestic worker ❑
- student ❑
- seeking work ❑
- other (please specify) ❑ ....

7. What was the highest grade that you attained at school?______________

		Yes	No
8.	Do you have a diploma or equivalent?	❑	❑

9. If you know the area/suburb in which you stay, please write it here................................

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Appendix A 10: Data collection sheets for clinical case series.

FUNCTIONAL OUTCOMES AT HOSPITAL DISCHARGE

Muscle power DATE: _____________

MUSCLE	LEFT LEG	RIGHT LEG
HIP FLEXORS		
HIP ABDUCTORS		
QUADRICEPS		
HAMSTRINGS		

Weight bearing status

FWB ☐ PWB ☐ TWB ☐ NWB ☐

TIMED UP AND GO TEST (TUG)

TYPE OF MOBILITY ASSISTIVE DEVICE USED: ______________________________________

TIME IN SECONDS TO PERFORM TEST: ____

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Range of motion measurements DATE: _____________

JOINT & MOVEMENT	SIDE	AROM	AAROM	PROM
HIP FLEXION	LEFT			
	RIGHT			
HIP ABDUCTION	LEFT			
	RIGHT			
KNEE FLEXION	LEFT			

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	RIGHT			
KNEE EXTENSION	LEFT			
	RIGHT			
ANKLE DORSIFLEXION	LEFT			
	RIGHT			

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Oedema measurements DATE: _____________

THIGH AND CALF VOLUME MEASUREMENTS:

LEFT LEG:

REFERENCE POINT	READING 1 in cm	READING 2 in cm	READING 3 in cm	AVERAGE
A: circumference 2cm below greater trochanter				
a: Circumference 1 cm suprapatellar				
Distance in cm between *A* and *a*				
B :Circumference around Tibial tuberosity				
b: Circumference 2cm proximal to lateral malleolus				
Distance in cm between *B* and *b*				

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RIGHT LEG:

REFERENCE POINT	READING 1 in cm	READING 2 in cm	READING 3 in cm	AVERAGE
***A*:** circumference 2cm below greater trochanter				
a: Circumference 1 cm suprapatellar				
Distance in cm between ***A*** and ***a***				
B :Circumference around Tibial tuberosity				
b: Circumference 2cm proximal to lateral malleolus				
Distance in cm between ***B*** and ***b***				

Leg length measurements DATE: ______________

ASIS to medial malleolus (in cm)

	READING 1	READING 2	READING 3	AVERAGE
LEFT LEG				
RIGHT LEG				

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Appendix A 11: GSH rehabilitation protocol for patients following femoral shaft fractures.

Day one post-surgery

- Education of patient re: injury, surgery, precautions and rehabilitation process
- Debulk dressings from affected limb by removing compression bandages
- Begin bed exercises according to exercise programme (see below) within limits of pain and comfort
- Teach patient bed mobility and transfers in and out of bed
- Teach sit to stand with frame
- Mobilise patient walking with Zimmer frame within limits of pain and discomfort
- Patient is made comfortable in a chair after treatment.
- Patient is allowed to walk in the ward with a Zimmer frame with supervision
- Bed exercise program is issued for patient to continue with exercises 3x daily

Day two post-surgery

- Continue with bed exercises; Increase ROM of hip and knee and number of repetitions per exercise
- Encourage strengthening of hip flexors and abductors and quadriceps muscles
- Gait education with crutches; increase distance of walking
- Encourage independent walking in ward
- Teach patient how to perform his own ADL's (washing, dressing, toileting)
- Ensure patient is independent in all bed mobility and transfers in and out of bed
- Patient continues with bed exercise programme 3x per day

Day three post-surgery

- Continue with bed exercises to increase active ROM and MP (aim for minimum of grade 3 MP of injured limb and 90º active flexion of the hip and knee and FROM active knee extension and hip abduction)
- Teach stair climbing with crutches
- Issue home exercise prescription programme, mobility assistive devices and physiotherapy referral letter to community health centre
- Ensure patient understands precautions and contra-indications of surgery
- Ensure patient is aware of follow up appointments and the need to attend these appointments
- Advice given to patient to manage oedema and improve MP and ROM with continuous outpatient physiotherapy and continuation of home exercise programme.
- Patient is discharged from hospital.

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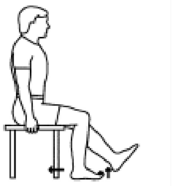
Toe up

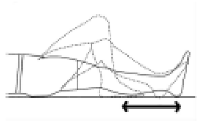


- Sit in chair.
- Slide foot back a few inches, keeping heel on floor.
- Next, lift toes and lower toes.
- Slide foot back a few more inches and lift toes again.
- Continue this sequence until you can no longer keep heel on floor.

Perform 3 sets of 30 Repetitions, three times a day.

Rest 1 Minute between sets.
Perform 1 repetition every 3 Seconds.

Heel slides

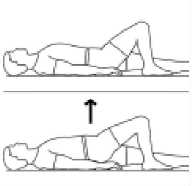


- Lie on back with legs straight.
- Slide heel up to buttocks.
- Return to start position.
- Repeat with other leg.

Perform 3 sets of 20 Repetitions, three times a day.

Rest 1 Minute between sets.
Perform 1 repetition every 3 Seconds.

Single leg bridge



- Lie on back with one knee bent.
- Lift buttocks off floor.
- Return to start position.

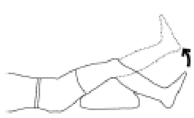
<u>Special Instructions:</u>

Maintain neutral spine.
Perform three sets with each leg.

Perform 3 sets of 20 Repetitions, three times a day.

Rest 1 Minute between sets.
Perform 1 repetition every 3 Seconds.

Short arc

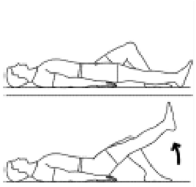


- Lie on back, with involved leg bent to 45 degrees, supported with a pillow, as shown.
- Straighten leg at knee.
- Return to start position.

Perform 3 sets of 20 Repetitions, three times a day.

Rest 1 Minute between sets.
Perform 1 repetition every 3 Seconds.

Straight leg raise

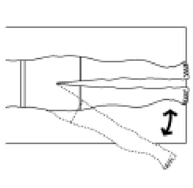


- Lie on back with uninvolved knee bent as shown.
- Raise straight leg to thigh level of bent leg.
- Return to starting position.

Perform 3 sets of 20 Repetitions, three times a day.

Rest 1 Minute between sets.
Perform 1 repetition every 3 Seconds.

Supine side leg



- Lie on back on firm surface, legs together.
- Move leg out to side, keeping knee straight.
- Return to start position.

<u>Special Instructions:</u>

Use a pillow case to reduce friction.

Perform 3 sets of 20 Repetitions, three times a day.

Rest 1 Minute between sets.
Perform 1 repetition every 3 Seconds.

Issued By: physiotherapist

Signature: ________________________

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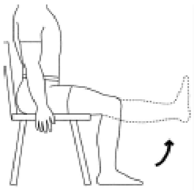
Long arc

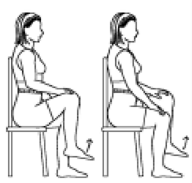


- Sit, with involved leg bent to 90 degrees, as shown.
- Straighten leg at knee.
- Return to start position.

Perform 3 sets of 20 Repetitions, three times a day.

Rest 1 Minute between sets.
Perform 1 repetition every 3 Seconds.

Seated marching

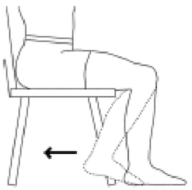


- Sit in chair with hips and knees at 90 degrees.
- Lift up left leg as shown.
- Lower leg.
- Repeat with right leg.

Perform 3 sets of 20 Repetitions, three times a day.

Rest 1 Minute between sets.
Perform 1 repetition every 3 Seconds.

Sitting ham curl

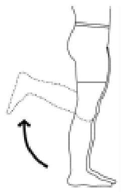


- Sit in chair, moving heel of involved leg under chair, through full range, as shown.
- Return to starting position.

Perform 3 sets of 20 Repetitions, three times a day.

Rest 1 Minute between sets.
Perform 1 repetition every 3 Seconds.

Standing one leg knee bend



- Stand, bend involved leg toward hip through full range.
- Return to starting position.
- Do not bend leg at hips.

Perform 3 sets of 20 Repetitions, three times a day.

Rest 1 Minute between sets.
Perform 1 repetition every 3 Seconds.

Issued By: physiotherapist **Signature:** ______________________

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Appendix A 12: Table of all variable outcomes for Participant One.

Week	0	2	4	6	12
Questionnaires					
PVN (scores 0 -10)	8	4	2	2	0
Activity limitations (scores 0 - 4)	0.75	0.5	0.25	0	0
HAQ 8 (scores 0 - 3)	0.125	0.25	0	0	0
EQ-5D index (scores -0.594 -1)	0.725	0.796	1	1	1
EQ-5D State of health	Worse	Better	Better	Better	Better
EQ VAS State of health (scores 0 - 100)	60	80	90	90	97
Muscle Power					
Hip flexors injured limb	45.7	92.8	114.7	114.9	112.3
Hip abductors injured limb	32.9	60.8	54.5	73.5	87.9
Quadriceps injured limb	35.9	48.4	55.5	96.0	132.9
Hamstrings injured limb	89.5	85.9	88.2	117.3	201.2
Hip flexors uninjured limb	91.5	130.9	155.2	187.8	156.1
Hip abductors uninjured limb	67.9	83.9	79.7	96.7	114.7
Quadriceps uninjured limb	83.9	136.5	112.0	122.2	166.3
Hamstrings uninjured limb	227.0	143.1	88.5	94.4	254.5
Percentage difference in hip flexors	50.0	29.2	26.1	38.8	28.0
Percentage difference in hip abductors	51.4	27.6	30.3	23.9	23.4
Percentage difference in quadriceps	57.2	64.6	50.4	21.4	20.0
Percentage difference in hamstrings	60.6	39.9	0.4	-24.2	20.9
TUG test time (seconds)	34.5	14.9	12.0	10.2	10.2
WB Status	NWB	NWB	TWB	PWB	FWB
Assistive device	Axillary crutches	Axillary crutches	Axillary crutches	Axillary crutches	Axillary crutches
Leg length discrepancy (mm)	1.7	0.0	1.7	0.0	5.0
Limb volume					
Volume injured limb (cm^3)	80116.3	54722.5	46533.8	54906.9	53728.7
Volume uninjured limb (cm^3)	68031.4	49358.2	46648.8	63065.2	53728.7
Percentage difference of limb volume of uninjured limb	17.8	10.9	-0.2	-12.9	0.0

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Range of Motion					
Hip flexion AROM (injured)	41.3	111.7	117.3	102.0	113.7
Hip flexion PROM (injured)	50.0	117.0	121.7	110.0	125.0
Hip abduction AROM (injured)	26.7	38.3	48.3	56.7	60.0
Hip abduction PROM (injured)	30.0	45.0	53.3	60.0	60.0
Knee flexion AROM (injured)	84.0	111.7	115.0	120.0	133.3
Knee flexion PROM (injured)	90.7	117.0	126.7	128.3	140.0
Knee extension AROM (injured)	170.0	100.0	174.0	175.7	180.0
Knee extension PROM (injured)	176.7	110.00	180.0	180.0	180.0
Dorsiflexion AROM (injured)	18.3	16.7	20.0	18.7	20.0
Dorsiflexion PROM (injured)	21.0	20.7	25.7	27.3	24.3
Hip flexion (uninjured)	93.7	135.0	120.0	105.0	125.0
Hip flexion PROM (uninjured)	103.7	135.0	126.7	115.3	133.3
Hip abduction AROM (uninjured)	30.0	49.7	54.3	60.0	55.3
Hip abduction PROM (uninjured)	30.0	50.0	60.0	60.0	60.0
Knee flexion AROM (uninjured)	130.7	135.0	135.0	135.0	140.0
Knee flexion PROM (uninjured)	130.7	135.0	135.0	135.0	140.0
Knee extension AROM (uninjured)	180.0	180.0	180.0	180.0	180.0
Knee extension PROM (uninjured)	180.0	180.0	180.0	180.0	180.0
Dorsiflexion AROM (uninjured)	17.3	17.0	19.0	20.3	20.0
Dorsiflexion PROM (uninjured)	23.3	21.7	23.7	29.7	25.3
Percentage difference in hip flexion AROM	55.9	17.3	2.2	2.9	9.1
Percentage difference in hip flexion PROM	51.8	13.3	3.9	4.6	6.3
Percentage difference in hip abduction AROM	11.1	22.8	11.0	5.6	-8.4
Percentage difference in hip abduction PROM	0.0	10.0	11.1	0.0	0.0
Percentage difference in knee flexion AROM	35.7	17.3	14.8	11.1	4.8
Percentage difference in knee flexion PROM	30.6	13.3	6.2	4.9	22.2
Percentage difference in knee extension AROM	5.6	44.4	3.3	2.4	0.0
Percentage difference in knee extension PROM	1.9	38.9	0.0	0.0	0.0
Percentage difference in dorsiflexion AROM	-5.8	1.9	-5.3	8.2	0.0
Percentage difference in dorsiflexion PROM	10.0	4.6	-8.5	7.9	17.1

Appendix A 13: Table of all variable outcomes for Participant Two.

Week	0	2	4	6
Questionnaires				
PVN (scores 0 - 10)	4	0	0	0
Activity limitations (scores 0 - 4)	3.5	2.75	2.75	1.25
HAQ 8 (scores 0 - 3)	0.625	0.75	0	0
EQ-5D index (scores -0.594 -1)	0.189	0.312	0.883	0.883
EQ-5D State of health	Worse	Worse	Worse	Worse
EQ VAS State of health (scores 0 – 100)	60	80	95	95
Muscle Power				
Hip flexors injured limb	36.3	72.5	115.6	179.0
Hip abductors injured limb	33.9	34.3	72.5	86.9
Quadriceps injured limb	25.1	57.2	94.1	123.1
Hamstrings injured limb	52.3	114.0	148.6	138.5
Hip flexors uninjured limb	107.1	84.9	131.6	152.9
Hip abductors uninjured limb	99.9	72.8	89.2	108.1
Quadriceps uninjured limb	75.8	94.4	147.0	204.2
Hamstrings uninjured limb	199.9	147.0	200.9	186.5
Percentage difference in hip flexors	66.2	14.6	12.2	-17.1
Percentage difference in hip abductors	66.0	52.9	-5.5	19.6
Percentage difference in quadriceps	66.8	39.4	36.0	39.7
Percentage difference in hamstrings	73.9	22.4	26.0	25.7
TUG test time (seconds)	24.6	16.7	9.4	10.1
WB Status	NWB	NWB	TWB	NWB
Assistive device	Axillary crutches	Axillary crutches	Axillary crutches	Axillary crutches
Leg length discrepancy (mm)	10.0	20.0	10.0	0.0
Limb Volume				
Volume injured limb (cm³)	46424.2	43446.1	48897.4	42744.3
Volume uninjured limb (cm³)	33247.6	41802.6	37853.2	25191.1
Percentage of limb volume of uninjured limb	39.6	3.9	29.2	69.7

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Range of Motion				
Hip flexion AROM (injured)	41.0	90.0	118.0	110.3
Hip flexion PROM (injured)	45.3	98.3	125.0	120.0
Hip abduction AROM (injured)	31.7	18.3	60.0	58.3
Hip abduction PROM (injured)	42.0	30.0	60.0	60.0
Knee flexion AROM (injured)	64.0	90.0	135.3	132.0
Knee flexion PROM (injured)	75.0	98.3	139.7	140.0
Knee extension AROM (injured)	153.0	160.7	179.0	180.0
Knee extension PROM (injured)	180.0	180.0	180.0	180.0
Dorsiflexion AROM (injured)	20.0	23.3	22.3	19.3
Dorsiflexion PROM (injured)	30.0	26.3	28.3	22.0
Hip flexion AROM (uninjured)	116.7	135.0	115.0	110.3
Hip flexion PROM (uninjured)	120.0	135.0	125.0	119.7
Hip abduction AROM (uninjured)	60.3	56.7	60.0	58.0
Hip abduction PROM (uninjured)	60.0	60.0	60.0	60.3
Knee flexion AROM (uninjured)	135.0	135.0	140.0	132.3
Knee flexion PROM (uninjured)	135.0	135.0	140.0	140.0
Knee extension AROM (uninjured)	180.0	180.0	180.0	180.0
Knee extension PROM (uninjured)	180.0	180.0	180.0	180.0
Dorsiflexion AROM (uninjured)	20.0	21.0	20.7	20.0
Dorsiflexion PROM (uninjured)	29.3	27.7	28.7	25.0
Percentage difference in hip flexion AROM	64.9	33.3	-2.6	0.0
Percentage difference in hip flexion PROM	62.2	27.2	0.0	-0.3
Percentage difference in hip abduction AROM	47.5	67.6	0.0	-0.6
Percentage difference in hip abduction PROM	30.0	50.0	0.0	0.5
Percentage difference in knee flexion AROM	52.6	33.3	3.3	0.3
Percentage difference in knee flexion PROM	44.4	27.2	0.2	0.0
Percentage difference in knee extension AROM	15.0	10.7	0.6	0.0
Percentage difference in knee extension PROM	0.0	0.0	0.0	0.0
Percentage difference in dorsiflexion AROM	0.0	-11.1	-8.1	3.3
Percentage difference in dorsiflexion PROM	-2.3	4.8	1.2	12.0

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Appendix A 14: Table of all variable outcomes for Participant Three.

Week	0	2	4
Questionnaires			
PVN (scores 0 - 10)	5	3	2
Activity limitations (scores 0 - 4)	1.75	1.5	0.5
HAQ 8 (scores 0 - 3)	0.625	0.375	0.125
EQ-5D index (scores -0.594 -1)	-0.17	0.585	0.689
EQ-5D State of health	Better	Better	Better
EQ VAS State of health (scores 0 – 100)	50	70	80
Muscle Power			
Hip flexors injured limb	31.0	41.8	114.0
Hip abductors injured limb	42.8	42.8	68.6
Quadriceps injured limb	26.5	70.9	118.9
Hamstrings injured limb	82.9	74.5	178.4
Hip flexors uninjured limb	78.4	122.2	168.9
Hip abductors uninjured limb	82.3	86.6	111.4
Quadriceps uninjured limb	110.4	109.1	144.1
Hamstrings uninjured limb	107.2	101.3	168.6
Percentage difference in hip flexors	60.4	65.8	32.5
Percentage difference in hip abductors	48.0	50.6	-6.7
Percentage difference in quadriceps	76.0	35.0	17.5
Percentage difference in hamstrings	22.6	26.4	-5.8
TUG test time (seconds)	29.6	12.5	9.2
WB Status	NWB	TWB	PWB
Assistive device	Axillary crutches	Axillary crutches	Axillary crutches
Leg length discrepancy (mm)	20.0	10.0	0.0
Limb Volume			
Volume injured limb (cm³)	42841.1	57171.3	51442.8
Volume uninjured limb (cm³)	43419.3	48305.8	48305.8
Percentage of limb volume of uninjured limb	-1.3	18.3	6.5

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Range of motion			
Hip flexion AROM (injured)	45.3	90.0	122.0
Hip flexion PROM (injured)	55.3	99.3	130.7
Hip abduction AROM (injured)	5.7	21.7	30.0
Hip abduction PROM (injured)	21.7	45.0	45.0
Knee flexion AROM (injured)	68.0	90.0	125.0
Knee flexion PROM (injured)	75.3	99.3	136.3
Knee extension AROM (injured)	174.0	164.0	180.0
Knee extension PROM (injured)	180.0	180.0	180.0
Dorsiflexion AROM (injured)	20.7	20.0	20.0
Dorsiflexion PROM (injured)	24.7	29.7	27.7
Hip flexion AROM (uninjured)	123.3	135.0	135.3
Hip flexion PROM (uninjured)	130.0	135.0	140.0
Hip abduction AROM (uninjured)	40.0	55.0	50.0
Hip abduction PROM (uninjured)	21.7	45.0	45.0
Knee flexion AROM (uninjured)	135.0	135.0	140.0
Knee flexion PROM (uninjured)	135.0	135.0	140.0
Knee extension AROM (uninjured)	180.0	180.0	180.0
Knee extension PROM (uninjured)	180.0	180.0	180.0
Dorsiflexion AROM (uninjured)	25.3	25.0	20.7
Dorsiflexion PROM (uninjured)	30.3	31.7	25.0
Percentage difference in hip flexion AROM	63.2	33.3	9.8
Percentage difference in hip flexion PROM	57.4	26.4	6.7
Percentage difference in hip abduction AROM	85.8	60.6	40.0
Percentage difference in hip abduction PROM	0.0	0.0	0.0
Percentage difference in knee flexion AROM	49.6	33.3	10.7
Percentage difference in knee flexion PROM	44.2	26.4	2.6
Percentage difference in knee extension AROM	3.3	8.9	0.0
Percentage difference in knee extension PROM	0.0	0.0	0.0
Percentage difference in dorsiflexion AROM	18.4	20.0	3.2
Percentage difference in dorsiflexion PROM	18.7	6.3	-10.7

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Appendix A 15: Table of all variable outcomes for Participant Four.

Week	0	2	4	6	12
Questionnaires					
PVN (scores 0 - 10)	3	2	1	1	0
Activity limitations (scores 0 - 4)	1.5	0.5	0.25	0.25	0.25
HAQ 8 (scores 0 - 3)	0.125	0	0	0	0
EQ-5D index (scores -0.594 -1)	0.656	0.516	0.796	0.727	1
EQ-5D State of health (scores 0 – 100)	Much the same	Better	Better	Much the same	Better
EQ VAS State of health	60	30	70	85	95
Muscle Power					
Hip flexors injured limb	34.6	69.2	102.6	100.9	124.8
Hip abductors injured limb	39.2	59.8	49.6	56.5	85.9
Quadriceps injured limb	48.7	61.1	80.0	93.7	124.8
Hamstrings injured limb	49.3	66.3	85.9	99.9	150.3
Hip flexors uninjured limb	55.2	90.8	156.5	114.0	124.8
Hip abductors uninjured limb	67.3	65.0	72.8	70.6	92.4
Quadriceps uninjured limb	67.3	87.5	104.5	114.3	130.7
Hamstrings uninjured limb	92.1	82.3	122.2	118.9	168.2
Percentage difference in hip flexors	37.3	23.7	34.4	11.5	0.0
Percentage difference in hip abductors	41.7	8.0	-9.9	19.9	7.1
Percentage difference in quadriceps	27.7	30.2	23.4	18.0	4.5
Percentage difference in hamstrings	46.4	19.4	29.7	15.9	10.7
TUG test time (seconds)	36.1	20.3	21.4	12.9	9.2
WB Status	NWB	NWB	TWB	TWB	FWB
Assistive device	Axillary crutches	Axillary crutches	Axillary crutches	Axillary crutches	Axillary crutches
Leg length discrepancy (mm)	20.0	0.0	0.0	0.0	0.0
Limb Volume					
Volume injured limb (cm³)	48369.5	53235.9	48112.4	45369.7	52361.7
Volume uninjured limb (cm³)	36336.2	44892.6	42912.3	44296.8	52361.7
Percentage of limb volume of uninjured limb	33.1	18.6	12.1	2.4	0.0

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Range of motion					
Hip flexion AROM (injured)	111.7	126.7	118.3	118.3	115.0
Hip flexion PROM (injured)	122.3	133.3	125.0	125.7	120.0
Hip abduction AROM (injured)	30.7	60.0	55.0	62.0	65.0
Hip abduction PROM (injured)	34.7	60.0	55.0	65.0	65.0
Knee flexion AROM (injured)	106.7	126.7	126.7	135.0	125.0
Knee flexion PROM (injured)	118.7	133.3	140.0	140.0	130.0
Knee extension AROM (injured)	178.3	169.3	171.3	170.0	180.0
Knee extension PROM (injured)	180.0	180.0	180.0	180.0	180.0
Dorsiflexion AROM (injured)	13.7	24.3	20.0	20.7	20.3
Dorsiflexion PROM (injured)	19.7	29.3	28.7	22.0	20.7
Hip flexion AROM (uninjured)	109.3	135.0	116.7	113.3	113.3
Hip flexion PROM (uninjured)	122.3	133.3	125.0	125.7	120.0
Hip abduction AROM (uninjured)	60.0	60.0	55.0	65.0	65.0
Hip abduction PROM (uninjured)	65.0	60.0	60.0	65.0	65.0
Knee flexion AROM (uninjured)	135.0	135.0	135.0	137.7	140.0
Knee flexion PROM (uninjured)	135.0	135.0	135.0	140.0	140.0
Knee extension AROM (uninjured)	180.0	180.0	180.0	180.0	180.0
Knee extension PROM (uninjured)	180.0	180.0	180.0	180.0	180.0
Dorsiflexion AROM (uninjured)	16.3	19.0	20.0	18.7	19.3
Dorsiflexion PROM (uninjured)	22.7	30.3	23.3	20.7	21.0
Percentage difference in hip flexion AROM	-2.1	6.2	-1.4	-4.4	-1.5
Percentage difference in hip flexion PROM	0.0	0.0	0.0	0.0	0.0
Percentage difference in hip abduction AROM	48.9	0.0	0.0	4.6	0.0
Percentage difference in hip abduction PROM	46.7	0.0	8.3	0.0	0.0
Percentage difference in knee flexion AROM	20.9	6.2	6.2	1.9	10.7
Percentage difference in knee flexion PROM	12.1	1.2	-3.7	0.0	27.8
Percentage difference in knee extension AROM	0.9	5.9	4.8	5.6	0.0
Percentage difference in knee extension PROM	0.0	0.0	0.0	0.0	0.0
Percentage difference in dorsiflexion AROM	16.3	-28.1	0.0	-10.7	-5.2
Percentage difference in dorsiflexion PROM	13.2	3.3	-22.9	-6.4	0.0

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Appendix A 16: Table of all variable outcomes for Participant Five.

Week	0	2	4	6
Questionnaires				
PVN (scores 0 - 10)	4	4	3	4
Activity limitations (scores 0 - 4)	4	3.75	3	3.25
HAQ 8 (scores 0 - 3)	1	0.375	0.25	0
EQ-5D index (scores -0.594 -1)	0.082	0.656	0.656	0.796
EQ-5D State of health	Worse	Better	Worse	Better
EQ VAS State of health (scores 0 – 100)	60	70	80	80
Muscle power				
Hip flexors injured limb	61.4	154.5	152.2	159.4
Hip abductors injured limb	35.6	36.6	52.3	40.2
Quadriceps injured limb	35.6	54.9	78.7	81.9
Hamstrings injured limb	60.8	114.7	124.5	143.1
Hip flexors uninjured limb	91.5	130.3	123.8	170.2
Hip abductors uninjured limb	86.2	92.8	116.9	95.1
Quadriceps uninjured limb	127.7	149.3	163.7	128.0
Hamstrings uninjured limb	107.5	148.9	152.2	180.3
Percentage difference in hip flexors	32.9	-18.5	-22.9	6.3
Percentage difference in hip abductors	58.7	60.6	32.7	57.7
Percentage difference in quadriceps	72.1	63.2	51.9	35.9
Percentage difference in hamstrings	43.5	23.0	18.2	20.6
TUG test time (seconds)	37.1	9.1	10.4	9.5
WB Status	FWB	FWB	FWB	FWB
Assistive device	Axillary crutches	Axillary crutches	Axillary crutches	Axillary crutches
Leg length discrepancy (mm)	0.0	0.0	0.0	0.0
Limb Volume				
Volume injured limb (cm³)	44672.1	40799.1	37202.8	40077.9
Volume uninjured limb (cm³)	48939.6	40791.6	38674.6	42461.0
Percentage of limb volume of uninjured limb	-8.7	0.0	-3.8	-5.6

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Range of Motion				
Hip flexion AROM (injured)	63.3	120.3	130.0	130.0
Hip flexion PROM (injured)	77.0	140.0	131.0	130.3
Hip abduction AROM (injured)	31.7	43.3	53.3	60.0
Hip abduction PROM (injured)	40.0	50.7	60.0	60.0
Knee flexion AROM (injured)	101.7	120.3	139.7	140.0
Knee flexion PROM (injured)	118.7	133.3	140.0	140.0
Knee extension AROM (injured)	162.0	170.0	170.7	180.0
Knee extension PROM (injured)	180.0	180.0	180.0	180.0
Dorsiflexion AROM (injured)	20.0	20.0	-19.3	20.7
Dorsiflexion PROM (injured)	28.3	28.7	-21.7	24.0
Hip flexion AROM (uninjured)	120.0	140.0	120.7	120.3
Hip flexion PROM (uninjured)	129.3	140.0	130.3	129.0
Hip abduction AROM (uninjured)	50.0	49.0	60.0	60.7
Hip abduction PROM (uninjured)	55.0	55.0	60.0	60.7
Knee flexion AROM (uninjured)	140.0	140.0	140.0	140.0
Knee flexion PROM (uninjured)	140.0	140.0	140.0	140.0
Knee extension AROM (uninjured)	180.0	180.0	180.0	180.0
Knee extension PROM (uninjured)	180.0	180.0	180.0	180.0
Dorsiflexion AROM (uninjured)	28.0	20.3	-18.3	20.0
Dorsiflexion PROM (uninjured)	32.0	30.3	-21.7	24.7
Percentage difference in hip flexion AROM	47.2	14.0	-7.7	-8.0
Percentage difference in hip flexion PROM	40.5	0.0	-0.5	-1.0
Percentage difference in hip abduction AROM	36.7	11.6	11.1	1.1
Percentage difference in hip abduction PROM	27.3	7.9	0.0	1.1
Percentage difference in knee flexion AROM	27.4	14.0	0.2	0.0
Percentage difference in knee flexion PROM	15.2	4.8	0.0	0.0
Percentage difference in knee extension AROM	10.0	5.6	5.2	0.0
Percentage difference in knee extension PROM	0.0	0.0	0.0	0.0
Percentage difference in dorsiflexion AROM	28.6	1.6	-5.4	-3.3
Percentage difference in dorsiflexion PROM	11.4	5.5	0.0	2.7

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Appendix A 17: Table of all variable outcomes for Participant Six.

Week	0	2	4	6	12
Questionnaires					
PVN (scores 0 - 10)	8	0	2	1	1
Activity limitations (scores 0 - 4)	1	0.25	2.75	1.75	2.5
HAQ 8 (scores 0 - 3)	0.75	1	0.875	0.5	0.375
EQ-5D index (scores -0.594 -1)	0.656	0.814	0.746	0.746	0.85
EQ-5D State of health	Much the same	Better	Much the same	Better	Better
EQ VAS State of health (scores 0 -100)	70	40	90	94	95
Muscle power					
Hip flexors injured limb	24.5	77.4	126.1	132.3	180.3
Hip abductors injured limb	23.8	27.4	31.7	39.5	83.9
Quadriceps injured limb	32.3	84.6	77.4	107.1	159.4
Hamstrings injured limb	61.7	109.8	103.9	122.8	143.1
Hip flexors uninjured limb	154.5	145.4	160.4	145.7	127.4
Hip abductors uninjured limb	79.0	70.6	91.5	86.2	97.0
Quadriceps uninjured limb	127.4	184.2	171.8	138.8	181.3
Hamstrings uninjured limb	114.0	119.2	165.9	199.9	174.8
Percentage difference in hip flexors	84.1	46.7	21.4	9.2	-41.5
Percentage difference in hip abductors	69.8	61.1	15.4	54.2	13.5
Percentage difference in quadriceps	74.6	54.1	54.9	22.8	12.1
Percentage difference in hamstrings	45.8	7.9	37.4	38.6	18.1
TUG test time (seconds)	69.4	18.6	14.8	14.5	10.7
WB Status	FWB	FWB	PWB	PWB	FWB
Assistive device	Axillary crutches	Axillary crutches	Axillary crutches	Axillary crutches	Axillary crutches
Leg length discrepancy (mm)	0.0	0.0	0.0	0.0	0.0
Limb Volume					
Volume injured limb (cm³)	64999.7	43646.9	48985.2	41043.5	48985.2
Volume uninjured limb (cm³)	43599.9	38311.1	43604.3	32794.1	40525.9
Percentage of limb volume of uninjured limb	49.1	13.9	12.3	25.2	20.9

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Range of motion					
Hip flexion AROM (injured)	21.7	91.0	95.0	94.0	100.0
Hip flexion PROM (injured)	48.3	103.0	109.7	110.0	111.3
Hip abduction AROM (injured)	0.0	41.7	47.0	48.3	48.3
Hip abduction PROM (injured)	30.0	48.0	58.0	57.7	53.3
Knee flexion AROM (injured)	41.7	91.0	100.0	128.7	129.7
Knee flexion PROM (injured)	60.0	103.0	125.0	135.0	138.7
Knee extension AROM (injured)	150.7	150.0	170.0	170.0	180.0
Knee extension PROM (injured)	180.0	180.0	180.0	180.0	180.0
Dorsiflexion AROM (injured)	16.3	14.7	14.7	16.3	15.0
Dorsiflexion PROM (injured)	21.3	21.7	20.3	20.7	20.0
Hip flexion AROM (uninjured)	98.3	130.0	90.3	91.3	93.3
Hip flexion PROM (uninjured)	108.3	139.7	110.3	109.3	108.7
Hip abduction AROM (uninjured)	48.3	55.0	57.3	61.7	58.7
Hip abduction PROM (uninjured)	54.7	60.0	65.0	65.7	64.7
Knee flexion AROM (uninjured)	139.0	130.0	130.7	130.0	131.0
Knee flexion PROM (uninjured)	140.0	139.7	136.3	135.0	140.0
Knee extension AROM (uninjured)	180.0	180.0	180.0	180.0	180.0
Knee extension PROM (uninjured)	180.0	180.0	180.0	180.0	180.0
Dorsiflexion AROM (uninjured)	14.3	14.0	11.3	13.0	20.0
Dorsiflexion PROM (uninjured)	23.7	24.0	20.0	17.7	20.7
Percentage difference in hip flexion AROM	77.9	30.0	-5.2	-2.9	-7.1
Percentage difference in hip flexion PROM	55.4	26.2	0.6	-0.6	-2.4
Percentage difference in hip abduction AROM	100.0	24.2	18.0	21.6	17.6
Percentage difference in hip abduction PROM	45.1	20.0	10.8	12.2	17.5
Percentage difference in knee flexion AROM	70.0	30.0	23.5	1.0	1.0
Percentage difference in knee flexion PROM	57.1	26.2	8.3	0.0	22.9
Percentage difference in knee extension AROM	16.3	16.7	5.6	5.6	0.0
Percentage difference in knee extension PROM	0.0	0.0	0.0	0.0	0.0
Percentage difference in dorsiflexion AROM	-13.9	-4.8	-29.4	-25.6	25.0
Percentage difference in dorsiflexion PROM	9.9	9.7	-1.7	-16.9	100.0

Appendix A 18: Table of all variable outcomes for Participant Seven.

Week	0	2	4	6	12
Questionnaires					
PVN (scores 0 - 10)	4	1	3	2	0
Activity limitations (scores 0 - 4)	2.5	0.5	1	0.5	0
HAQ 8 (scores 0 - 3)	0.125	0	0.125	0	0
EQ-5D index (scores -0.594 -1)	0.433	0.727	0.516	0.656	1
EQ-5D State of health	Better	Better	Better	Better	Better
EQ VAS State of health	50	40	70	90	100
Muscle Power					
Hip flexors injured limb	77.4	236.8	170.5	228.7	226.7
Hip abductors injured limb	35.3	75.1	104.5	123.1	152.2
Quadriceps injured limb	48.0	109.4	152.2	174.1	165.3
Hamstrings injured limb	83.3	193.1	209.1	234.9	244.3
Hip flexors uninjured limb	166.6	172.1	187.8	197.9	229.9
Hip abductors uninjured limb	112.4	113.0	119.6	131.3	165.9
Quadriceps uninjured limb	156.5	178.7	197.6	209.4	199.9
Hamstrings uninjured limb	232.6	264.6	212.9	306.7	277.7
Percentage difference in hip flexors	53.5	-37.6	9.2	-15.5	1.4
Percentage difference in hip abductors	68.6	33.5	-27.3	6.2	8.3
Percentage difference in quadriceps	69.3	38.8	22.9	16.8	17.3
Percentage difference in hamstrings	64.1	27.0	1.8	23.4	12.0
TUG test time (seconds)	40.3	11.2	10.9	7.5	7.8
WB Status	NWB	PWB	FWB	FWB	FWB
Assistive device	Axillary crutches	Axillary crutches	Axillary crutches	Axillary crutches	Axillary crutches
Leg length discrepancy (mm)	10.0	0.0	0.0	0.0	0.0
Limb Volume					
Volume injured limb (cm³)	37964.1	37981.5	35905.1	35098.1	39340.1
Volume uninjured limb (cm³)	36303.5	36042.4	37182.3	35098.1	38873.6
Percentage of limb volume of uninjured limb	4.6	5.4	-3.4	0.0	1.2

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Range of Motion					
Hip flexion AROM (injured)	62.7	135.3	120.3	115.0	113.3
Hip flexion PROM (injured)	68.7	140.0	120.7	120.0	118.0
Hip abduction AROM (injured)	19.3	52.7	65.0	66.0	60.7
Hip abduction PROM (injured)	31.7	60.7	65.0	66.7	61.0
Knee flexion AROM (injured)	121.7	135.3	140.0	138.3	135.0
Knee flexion PROM (injured)	129.3	140.0	140.0	140.0	135.0
Knee extension AROM (injured)	152.3	180.0	180.0	180.0	180,0
Knee extension PROM (injured)	180.0	180.0	180.0	180.0	180.0
Dorsiflexion AROM (injured)	15.7	15.0	18.7	14.3	19.0
Dorsiflexion PROM (injured)	21.7	20.7	20.3	20.0	21.0
Hip flexion AROM (uninjured)	92.3	140.0	93.3	110.7	113.0
Hip flexion PROM (uninjured)	100.0	140.0	116.7	115.7	115.0
Hip abduction AROM (uninjured)	60.0	60.0	65.0	65.0	60.0
Hip abduction PROM (uninjured)	64.0	65.0	65.0	66.0	61.0
Knee flexion AROM (uninjured)	131.7	140.0	140.0	135.0	136.0
Knee flexion PROM (uninjured)	140.0	140.0	140.0	140.0	136.0
Knee extension AROM (uninjured)	180.0	180.0	180.0	180.0	180.0
Knee extension PROM (uninjured)	180.0	180.0	180.0	180.0	180.0
Dorsiflexion AROM (uninjured)	12.3	15.7	11.7	15.3	19.3
Dorsiflexion PROM (uninjured)	18.7	21.0	21.0	20.0	21.0
Percentage difference in hip flexion AROM	32.1	3.3	-28.9	-3.9	-0.3
Percentage difference in hip flexion PROM	31.3	0.0	-3.4	-3.7	-2.6
Percentage difference in hip abduction AROM	67.8	12.2	0.0	-1.5	-1.1
Percentage difference in hip abduction PROM	50.5	6.7	0.0	-1.0	0.0
Percentage difference in knee flexion AROM	7.6	3.3	0.0	-2.5	0.7
Percentage difference in knee flexion PROM	7.6	0.0	0.0	0.0	25.0
Percentage difference in knee extension AROM	15.4	0.0	0.0	0.0	0.0
Percentage difference in knee extension PROM	0.0	0.0	0.0	0.0	0.0
Percentage difference in dorsiflexion AROM	-27.0	4.3	-60.0	6.5	1.7
Percentage difference in dorsiflexion PROM	-16.1	1.6	3.2	0.0	100.0

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Appendix A 19: Table of all variable outcomes for Participant Eight.

Week	**0**
Questionnaires	
PVN (scores 0 - 10)	5
Activity limitations (scores 0 - 4)	1.5
HAQ 8 (scores 0 - 3)	0.625
EQ-5D index (scores -0.594 -1)	0.62
EQ-5D State of health	Worse
EQ VAS State of health (scores 0 – 100)	60
Muscle Power	
Hip flexors injured limb	27.4
Hip abductors injured limb	38.2
Quadriceps injured limb	33.9
Hamstrings injured limb	55.5
Hip flexors uninjured limb	94.1
Hip abductors uninjured limb	53.2
Quadriceps uninjured limb	108.8
Hamstrings uninjured limb	86.9
Percentage difference in hip flexors	70.8
Percentage difference in hip abductors	28.2
Percentage difference in quadriceps	68.8
Percentage difference in hamstrings	36.1
TUG test time (seconds)	38.2
WB Status	NWB
Assistive device	Axillary crutches
Leg length discrepancy (mm)	0.0
Limb Volume	
Volume injured limb (cm³)	55070.8
Volume uninjured limb (cm³)	34140.0
Percentage of limb volume of uninjured limb	61.3

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Range of Motion	
Hip flexion AROM (injured)	10.0
Hip flexion PROM (injured)	28.3
Hip abduction AROM (injured)	18.3
Hip abduction PROM (injured)	30.0
Knee flexion AROM (injured)	35.0
Knee flexion PROM (injured)	41.7
Knee extension AROM (injured)	165.3
Knee extension PROM (injured)	180.0
Dorsiflexion AROM (injured)	10.0
Dorsiflexion PROM (injured)	16.0
Hip flexion AROM (uninjured)	113.3
Hip flexion PROM (uninjured)	115.0
Hip abduction AROM (uninjured)	45.0
Hip abduction PROM (uninjured)	50.0
Knee flexion AROM (uninjured)	140.0
Knee flexion PROM (uninjured)	140.0
Knee extension AROM (uninjured)	180.0
Knee extension PROM (uninjured)	180.0
Dorsiflexion AROM (uninjured)	19.0
Dorsiflexion PROM (uninjured)	21.0
Percentage difference in hip flexion AROM	91.2
Percentage difference in hip flexion PROM	75.4
Percentage difference in hip abduction AROM	59.3
Percentage difference in hip abduction PROM	40.0
Percentage difference in knee flexion AROM	75.0
Percentage difference in knee flexion PROM	70.2
Percentage difference in knee extension AROM	8.1
Percentage difference in knee extension PROM	0.0
Percentage difference in dorsiflexion AROM	47.4
Percentage difference in dorsiflexion PROM	23.8

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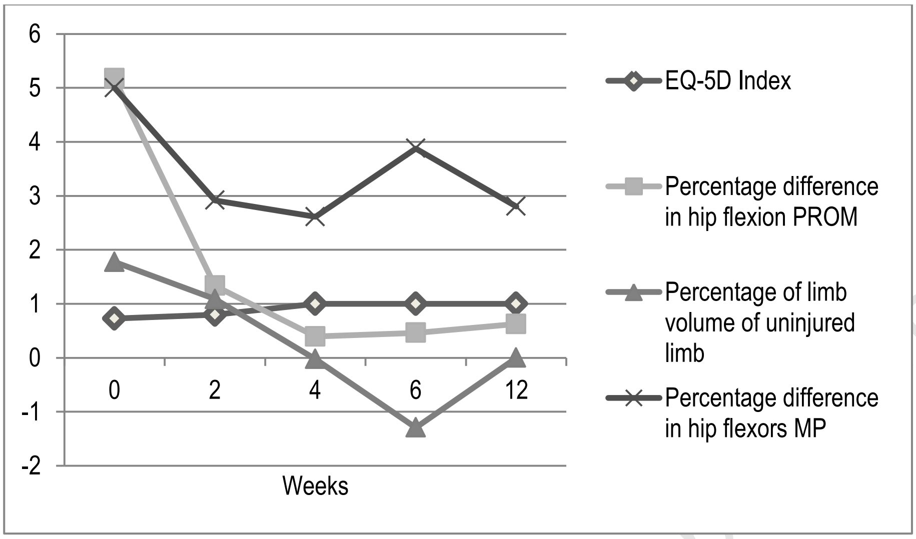
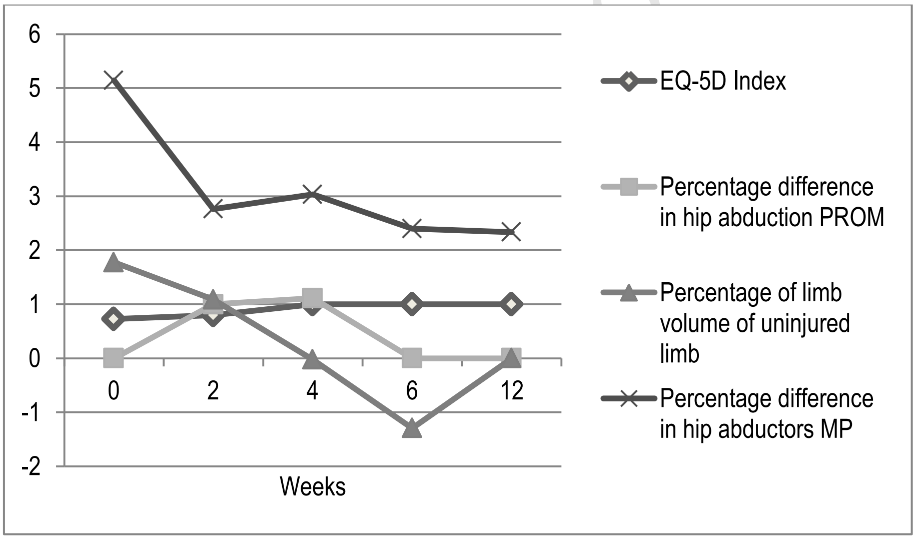
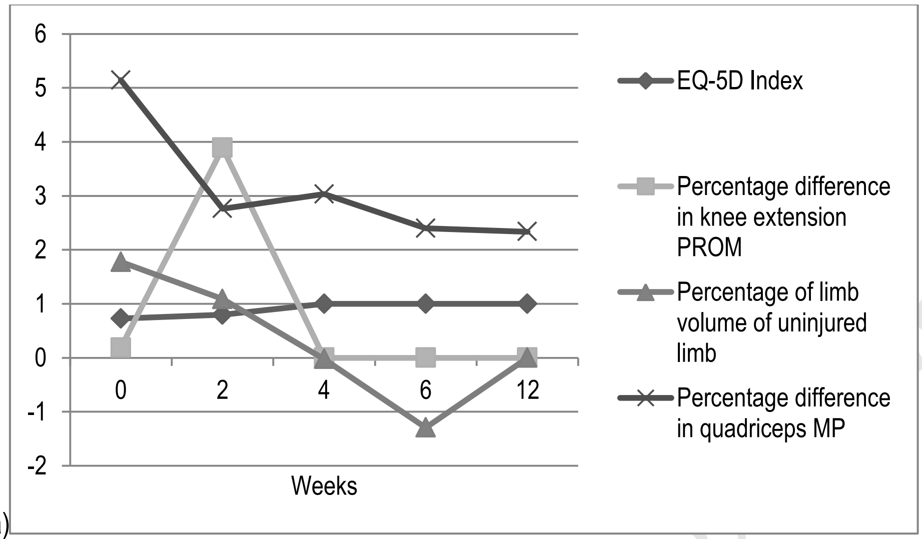
Appendix A 20: Participant One: EQ-5D index and hip function associated with PROM of (a) hip flexion and (b) hip abduction.

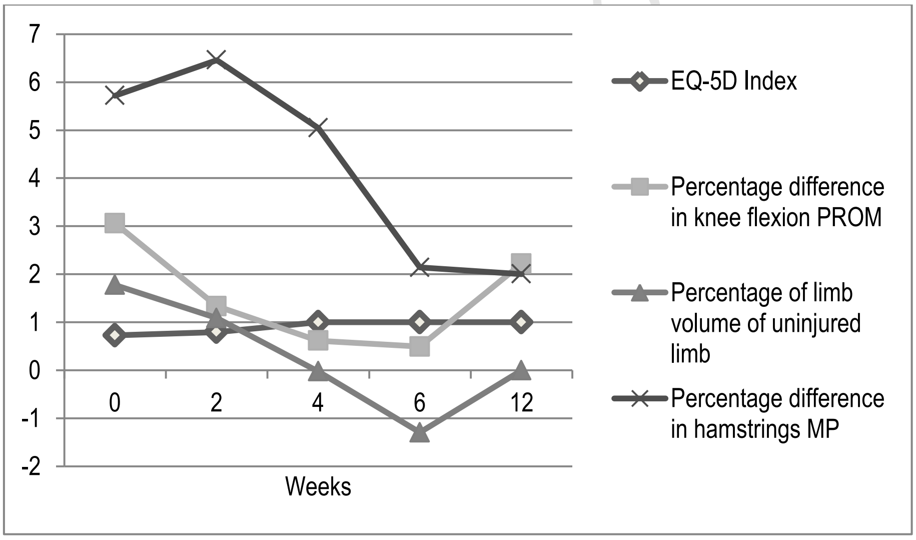
a)


b)


Appendix A 21: Participant One: EQ-5D index and knee function associated with PROM of (a) knee extension and (b) knee flexion.

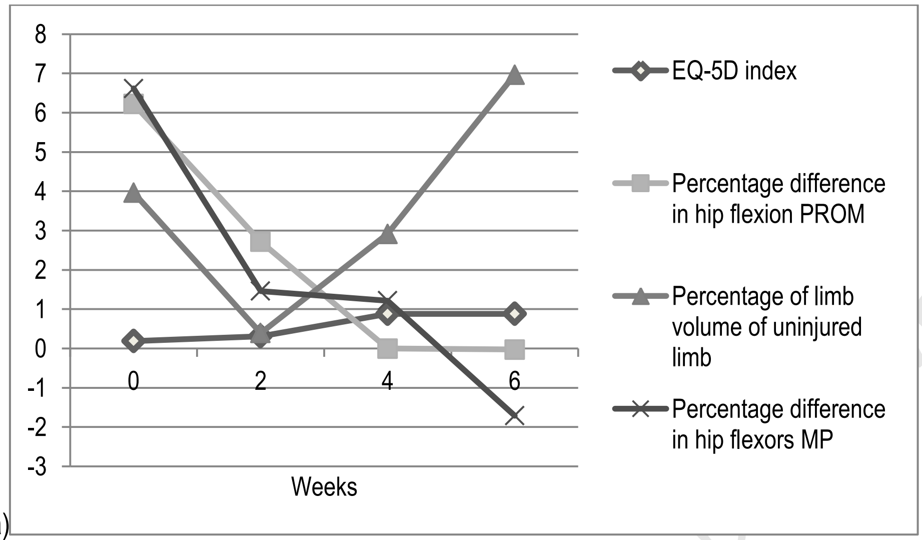


a)

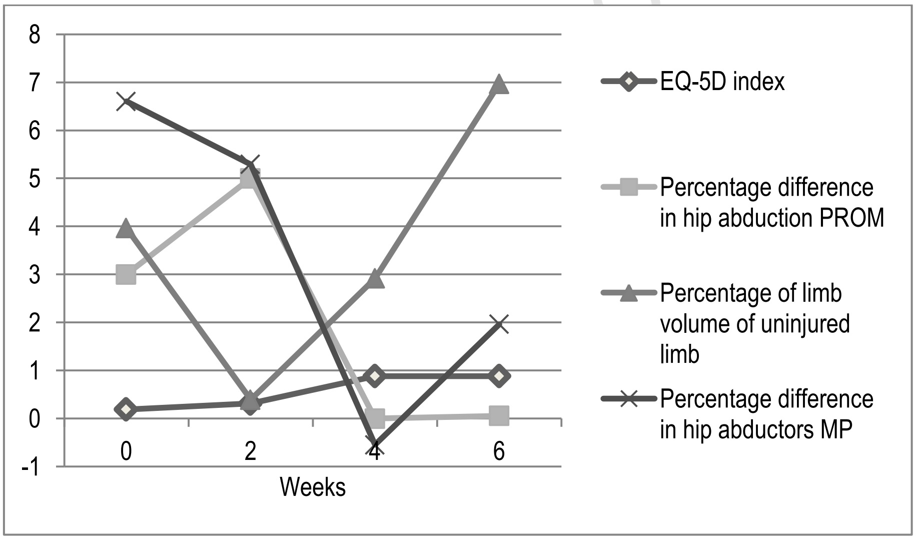


b)

Appendix A 22: Participant Two: EQ-5D index and hip function associated with PROM of (a) hip flexion and (b) hip abduction.

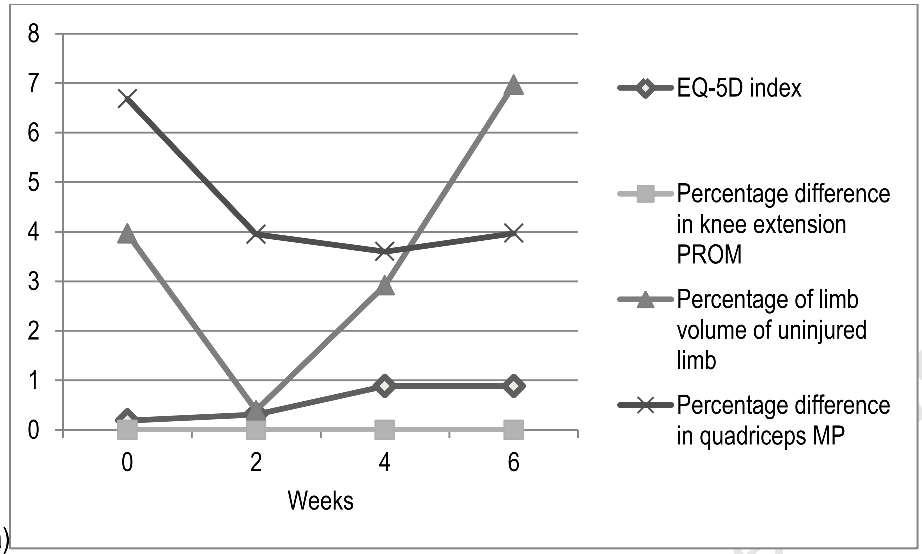


a)

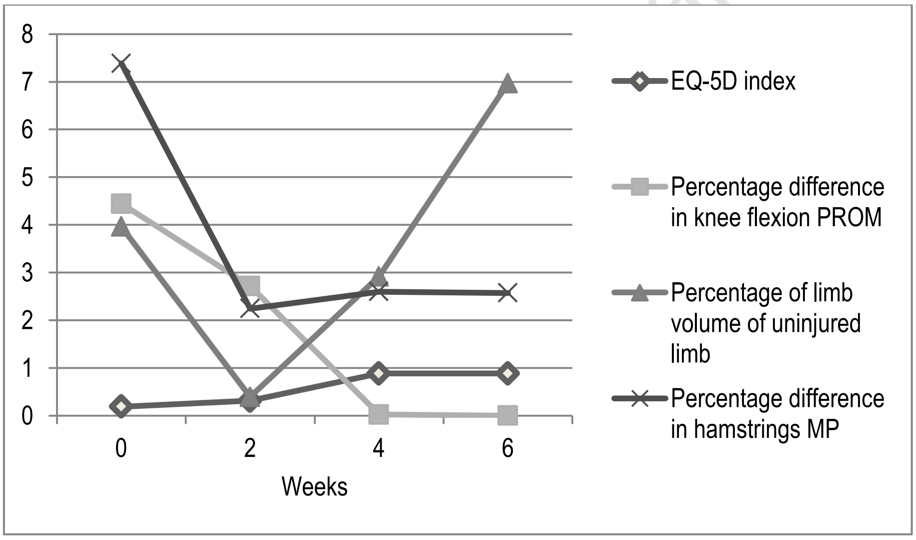


b)

Appendix A 23: Participant Two: EQ-5D index and knee function associated with PROM of (a) knee extension and (b) knee flexion.

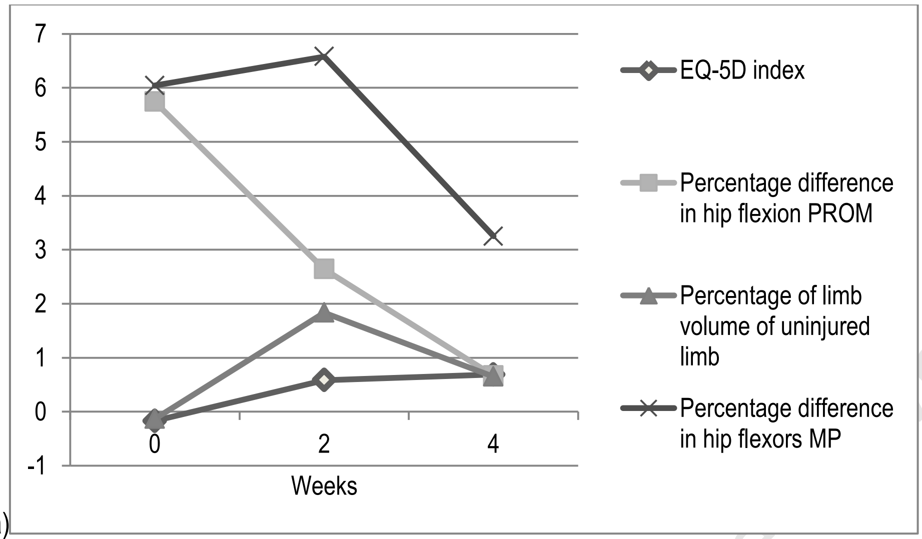


a)

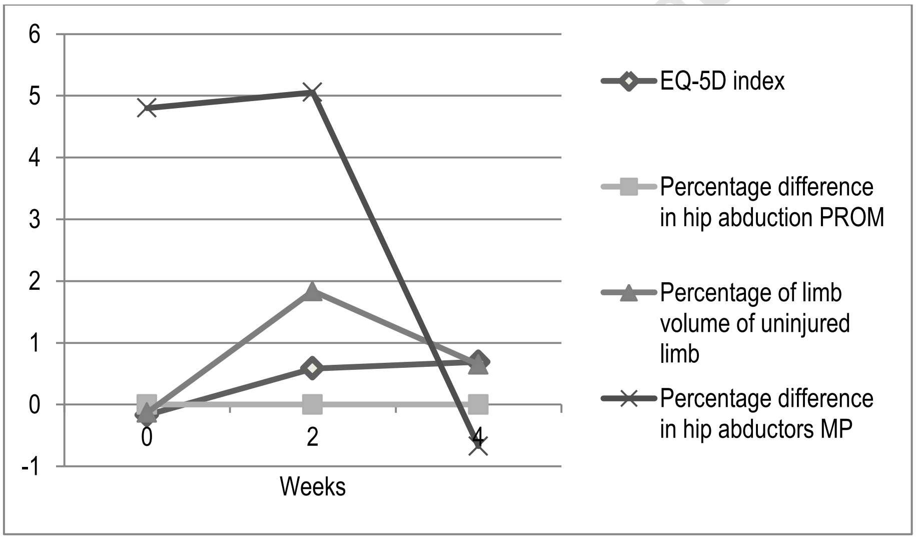


b)

Appendix A 24: Participant Three: EQ-5D index and hip function associated with PROM of (a) hip flexion and (b) hip abduction.

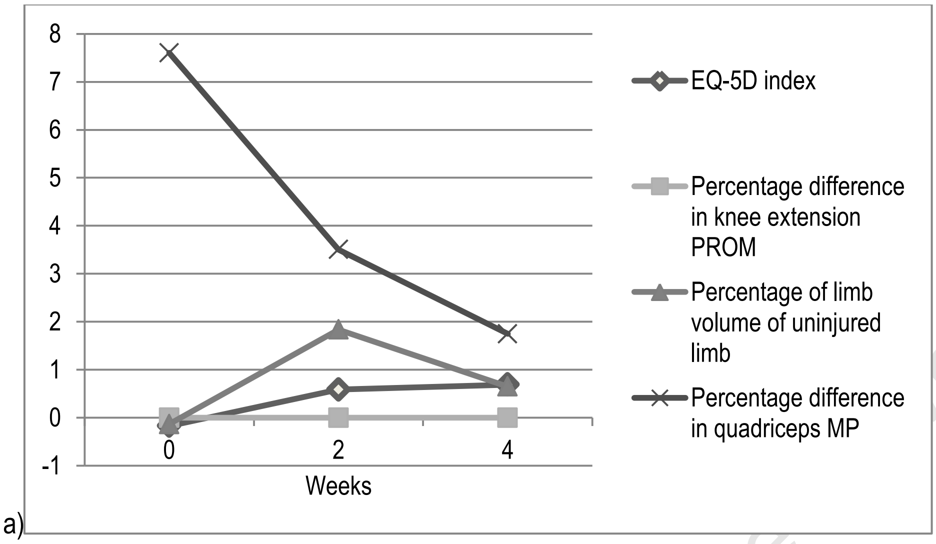


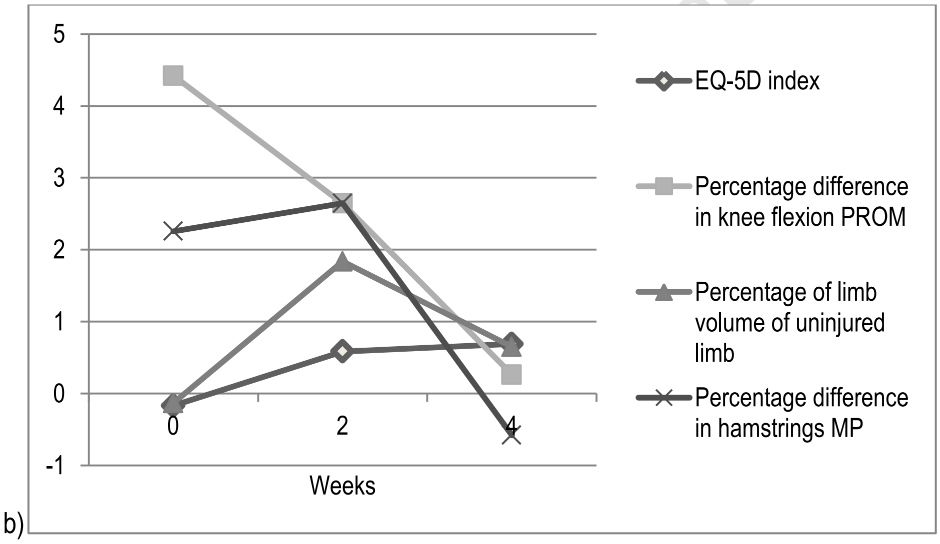
a)



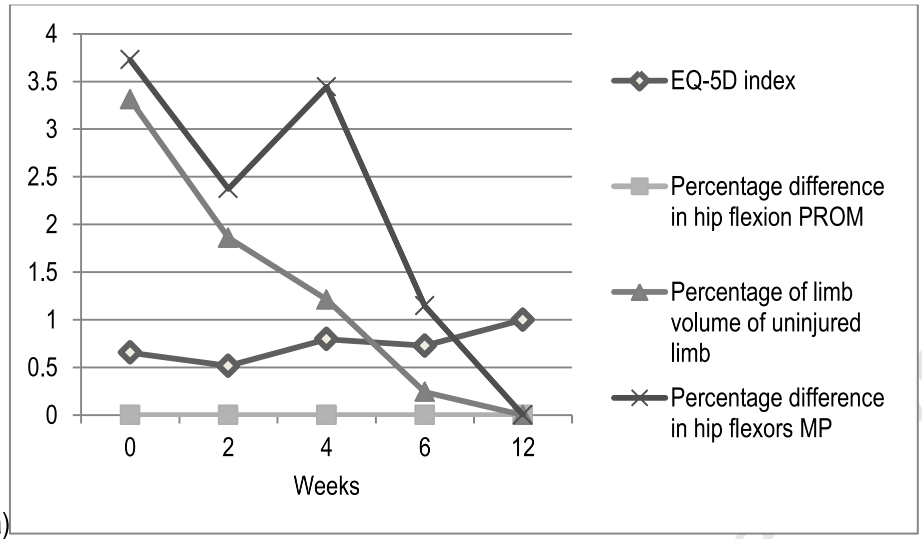
b)

Appendix A 25: Participant Three: EQ-5D index and knee function associated with PROM of (a) knee extension and (b) knee flexion.

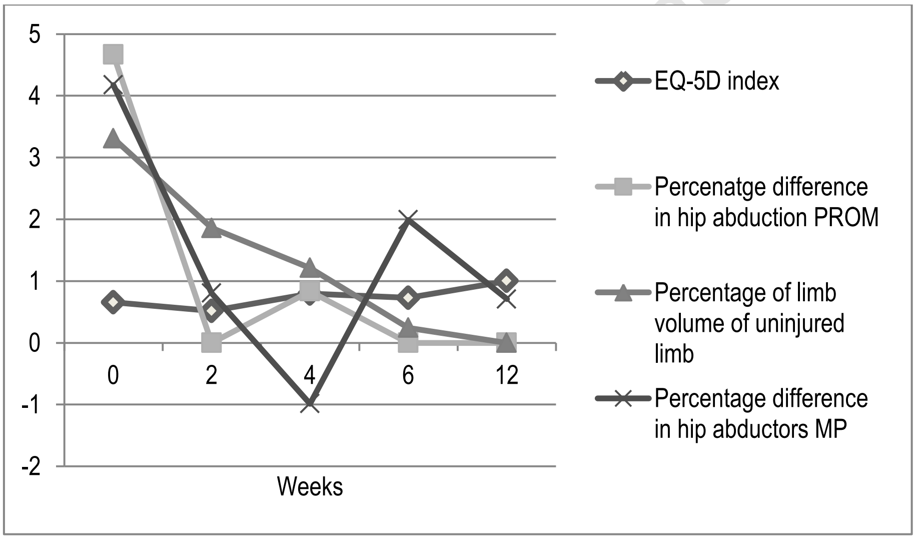




Appendix A 26: Participant Four: EQ-5D index and hip function associated with PROM of (a) hip flexion and (b) hip abduction.

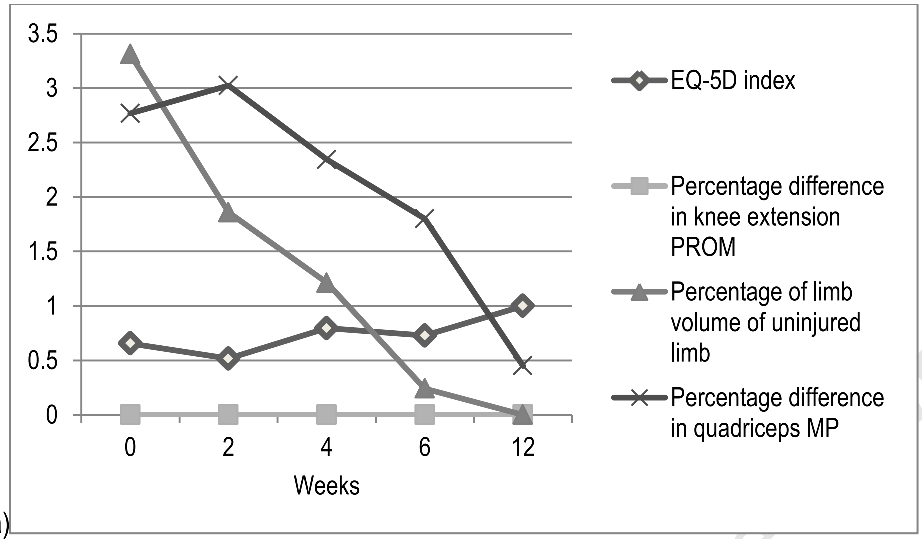


a)

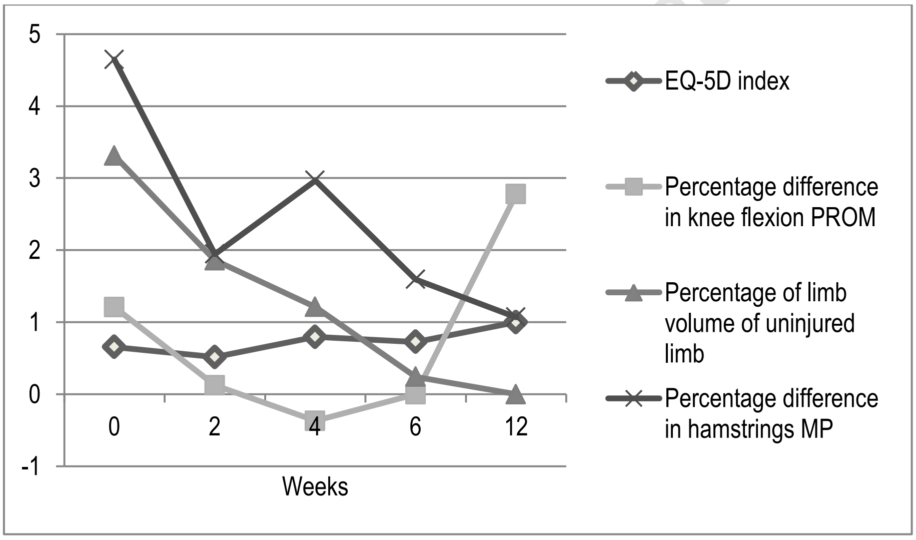


b)

Appendix A 27: Participant Four: EQ-5D index and knee function associated with PROM of (a) knee extension and (b) knee flexion.

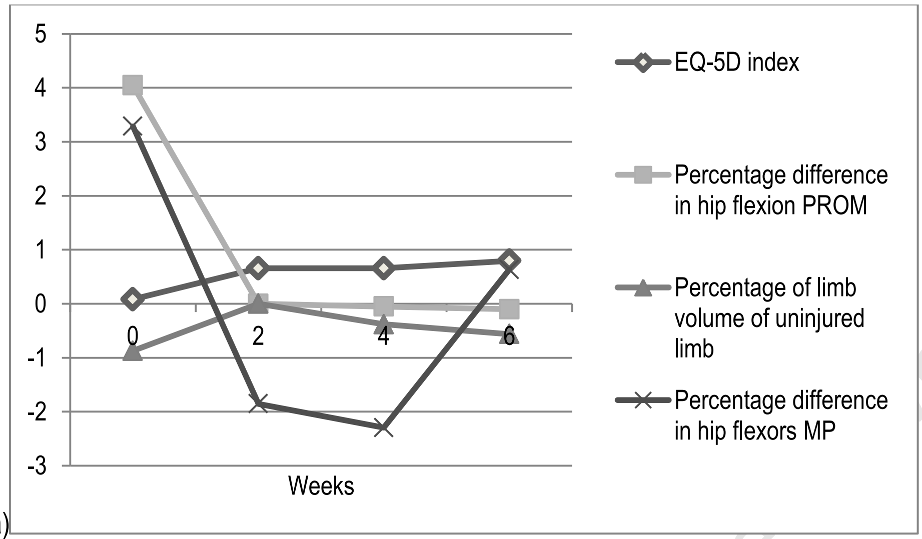


a)

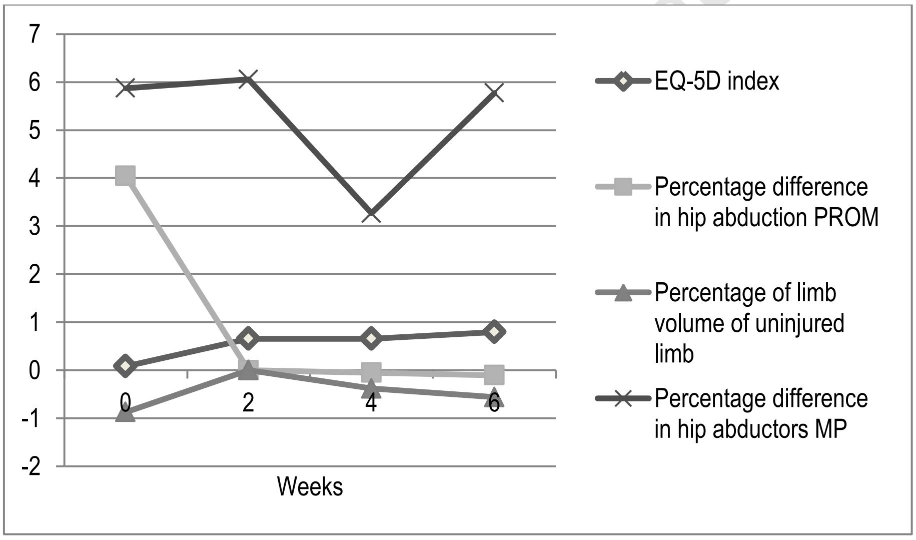


b)

Appendix A 28: Participant Five: EQ-5D index and hip function associated with PROM of (a) hip flexion and (b) hip abduction.

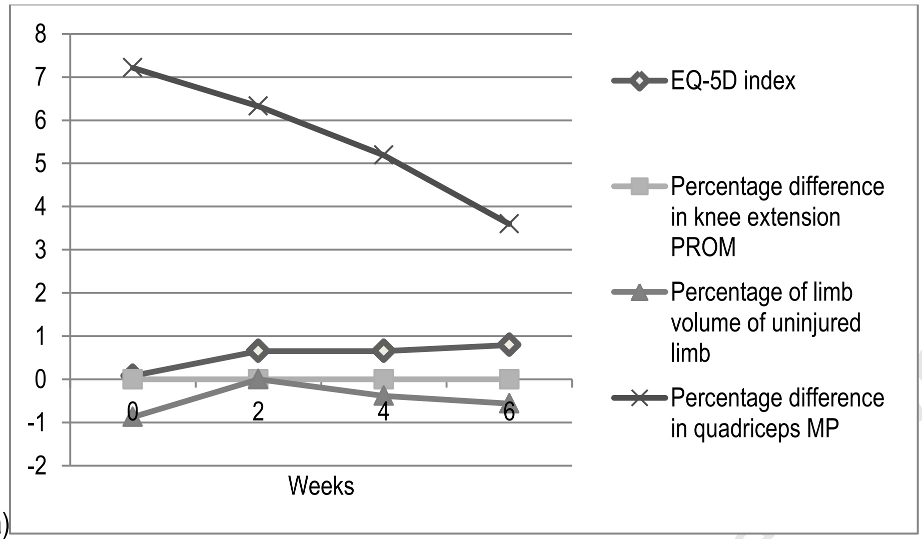


a)

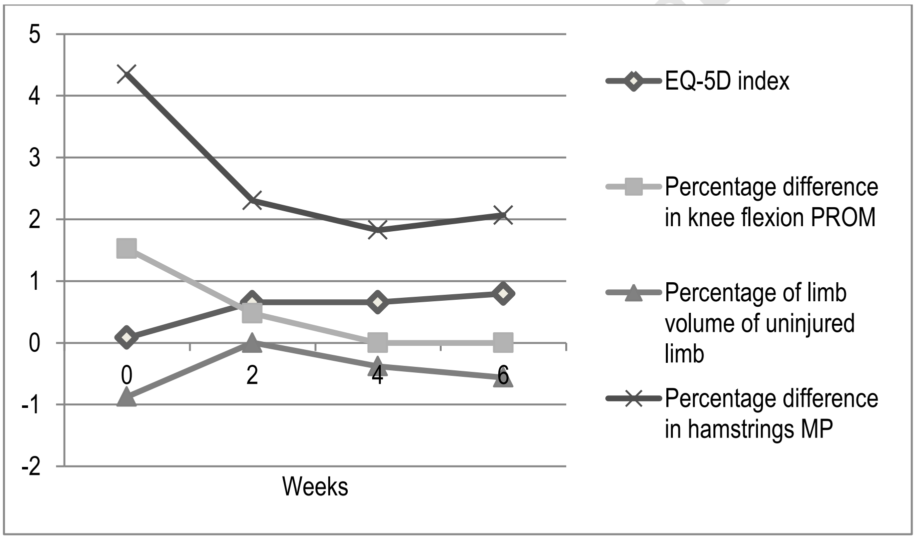


b)

Appendix A 29: Participant Five: EQ-5D index and knee function associated with PROM of (a) knee extension and (b) knee flexion.

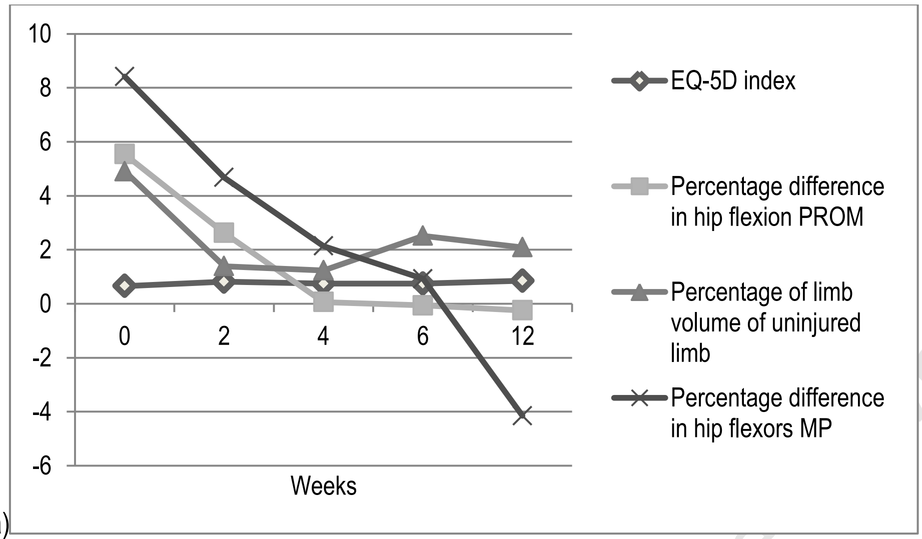


a)

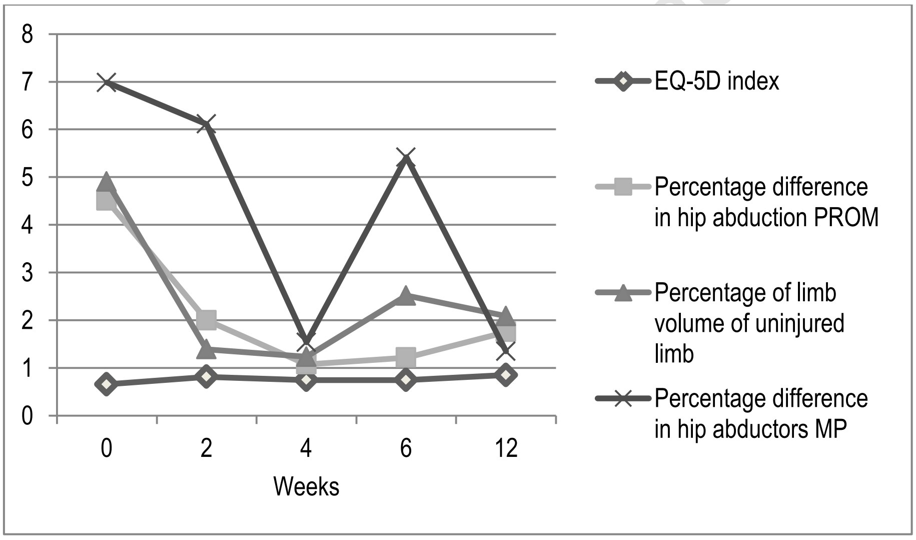


b)

Appendix A 30: Participant Six: EQ-5D index and hip function associated with PROM 0f (a) hip flexion and (b) hip abduction.

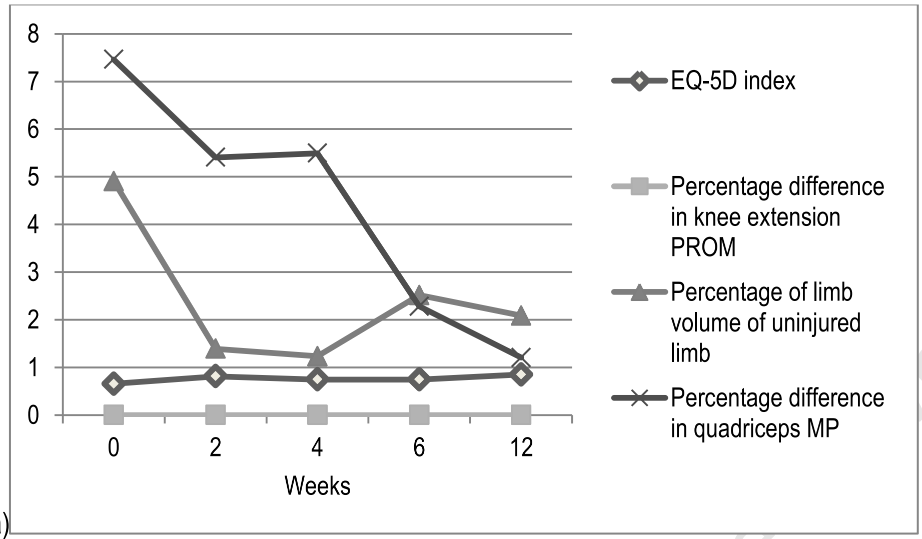


a)

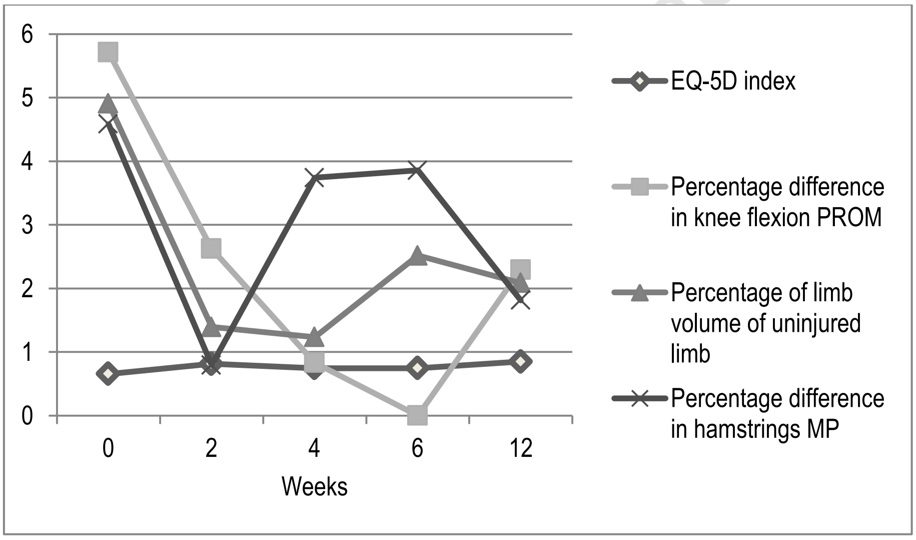


b)

Appendix A 31: Participant Six: EQ-5D index and knee function associated with PROM of (a) knee extension and (b) knee flexion.

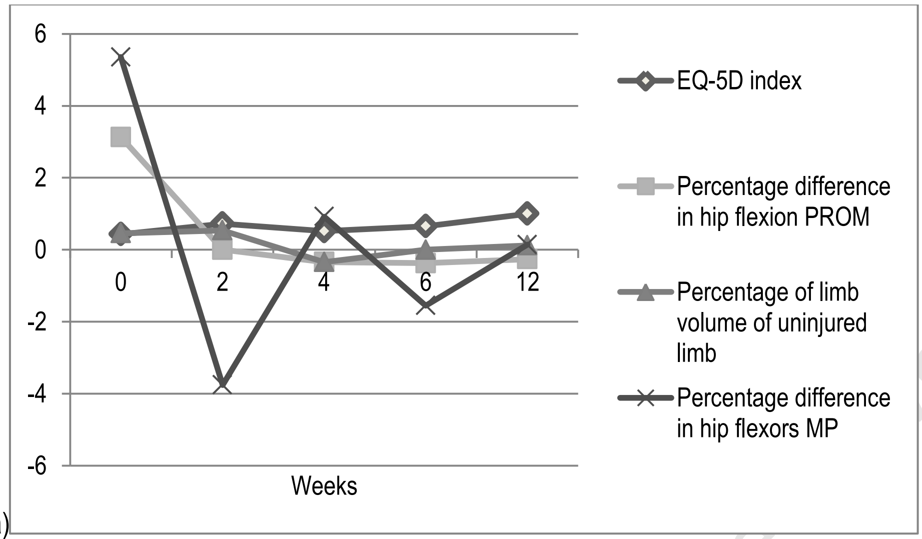


a)

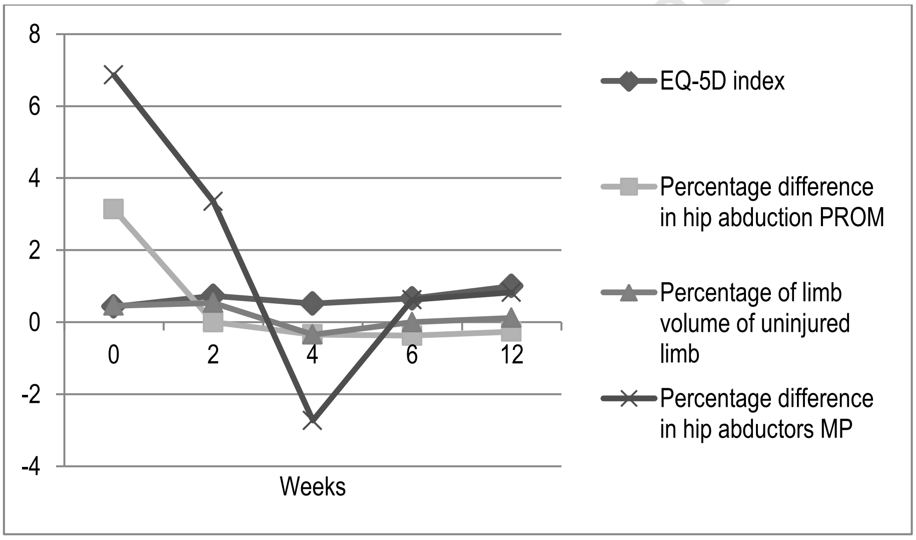


b)

Appendix A 32: Participant Seven: EQ-5D index and hip function associated with PROM of (a) hip flexion and (b) hip abduction.

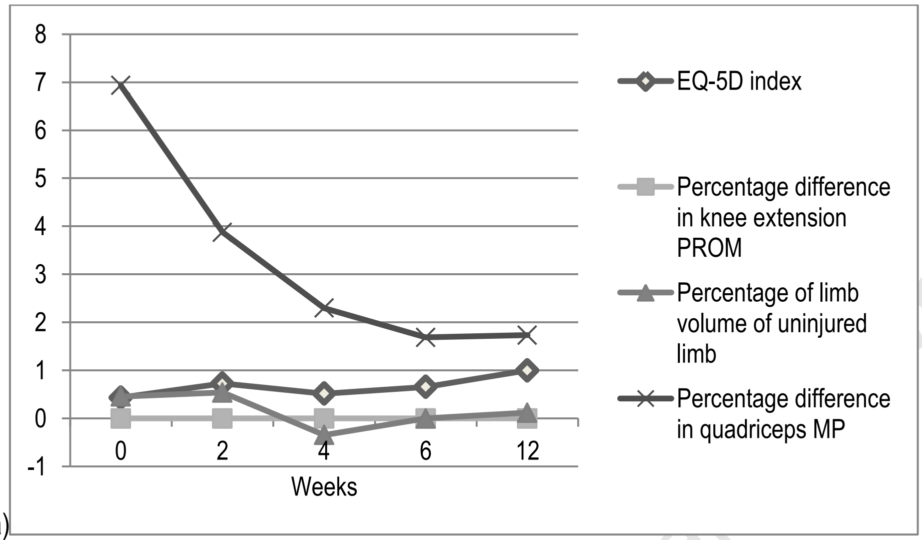


a)

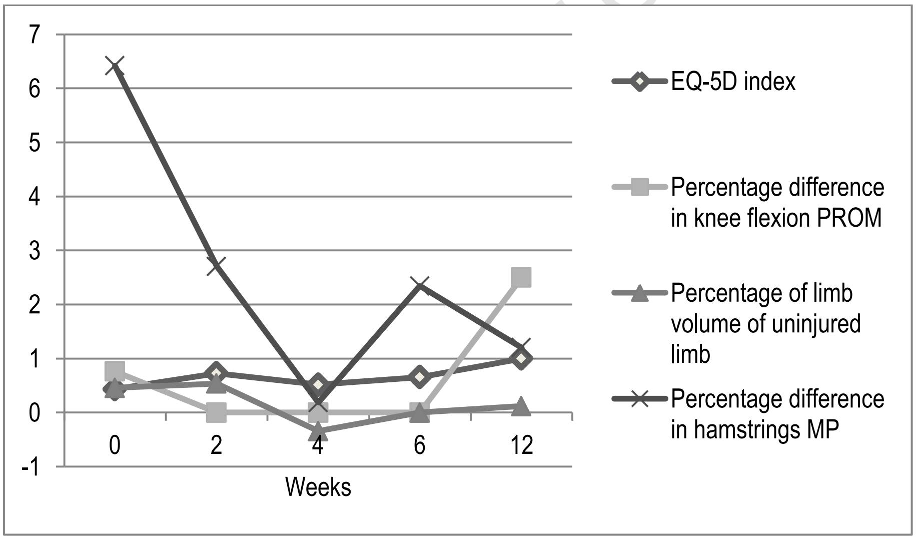


b)

Appendix A 33: Participant Seven: EQ-5D index and knee function associated with PROM of (a) knee extension and (b) knee flexion.

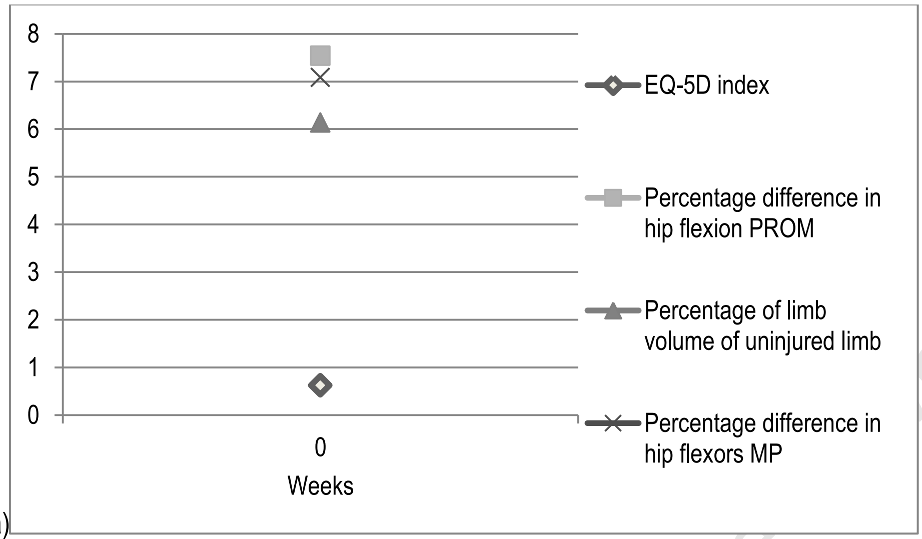


a)

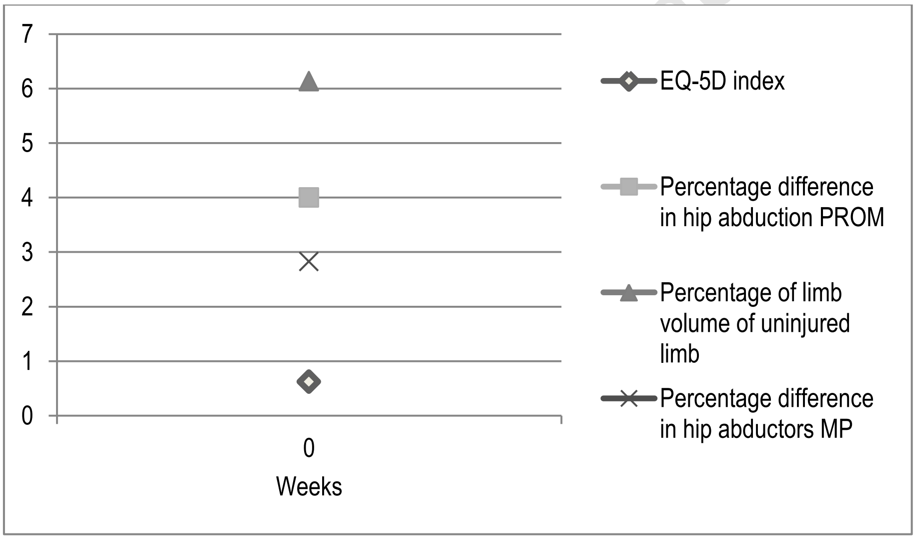


b)

Appendix A 34: Participant Eight: EQ-5D index and hip function associated with PROM of (a) hip flexion and (b) hip abduction.

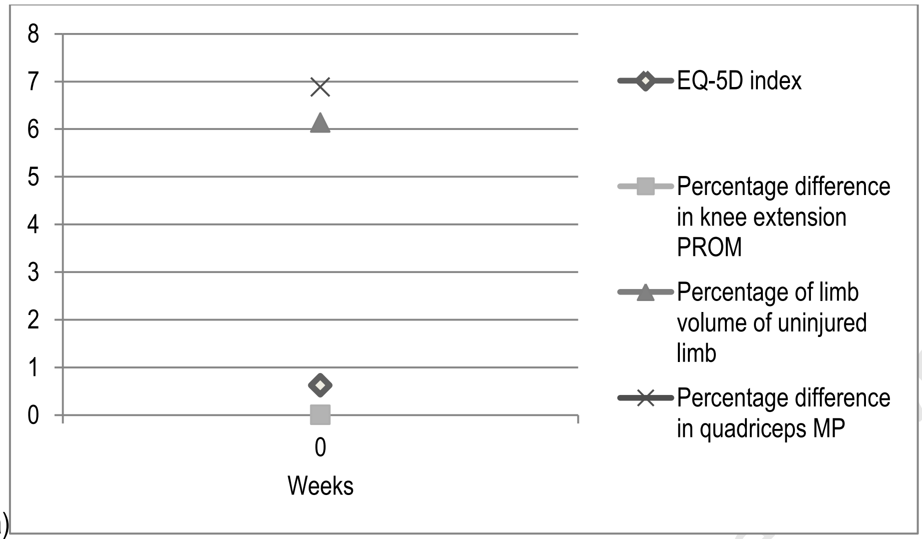


a)

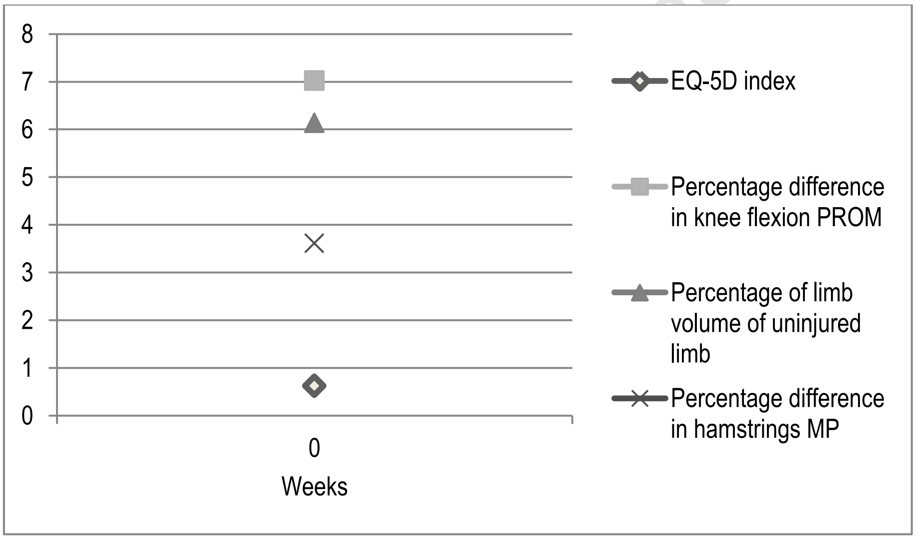


b)

Appendix A 35: Appendix Eight: EQ-5D index and knee function associated with PROM of (a) knee extension and (b) knee flexion.



a)



b)

Appendix A 36: Ethics approval letters for the chart review study.

UNIVERSITY OF CAPE TOWN

Health Sciences Faculty
Human Research Ethics Committee
Room E52-24 Groote Schuur Hospital Old Main Building
Observatory 7925
Telephone [021] 406 6338 • Facsimile [021] 406 6411
e-mail: shuretta.thomas@uct.ac.za

20 February 2012

HREC REF: 051/2012

Ms R Siebritz
c/o Ms R Parker
Physiotherapy
Health & Rehab
F-Floor, OMB

Dear Ms Siebritz

PROJECT TITLE: PREDICTORS OF HEALTH-RELATED QUALITY OF LIFE IN PATIENTS WITH FEMORAL SHAFT FRACTURES.

Thank you for submitting your study to the Faculty of Health Sciences Human Research Ethics Committee for review.

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study.

Approval is granted for one year till the 28th February 2013.

Please submit a progress form, using the standardised Annual Report Form (FHS016), if the study continues beyond the approval period. Please submit a Standard Closure form (FHS010) if the study is completed within the approval period.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please quote the HREC. REF in all your correspondence.

Yours sincerely

PROFESSOR M BLOCKMAN
CHAIRPERSON, HSF HUMAN ETHICS
Federal Wide Assurance Number: FWA00001637.
Institutional Review Board (IRB) number: IRB00001938

This serves to confirm that the University of Cape Town Human Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical Research Council (MRC-SA), Food and Drug Administration (FDA-USA), International Convention on Harmonisation Good Clinical Practice (ICH GCP) and Declaration of Helsinki guidelines.

The Human Research Ethics Committee granting this approval is in compliance with the ICH Harmonised Tripartite Guidelines E6: Note for Guidance on Good Clinical Practice (CPMP/ICH/135/95) and FDA Code Federal Regulation Part 50, 56 and 312.

s.thomas

Western Cape Government

Health

DIRECTORATE: HEALTH
Groote Schuur Hospital
Enquiries: Dr Bhavna Patel
E-mail : *Bhavna.Patel@pgwc.gov.za*

Ms R. Siebritz
Physiotherapy Department
E-55 – Old Main Building

E-mail: ruthiesiebritz@gmail.com

Dear Ms Siebritz

RESEARCH: Predictors Of Health-Related Quality Of Life In Patients With Femoral Shaft Fractures

Your recent letter to the hospital refers.

You are hereby granted permission to proceed with your research.

Please note the following:

a) Your research may not interfere with normal patient care
b) Hospital staff may not be asked to assist with the research.
c) No hospital consumables and stationary may be used.
d) No patient folders may be removed from the premises or be inaccessible.
e) Please introduce yourself to the person in charge of an area before commencing.

I would like to wish you every success with the project.

Yours sincerely

DR BHAVNA PATEL
SENIOR MANAGER: MEDICAL SERVICES
Date: 27th January 2012

G46 Management Suite, Old Main Building,
Observatory 7925

Private Bag X,
Observatory, 7935

Appendix A 37: Data collection sheet for the chart review study.

Category:	Drop down menu options:	References
DEMOGRAPHIC DATA		
Patient Number	None	
Date of birth	None	
Age	1,2,3,4,5,6,7, etc	[41-42]
Sex	Male Female	[28, 41]
Employment status	Employed Unemployed Social grant recipient Unknown	
MEDICAL HISTORY DATA		
Source of referral to Groote Schuur Hospital	Community Health Centre (CHC) Secondary Hospital Tertiary Hospital Trauma Unit	[43]
Date of admission	None	
Mechanism of injury	GSW, MVA pedestrian, MVA driver, MVA passenger, MVA cyclist, cyclist, fall, sports injury, recreational	[6, 14, 21]
Site of injury	Left (L) or right (R) leg	
Type of fracture pattern	Comminuted, transverse, spiral, segmental, oblique, pathological	[61]
Type of surgical approach	Trochanteric or piriformis entry point	[49]
Date of hospital discharge	None	
Length of hospital stay	Days: 1 - 20	[46]
Duration of surgery	Minutes	[28]
Duration of anaesthesia	Minutes	
Qualification of individual who performed initial physiotherapy assessment	4^{th} year Physiotherapy student Physiotherapy Assistant Community Service Physiotherapist Physiotherapist	

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Number of inpatient physiotherapy sessions	1,2,3,4,5,6,7 etc	52
Date of first OPD appointment	None	
Date of discharge from OPD	None	
Number of OPD visits	1,2,3,4,5,6,7 etc	
Known co-morbidities	Endocrine disorders Diabetes mellitus type 1 Diabetes mellitus type 2 Hyperthyroidism. Cardiac disease Hypertension Myocardial infarction Ischaemic heart disease Respiratory disease COPD TB Neurological disease Gulliane Barre Syndrome Psychological disorders Depression Schizophrenia Bi Polar Psychosis Rheumatologic Osteoarthritis Rheumatoid arthritis Fibromyalgia Ankylosing spondylitis Osteoporosis Nutritional deficiency Obesity Anorexia RVD None	28, 43

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Adherence with fracture treatment	Yes No	28
Reason for loss of adherence with attendance at OPD		
Reason for discharge from OPD	Discharged by surgeon, Transferred to another institution for continuation of management Non attendance Refusal of treatment by patient	
Date of discharge from OPD	none	
Referral route if not followed up at GSH	Peripheral hospital Hospital in a different province	

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Appendix A 38: Revised version of the WHODAS II used in the chart review study.

I Demographic Information Sex	M \ F
Age	
How many years spent studying at school, college or university	
Best description of the main work status	Paid work Self employed Non-paid work (volunteer, charity worker) Student Keeping house/ home maker Unemployed (health reasons) Unemployed (other reasons) Other (specify) ____________________

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Key:

1 No disability observed

2 Mild disability; the patient is able to complete a task independently with slight effort

3 Moderate disability; the patient has difficulty completing a task but is able to perform the task independently with increased effort

4 Severe disability; the patient has much difficulty in completing a task and may require help

5 Cannot do; the patient is unable to perform a task specified

6 Not enough information available in the folder

II Mobility Does the patient struggle to walk independently?	**Admission to Hospital**	**Discharge from Hospital**	**OPD Follow up**
Does the patient require the use of an assistive device to mobilise? (crutches, Zimmer frame, walking stick, wheelchair)			
How far can the patient walk?			
Is the patient able to stand up from sitting down independently?			
III Self Care Is the patient able to wash and dry his\her entire body?			
Is the patient able to dress him\herself?			
Is the patient able to feed him\herself?			
Is the patient able to toilet independently?			
IV Life Activities Is the patient able to cope with household errands and duties?			
V Participation Is the patient able to engage in normal activities with neighbours, friends and families in the community?			

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