A STUDY ON RANGE OF HIP AND KNEE MOTION IN NORMAL INDIVIDUALS PERFORMING MUSLIM PRAYERS

Dr. Siva Thangaraju

MMed Orthopaedic

Department of Orthopaedic

School Of Medical Sciences, University Sains Malaysia

Health Campus, 16150 Kelantan, Malaysia

Introduction: There are 1.6 billion Muslims in the world, and the act of praying represent a paramount and fundamental activity of daily living in their community. They need to adopt several postures that require deep flexion of knee and hip joints to carry out this daily ritual. The increased demand in the range of motion for the lower limb joints has been a focus of interest, in the improvement of arthroplasty implants. This will allow an individual to carry out their responsibility as a Muslim and be well received in this society. However, there is a lack of data on normative range of motion studies for the knee and hip joint during Muslim prayers.

Objectives: The main intention of this study was to simultaneously obtain normative passive range of flexion data and the functional range of flexion during Muslim prayers in the knee and hip joints of normal young Malay individuals. The secondary aim of the study was to

associate the body mass index, abdomen and limb circumference influencing the differences in hip and knee flexion angles.

Samples and Methods: A cohort of 127 Malay males aged between 20 and 30 years were recruited in this cross sectional study. Passive range of motion (PROM) and the flexion angle of the knee and hip joints were measured using a standard goniometer. Demographic and the range of motion data were collected. The effects of body mass index (BMI), abdominal circumference (AC) and limb circumferences (LC) on range of motion were analyzed.

Results: The recorded mean flexion for Muslim prayers was 0.24, 128.52 and 163.59 degrees for the knee during bowing, prostration and sitting respectively. The mean flexion in the hip joint for the said movement was 53.67, 92.52 and 75.15 correspondingly. The variables BMI and AC demonstrated a significant correlation with the knee joint (R^2= 0.66). Whereas BMI was the only variable showing correlation for the hip joint (R^2= 0.49).

Conclusions: The mean (SD) of the passive knee flexion and passive hip flexion were 141.10(6.60) and 122.10(8.70) degrees respectively which are similar to the values reported previously in the literature. The BMI had significant correlation with both the knee PROM as well as the hip PROM, whereas, the abdominal circumference had only significant correlation for the knee PROM. The limb circumference did not have any significant correlation with both the knee and hip PROM. The predictive equation was also obtained by regression analysis to determine the expected degree of flexion in our local population and is included in the study.

The mean ranges of knee and hip flexion arc in this study were from 0.24 to 163.59 and from 53.67 to 92.52 degrees respectively for Malay youths, to perform prayers.

Dr. Abdul Nawfar Sadagatullah: Supervisor

Dr. Mohammad Paiman: Co- Supervisor

A STUDY ON RANGE OF HIP AND KNEE MOTION IN NORMAL INDIVIDUALS PERFORMING MUSLIM PRAYERS

BY: DR SIVA THANGARAJU

DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT

FOR THE DEGREE OF MASTER OF MEDICINE

(ORTHOPAEDICS)

UNIVERSITI SAINS MALAYSIA

MAY 2010

ACKNOWLEDGEMENTS

I wish to express my utmost gratitude to the following individuals without whose efforts, it would have become impossible for me to submit this thesis:

First and foremost I would like to thank Dr. Abdul Nawfar Sadagatullah my supervisor who conceptualized the idea of doing this research and guided me till the end. I am ever grateful for his enthusiasm and support. I thank Dr. Mohammad Paiman from the Department of Orthopaedic, University Sains Malaysia, for extending his knowledge and contribution to this study. My appreciation goes to Dr Kamarul Imran from the Department of Community Medicine, University Sains Malaysia, for his help in rendering the statistical analysis and inference.

The contribution of all the students who participated and made this possible is much appreciated and will be treasured.

The role of Razi B. Masani and Mohd Hatif B. Kamail in helping me during collection of data can never be thanked enough. Their contribution will always be remembered.

Dr. Siti Sara , Dr. Najib Majdi and Dr Suhaily for their combined efforts in solving the difficult equations during statistical analysis of this study.

My dearest friend Dr. TP Kannan for his support and encouragement to complete this dissertation.

Last but not least, this will not be possible without my understanding and lovely wife, Aarthie and my naughty loving daughter, Aditi who gave me an inner strength and support to complete this study.

TABLE OF CONTENT

CHAPTER 4 –RESULTS

CHAPTER 5 – DISCUSSION

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATION

ADL	**Activity of daily living**
AC	**Abdominal circumference**
BMI	**Body mass index**
LC	**Limb circumference**
PROM	**Passive range of motion**
ROM	**Range of motion**

ABSTRAK

PENGUKURAN JULAT PERGERAKAN SENDI PINGGUL DAN LUTUT KETIKA MENGERJAKAN SOLAT BAGI INDIVIDU NORMAL

Umat Islam diseluruh dunia berjumlah lebih kurang 1.6 juta dan solat adalah merupakan ibadat terpenting di dalam aktiviti kehidupan seharian mereka. Ibadat solat memerlukan pergerakan yang maksima pada sendi pinggul dan sendi lutut untuk melaksanakan posisi- posisi khas ketika bersolat. Kesempurnaan pergerakan sendi pinggul dan sendi lutut menjadi isu utama khususnya untuk pembedahan penukaran sendi digolongan masyarakat Muslim. Walaubagaimanapun, data untuk pergerakan biasa sendi pinggul dan sendi lutut sewaktu mengerjakan solat masih kurang. Kepentingan kajiaan ini adalah untuk mendapatkan sudut pergerakan normal sendi pinggul dan sendi lutut termasuk ketika melaksanakan ibadat solat untuk masyarakat Islam.

KAEDAH

Sebanyak 127 subjek lelaki Melayu berumur antara 20 hingga 30 tahun telah dipilih untuk kajian ini. Sudut pergerakan sendi pinggul dan sendi lutut diukur menggunakan alat ‘goniometer’. Data keseluruhan pergerakan sendi pasif dan ketika solat dicatatkan. BMI, ukur lilit perut, peha dan betis turut di ambil untuk analisis berkaitan dengan pergerakan sendi-sendi yang terlibat dalam kajian ini.

KEPUTUSAN

Corak keseluruhan pergerakan sendi terbabit telah dianalisa dan disertakan sebagai ukuran maksima, minima dan min berserta ralat SD. Pergerakan pasif sendi pinggul dan sendi lutut yang diperolehi dalam kajian ini telah dibandingkan dengan data-data yang sedia ada. BMI dan ukur lilit perut menunjukkan hubungan dengan pergerakan sendi lutut (R^2=0.66). Manakala BMI sahaja menunjukkan hubungan dengan sendi pinggul (R^2=0.49).

Secara keseluruhan tahap belok (flexion) min sendi lutut semasa solat adalah 0.24, 128.52 dan 163.59 darjah semasa rukuk, sujud dan duduk antara dua sujud. Tahap belok min sendi pinggul pula adalah 53.67, 92.52 dan 75.15 darjah untuk pergerakan tersebut.

KESIMPULAN

Min (SD) untuk pergerakan pasif sendi lutut dan sendi pinggul adalah 141.10(6.60) dan 122.10(8.70) darjah, seperti mana dalam kajian-kajian lain yang seumpamanya. BMI berhubungkait untuk pergerakan sendi lutut dan sendi pinggul. Manakala ukur lilit perut berhubungkait untuk pergerakan sendi lutut sahaja. Ukur lilit peha dan betis tidak berhubungkait untuk pergerakan sendi lutut dan pinggul. Analisa regrasi telah digunakan untuk membuktikan kaitan- kaitan tersebut.

Secara keseluruhan pergerakan min sendi lutut dan pinggul yand didapati dalam kajian ini adalah dari 0.24 hingga 163.59 darjah dan dari 53.67 hingga 92.52 darjah untuk keperluan masyarakat Melayu muda melaksanakan ibadat solat.

ABSTRACT

RANGE OF HIP AND KNEE MOTION IN NORMAL INDIVIDUALS PERFORMING MUSLIM PRAYERS

INTRODUCTION

There are 1.6 billion Muslims in the world, and the act of praying represent a paramount and fundamental activity of daily living in their community. They need to adopt several postures that require deep flexion of knee and hip joints to carry out this daily ritual. The increased demand in the range of motion for the lower limb joints has been a focus of interest, in the improvement of arthroplasty implants. This will allow an individual to carry out their responsibility as a Muslim and be well received in this society. However, there is a lack of data on normative range of motion studies for the knee and hip joint during Muslim prayers. The intention of this study was to simultaneously obtain normative passive range of flexion data and the functional range of flexion during Muslim prayers in the knee and hip joints of Malay individuals.

METHODS

A cohort of 127 Malay males aged between 20 and 30 years were recruited in this cross sectional study. Passive range of motion (PROM) and the flexion angle of the knee and hip joints were measured using a standard goniometer. Demographic and the range of motion data were collected. The effects of body mass index (BMI),

abdominal circumference (AC) and limb circumferences (LC) on range of motion were analyzed.

RESULTS

The demographic and range of motion data was tabulated and presented as minimum and maximum range, mean and standard deviation. The passive range of motion for the knee and hip joints in this study was comparable to other existing normative range of motion database. The variables BMI and AC demonstrated a significant correlation with the knee joint (R^2= 0.66). Whereas BMI was the only variable showing correlation for the hip joint (R^2= 0.49).

The recorded mean flexion for Muslim prayers was 0.24, 128.52 and 163.59 degrees for the knee during bowing, prostration and sitting respectively. The mean flexion in the hip joint for the said movement was 53.67, 92.52 and 75.15 correspondingly.

CONCLUSION

The mean (SD) of the passive knee flexion and passive hip flexion were 141.10(6.60) and 122.10(8.70) degrees respectively which are similar to the values reported previously in the literature. The BMI had significant correlation with both the knee PROM as well as the hip PROM, whereas, the abdominal circumference had only significant correlation for the knee PROM. The limb circumference did not have any significant correlation with both the knee and hip PROM. The predictive equation was also obtained by regression analysis to determine the expected degree of flexion in our local population and is included in the study.

The mean ranges of knee and hip flexion arc in this study were from 0.24 to 163.59 and from 53.67 to 92.52 degrees respectively for Malay youths, to perform prayers.

Introduction

1.1 Background of the study

The knee and hip are major weight bearing joints that play an important role in attaining necessary postures vital to our activities of daily living. Restrictions in these joint functions will impede our lifestyle significantly. One of the many causes for limitation in the range of motion is osteoarthritis, a leading chronic illness affecting the joint in the world (Das and Farooqi, 2008, Michael *et al.*, 2010). The treatment modalities are primarily aimed to reduce pain and to provide adequate function of the affected joint. Total joint replacement is the mainstay of surgical treatment for knee and hip osteoarthritis that has evolved over the years and the current focus is on improvement of function by attaining satisfactory motion that allows the patient to return to an everyday lifestyle.

Joint range of motion assessment is a significant clinical variable in the assessment of musculoskeletal system. This measurement is widely applied to evaluate outcomes of treatment such as in knee or hip replacement and in research fields. Physicians, therapists and researchers rely on normal range of motion data as reference value in the assessment of disabilities, effectiveness of therapy and development of orthopedic devices. Normative data proves to be of more value if assessed in activities of daily living. Previous work had established satisfactory knee flexion is required for various activities of daily living; 67 degrees is required for the swing phase of gait, 83 degrees for climbing up stairs, 90 degrees for descending stairs, and 93 degrees for rising up from a chair (Laubenthal *et al.*, 1972). This reported knee range of motion is considered adequate for European and North

American lifestyle. However, a much higher range is required in the Muslim population as their cultural and religious activities demands full flexion of the lower limbs (Hefzy *et al.*, 1998).

Among the various activities of daily living, one that is important and common for the majority of our local population (all Malays) is the act of prayers. Muslim prayers or "Salat" is a spiritual and physical act involving standard movements of the body; this ritual includes standing, bowing, prostration and sitting. Several components acting in concert helps to attain the necessary postures for their daily act of worship, and the knee and hip joint movement is an important and relevant component. Thus, the ability to perform prayers significantly relies on the range of knee and hip flexion and it is of main concern for Muslim patients indicated for total knee or hip replacement. Hence, an implant that is capable of alleviating the pain and provide the range of motion necessary for prayers will have an enhanced impact in this community. The former is the success story of all total hip and knee implants; where else the latter remains a hotly debated issue. Clearly defining the range of motion for the hip and knee joint during prayers will lead the way towards development of implant that will satisfy the basic needs of this wide group of people.

1.2 Problem statement

There are 1.65 billion Muslims in the world constituting 24% of the world population. A very significant number of them (236 million) reside in the Southeast Asia region that includes Malaysia (Kettani, 2010). Cultures are different among the eleven countries in this region but a common and a vital part of their activity of daily

living is the act of praying. It is documented that a person may be expected to pray from the age of 7 years, five times a day resulting in a significant number of knee and hip flexion over a lifetime an estimate of 70 times a day (Gibson *et al*., 1996).

It is crucial for every Muslim to be able to perform various postures which requires significant amount of flexion of the lower limb joints to fulfill their responsibilities. Mulholland and Wyss, (2001) acknowledged in their review article, that these positions in non-westerners demands greater range of motion as compared to their western counterparts. This increased demand of flexion has been the focus of research into development of knee and hip replacement implants suitable for this vast community (Nakamura *et al.,* 2009). Normative range of motion studies during functional activities have laid the ground work for detailed and specific studies, which have contributed in the design and development of joint prosthesis and ascertain the goal to thrive in arthroplasty surgery (Laudoucer, 2000). However, there remains until today, a lack of information on the knee and hip flexion angles related to different postures in Muslim prayers from an orthopedic point of view.

1.3 Justification of the study

Research in this field will provide us a reference range on the flexion of hip and knee joints that is required for a Muslim to perform the daily prayers. This data can used for counseling patients elected for joint replacement, in setting of rehabilitative goals and in development of orthopedic devices that meets the range of knee and hip flexion necessary for the daily prayers for Muslims.

1.4 Objectives

1.4.1 General objective

To determine the characteristics of knee and hip flexion during Muslim Prayers in the local population.

1.4.2 Specific objectives

1. To determine the hip and knee flexion angles during different postures of Muslim prayers in healthy young Malays

2. To determine the normal passive range of motion for the hip and knee joints in healthy young Malays

3. To associate the body mass index, abdomen and limb circumference influencing the differences in hip and knee flexion angles

1.5 Research hypothesis

The range of motion obtained in this study does not significantly influence the flexion of hip and knee joints as compared to existing normative data.

2.0 Literature review

2.1 Activities of daily living

Activities of daily living (ADL) are defined as the activities which are both necessary and optional to experience a full and healthy life (Mulholland and Wyss, 2001). As the term implies many activities are universal and performed on a daily basis such as eating, dressing and toileting. However, they are done differently according to various cultures.

Religious practices are identified as being essential to the experience of life and are included as ADL. It is influenced by culture, climate, geography and religion. Though religious beliefs remains the same, the activities or postures adopted to conduct these activities vary both between and within a given culture (Meghani and Wise, 1996).

This has been recognized and its importance has lead to substantial work towards research and development of medical technologies, tailored to suit individuals of various cultural backgrounds. In order to develop cultural sensitive technologies, it is important to fully understand which activities are important to a given culture and how these activities are preformed (Meghani and Wise, 1996, Mulholland and Wyss, 2001). When dealing with joint replacement, for the prosthesis to be well accepted, it must allow the patient to be able to perform their activities of daily living. This was reflected by the works of several researchers contributing to range of motion studies in activities of daily living in the non western community (Laubenthal *et al.*, 1972, Hefzy *et al.*, 1998, Laudoucer, 2000, Mulholland and Wyss, 2001, Brown,

2004). It has been established that satisfactory range of motion (ROM) is one that allows an individual to accomplish a certain posture to perform ADL adequately. Studies on range of motion are the foundation for development of improved implants; customized to accomplish key activities of daily living for the respective individual of various cultures.

2.2 Previous normative data

The most cited and used data bases for ROM was published in a handbook in 1965 by the American Academy of Orthopaedic Surgeons (AAOS) (Desrosiers *et al.*, 1995b, McIntosh *et al.*, 2003). It was the first standardized manual for recording and measuring joint motion that was published (AAOS, 1965). However, the methodology used and the details of samples were not clearly specified. This database has been used as the gold standard for range of motion studies, but the values obtained in the other studies were consistently smaller (Desrosiers *et al.*, 1995b, Ira *et al*., 1995). Because of discrepancies when compared with other normative studies, the use of AAOS database as reference may be inappropriate (Macedo, 2007).

Boone and Azen, (1979) created a normative database from 109 normal male subjects, measuring range of motion of the upper and lower extremities. The subjects were divided into six groups based on age and they found significant difference in the ROM between age groups, with younger group having more range than the older group in most joints. Their data was compared to the manual by AAOS and represent a more detailed set of measurement, based on a sample described according to height and age.

In Sweden, Roaas and Andersson, (1982) studied the normal range of motion of the hip, knee and ankle joints in male subjects between 30 and 40 years of age from a randomized sample from the population in the city of Goteborg. This study used techniques suggested by the AAOS and noted significant difference. They attributed the variation due to measurement procedure, difficulties in measurement techniques, patient material and inter individual variations. This study suggested that there was no statistical significant between the range of motion obtained for the left and right side.

Roach and Miles, (1991) established a large population based normative values for hip and knee ROM by age, race and sex. This study involves a secondary data analysis of public use data from the first National Health and Nutrition Examination Survey conducted by National Center for Health Statistics between 1971 and 1975, which involved a national probability sample of persons drawn from the civilian non-institutionalizes population of the United States. The analytical sample consists of 1,892 subjects of which 1,313 whites and 370 blacks were used. They found difference between data obtained in this study and estimates found in textbooks (Appendix A). The differences in the mean active ROM were generally small ranging from 3 to 5 degrees between the oldest age group and youngest age group and concluded that at least to the age of 74 years, any substantial loss of joint mobility should be viewed as abnormal and not attributable to aging and therefore should be treated much as it would be in a younger individual.

There were other papers in the literature that have tried to develop normal data for ROM. Some determines ROM in newborn, children, elderly from 60 years and up and others were specific to joints of the upper limb (Pellino *et al*., 1984, Broughton *et al.*, 1993, Schwarze and Denton, 1993, Desrosiers *et al.*, 1995a, Gunal *et al.*,

1996, Sabari *et al.*, 1998, McIntosh *et al.*, 2003). These studies used different instruments or positioning techniques, different protocols and methods making the reproducibility and comparisons between their normal data difficult.

A much recent normative database for range of motion was created by Norkin and White (2003) in their book 'Measurement of a joint motion: a guide to goniometry' based on available values of different studies in the literature. They have tabulated the range of motion according to specific joints and the studies providing the data along with number and age of the subject (Appendix B). It is notable that the most of these papers addressed ROM of shoulder, hip, and knee joints. Based on the joint, different age groups were measured and the data varies for each age group and for each joint. Again, the studies mentioned cannot be generalized as different techniques and protocols were used, making comparisons between the values inappropriate.

2.2.1 Active Range of Motion

Movement of joints can be measured differently depending on the actual force acting to produce the arc of motion, active range of motion or passive range of motion. Active ROM is defined as the voluntary motion of the subject's body parts through its full range of motion, without assistance of someone applying an external force. Active ROM is a better indicator of actual motion used during normal activities of daily living and function. However, this measurement is strongly dependent on the subjects and can be influenced by many factors such as muscle strength, pain, individual's threshold for pain, effort, motivation and attitude (Gerhardt *et al.*, 2002).

2.2.2 Passive Range of Motion

Passive joint motion was defined as any movement of an articulation that is "produced by some external source". The source is any force other than the neuromuscular unit that would normally be powering the joint under voluntary control (active joint motion). Example of such external forces include force of nature (gravity) other muscles (supportive motion by the patients normal extremity or supportive motion by a therapist) and artificially applied devices (Frank *et al.*, 1984).Thus passive range of motion occurs when the examiner moves the subject's articulated joints through their full range of motion. This is reported to be a better indicator of the actual ROM of a joint, however passive ROM is greatly influenced by the amount of external force applied by the examiner and it is hard to standardize (Gerhardt et al., 2002). The ability of the examiner to consistently determine the end range through the end feel of the joint motion or the compensations happening at a joint or its consecutive joints (Norkin and White, 2003).

2.2.3 Range of motion in Activities of Daily Living in non-western culture

In a literature review on activities of daily living in non western culture, the range of motion requirements for the hip and knee joint implants were investigated. This study highlights that though there are several activities common in Asia and the Middle East which demands greater range of motion compared to that typically required in western population, there is still a lack of documented research and inconsistent data in this area. The authors stressed the importance of culture and function in development of arthroplasty implants (Mulholland and Wyss, 2001). Several studies have embarked on analyzing the common activities in these regions; various postures have been documented like squatting, sitting cross legged, and

kneeling (Hefzy *et al.*, 1998, Schai *et al.*, 1999, Laudoucer, 2000, Hassaballa *et al.*, 2002, Hemmerich, 2004, Hemmerich *et al.*, 2006, Kapoor *et al.*, 2008).

Literature documenting Muslim prayer postures and the respective functional ROM are sparse. Hefzy *et al.* (1998) described knee flexion during kneeling in four subjects as 150 to 160 degrees of flexion in Saudi Arabia. However, this was a radiological study on kinematics on deep knee flexion. A normative ROM study in Saudi reports average passive knee and hip flexion to be 159.6 and 130.8 degrees respectively. This study reflects the increased demand of joint flexion in non-westerners and attributes the difference to cultural and racial factors in different geographic areas (Ahlberg *et al.*, 1988). In contrast, a Japanese, an Iranian and an Indian ROM normative data studies document ranges that were comparable to western studies (Tomoaki Shimada, 1988, Khalwat, 2005, Singh, 2008).

2.2.4 Range of motion in joint replacements

It has been documented in various studies that the average knee flexion after total knee replacement is around 120 degrees (Adam and Riyaz, 2009) in the past. However with the recognition of increased knee flexion that is essential in the activities leisure and of daily living the need of high flexion implants is realized. The flexion angle achieved with newer high flexion implants has been reported by many authors, the average being 140 degrees (Adam and Riyaz, 2009), but long term data is lacking. In contrast, investigations with regards to hip implant and the range of motion post operatively are not as extensive as research in knee arthroplasty. The reported hip flexion was as high as 115 degrees (Kenneth *et al.*, 2007). No other significant literatures citing better implant range of motion was present during the extensive literature search.

2.3 Range of Motion measurements

There are various methods and protocols described in the literature for measuring ROM in different joints. The two most cited protocols are the AAOS's manual and Norkin and White's ROM data base guide (Boone and Azen, 1979). The position of the patient, the position of the goniometer, and the stabilization of the joint and whether active or passive ROM was studied are some of the variations in methods that influence the results (Boone *et al.*, 1978). Another important factor leading to discrepancy in ROM data, is the avoidance of any type of compensatory movement at the joint being measured or at the adjacent joints. It was found in one study that by simple stabilization of the scapula and avoidance of compensatory movement, inter and intra examiner reliability of the measurement was improved significantly (Awan *et al*., 2002). Standardization of methods can increase the reliability of ROM measurement (Gajdosik and Bohannon., 1987). Validated and reliable methods ROM measurements are important for comparison between measurement and can only be done if there is no significant variation between the testing techniques (Bohannon *et al.*, 1989). The protocol of ROM measurement described by Norkin and White (2003) was often used and cited in the literature because it was well designed taking into consideration an important number of reliability studies and the stabilization concept and hence it was decided to use this protocol to measure ROM in this study.

2.3.1 Methods of measurement of Range of Motion

There are many different instruments that can be used to measure range of joint motion. They range from the simplest device to the highly sophisticated. A standard goniometer is simple, cheap and is extremely user friendly as compared to a three

dimensional motion system which is expensive, complicated and technically challenging. There are many reports on the use and properties of these instruments where some studies have examined the reliability of individual devices and reliability between devices. Most papers agree that these devices should not be used interchangeably (Rome and Cowieson, 1996; Armstrong *et al*., 1998).

The most cited and used instrument is the universal or standard goniometer followed by the inclinometer. The term “inclinometer” is defined as any of various instruments for measuring the inclination or amount of deviation from the vertical or horizontal degree of slope or slant. The standard goniometer, fluid goniometer, gravity reference inclinometer and electronic digital inclinometer all fall within this definition. The inclinometer has been reported to have good intrarater reliability and poor interrater reliability (Reese and Bandy, 2003). The goniometer was shown to have a similar reliability (Gajdosik and Bohannon, 1987, Gogia *et al.*, 1987, Riddle *et al*., 1987) and was most widely used tool in the literature and clinical practice.

2.3.2 Validity and reliability of goniometric measurements

Validity of an instrument of ROM measurement is the degree of correlation of that tool against a gold standard method that is universally acceptable. A radiographic technique to measure ROM has been used as the gold standard (Norkin and White , 2003). Two studies showed moderate to strong correlation between goniometer measurement and the gold standard (Brosseau *et al.*, 2001). Gogia *et al*., (1987), analyzed the reliability and validity of goniometer in measuring the knee joint ROM and comparing with radiographic ROM measurement. They used Pearson product-moment correlation coefficients (r's) and intraclass correlation coefficients (ICCs) to analyze the data. The data analysis revealed that the intertester reliability (r = .98;

ICC = .99) and validity (r = .97-.98; ICC = .98-.99) were high. The results of this study indicate that goniometric measurements of the knee joint are both reliable and valid.

Most studies on reliability of goniometric measurement concluded that the level of reliability was acceptable and that the intrarater reliability was higher than interrater reliability (Boone *et al.*, 1978, Gogia *et al.*, 1987, Gajdosik and Bohannon, 1987, Sabari *et al.*, 1998, Ellis and Bruton, 2002).

It is suggested, that emphasis on standardized technique, instrument calibration and well standardized stabilization are necessary to produce highly reliable results when the ROM is tested by the same examiner (Sabari *et al.*, 1998, Awan *et al*., 2002).

2.4 Factors influencing the measurement of Range of Motion

Barnes *et al.*, (2001), in his study on ROM of the shoulder joint suggested factors that may affect range of motion include age, gender, dominant side, occupation, level of physical activities and measurement technique used. No study for the knee and hip joints exist despite extensive literature search.

2.4.1 Age

It is assumed that ROM generally reduce with age because of the numerous changes occurring during the aging process, such as connective tissue changes that lead to loss of elasticity (Ira *et al*., 1995). There remains controversies regarding influence of age on ROM after the maturity with some reporting a decline with age (Youdas *et al.*, 1993, Barnes *et al.*, 2001) and others reporting no significance in ROM (Ira *et al*., 1995). Difference in age group, joint studied and methods of measurement make comparison inappropriate. ROM is reported to decrease with age between newborns

and 18 years of age as young children are very mobile and lose their mobility as the age increases (Steinberg *et al.,* 2006)

2.4.2 Gender

Studies shows women generally have greater range of motion than men (Svenningsen *et al.,* 1989, Desrosiers *et al.,* 1995b, Ira et al., 1995). These authors did not find the difference in all the joints nor the joints found to have the highest difference between genders the same for all studies. Most of the differences found were less than 10 degrees. The frequent joint that was studied was the large joints and normally has greater ROM and difference of less than 10 degrees may not be clinically significant.

2.4.3 Dominant side

Gunal *et al*., (1996), found that ROM of the non dominant side was generally greater than the dominant side with most of the difference being less than 7 degrees, in his study of upper limb ROM (Mulholland and Wyss, 2001). Boone and Azen, (1979) and Roaas and Andersson, (1982) respectively found that the ROM between sides were similar and concluded that non injured side could be used as reference for comparison if the presenting pathology was unilateral.

2.4.4 Other factors

Other factors that have associations with ROM have been explored with lesser vigor in the literature. These factors include body mass index, abdominal girth, and limb circumference. A population survey data in San Antonio community dwelling elderly, the BMI was documented to be negatively related to hip and knee flexion range (Escalante *et al.,* 1999). However, there were no documentation on correlation

between ROM and the abdominal circumference. One article discussing thigh-calf contact in deep knee flexion reports the contact occurs at smaller angle of flexion with increased circumference (Zelle *et al.*, 2007).

2.5 Praying postures in Muslim

"Salat" is the Arabic word for prayers offered by the Muslims. A Japanese group set out to emphasize the therapeutic value of 'salat' as a physical exercise of the musculoskeletal system for geriatric and disabled or handicapped people in rehabilitation program (Mohammed Faruque Reza *et al.*, 2002). They concluded that 'salat' involves little effort, has a short duration and is beneficial for mental and physical health. They have clearly described the various aspect of the prayer ritual that includes standing (Fig 2.1), bowing, prostration and sitting. Bowing is done by forward movement of the vertebral column, and supported by two straight hands grasping the two hyperextended knees (Fig 2.2). The act of prostration is done from the standing position to kneeling, putting the head down and touching the ground with the forehead, with the palms remaining parallel to the ears, and touching the ground with flexed elbows for a few seconds (Fig 2.3). Prayers are concluded by sitting on totally flexed knees with the feet in full plantar flexion (Fig 2.4). The active range of motion for each joint that were involved during different postures of 'salat' was measured using a standard goniometer in this study. However, the protocol of measurement and number of sample used was not defined in the study by Mohammed Faruque Reza *et al.* (2002).

There is yet another posture not defined in the above mentioned paper which is a variation of the sitting posture called the "Tahyat" where the individual sits

supported on a single limb. In this study the position of “Tahyat” was not included as a posture during prayers as it is not an agreed position in all the sects of Islam. This was based to the recommendation of the local religious authorities of the Islamic Center of the university where the study was done.

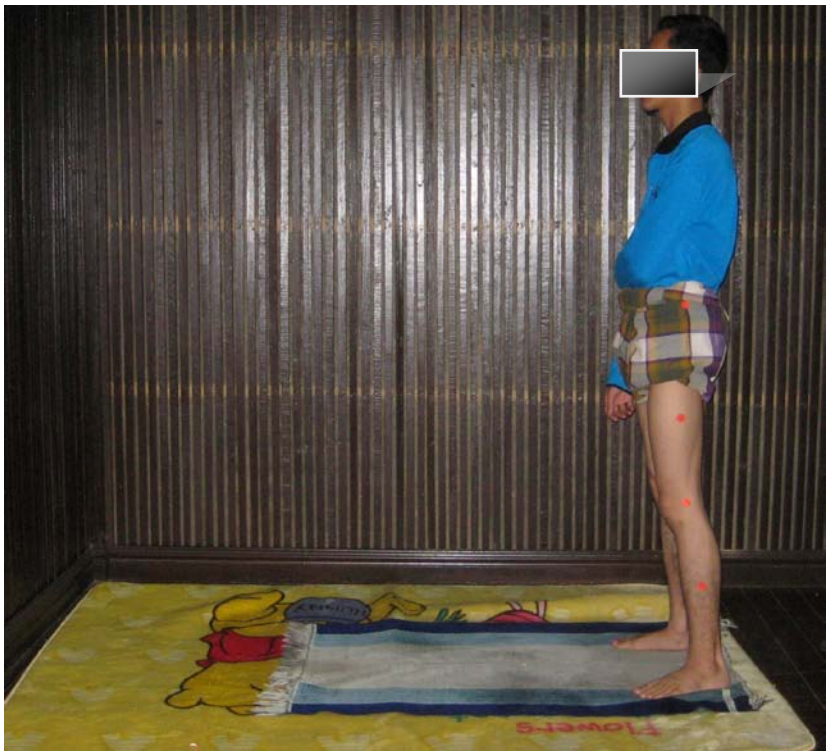

Figure 2.1 Standing - The starting posture of Muslim prayers

Figure 2.2 Bowing is done by flexing at the hip joint and extending the knee joint

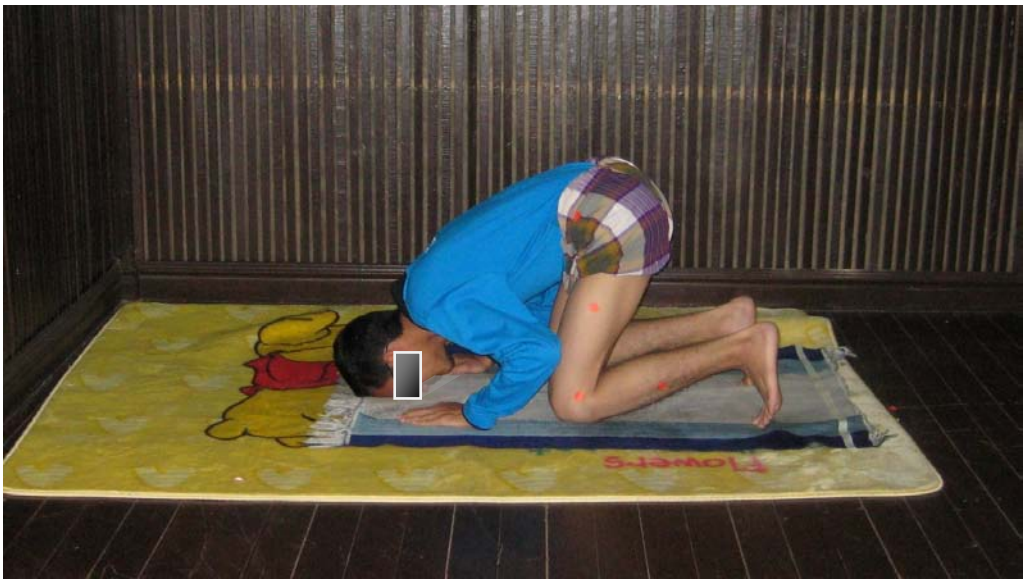

Figure 2.3 Prostration is done by touching the ground with the forehead

Figure 2.4 Final position of prayer done by sitting with maximum flexion of the knee joint

3.0 Materials and Methods

3.1 Study design

This is an observational cross-sectional study, which was conducted from February 2009 till January 2010 at Health Campus, Universiti Sains Malaysia, Kubang Kerian, Kelantan, Malaysia. This design focuses on the estimation of hip and knee ROM during Muslim prayers. The difference against existing normative ROM data base and the influence of different factors formed the core matter of this study.

3.2 Study samples

The reference population comprised of adult Malays of Malaysian origin. The undergraduate students from the School of Medical, Dental and Health Sciences, Health Campus, Universiti Sains Malaysia were the source population recruited in this study. The selection of only male Malays aged between 20 and 30 years were done to avoid possible confounders of age, race and gender to assure homogeneity of the samples. The exclusion of females from this study was at the recommendation of the school ethic committee. The reason cited was the certain degree of exposure of subjects involved was deemed inappropriate in view of the main and co-investigators were of the male gender.

3.3 Inclusion criteria

- Adult male Malays of Malaysian origin aged between 20 and 30 years
- No history of acquired or congenital affections or deformities of spine, hip and knees

3.4 Exclusion criteria

- Any pathological conditions like neurological or systemic that can affect the musculoskeletal system such as knee, hip, ankle or lumbosacral joint pain, stiffness or deformity
- History of previous surgeries to lower limbs or spine
- Involvement in high level of sports activities

3.5 Sample size calculation and sample recruitment

The sample size calculated with added non respondents of 10%, to fulfill the objective in comparing the difference between ROM for Muslim prayers and normative ROM for the hip and knee was 135. This was determined using the statistical analysis software (Stata) to estimate sample size for Pearson Correlation. A total of 127 subjects were recruited for this study.

Sample size calculation

.sampsi_rho, alt(0.25) power (.8)

Estimated sample size for Pearson Correlation

Test Ho: Rho alt = Rho nul, usually null Rho is 0

Assumptions:

Alpha = 0.0500 (two-sided)

Power = 0.8000

Null Rho = 0.0000

Alt Rho = 0.2500

Estimated required sample size:

n = 123.3157

Subjects were recruited using an advertisement directed at the local population (students) at the Health campus in USM, Kubang Kerian, Kelantan, Malaysia. The subjects were informed of the nature of study and explained about the inclusion and exclusion criteria. Only those who were willing to participate, met the criteria and gave consent were recruited in this study.

3.6 Research tools

3.6.1 Goniometer

A standard transparent goniometer with arms length of 35 cm and a protraction portion divided to 2 degrees segment was used to measure the ROM in this study. Prior to the study, the accuracy of the goniometer was determined by measuring 10 predetermined angles drawn using a protractor. Out of five goniometers tested, two that measured accurately were used alternatively for this study. The said goniometers measured the predetermined angles accurately at the end of the study

ruling out any possibility of instrument wear. The hip and knee joint ROM were measured bilaterally according to the goniometry technique suggested by Norkin and White, (2003) and hip and knee ROM during prayers was measured adhering to a standard protocol. Both these measurements were done by the same single examiner to avoid any discrepancies in the measurement values.

Figure 3.1 Standard goniometers used in this study

3.6.2 Anthropometric measurement

A standard clinical weighing scale and height scale were used to measure the height and weight of each subjects and recorded in kilograms and centimeters respectively. The true limb length, abdominal circumference and limb circumference was measured using a flexible measuring tape graduated by 1mm. These parameters were measured and recorded for both limbs in centimeters.

Figure 3.2 Flexible measuring tape

Figure 3.3 Height and weighing scale

3.7 Data collection

Those who were willing to participate in this study were briefed of the objectives and methodology of the study. The participants who met the inclusion and not excluded by the exclusion criteria were instructed to change into shorts or sarong which allowed full movement and facilitated measurement and localization of bony landmarks. This exercise was conducted in the “Dewan Utama”, a multipurpose hall of the university. The examination area was well enclosed, care being taken to protect the modesty of the subjects at all times during the course of observations.

After the consent forms (Appendix C) were filled in and signed, the subjects' anthropometric measurements were recorded in the data collection form (Appendix D). Next the measurements of passive knee and hip range of flexion was taken in a supine position on an examination couch. Data collection was completed by measuring the hip and knee range of motion during the postures of prayer, namely, bowing, prostration and sitting. These positions and photographs taken were verified by local authorities from the Islamic Center at the university (Appendix E).

3.7.1 Demographic and ROM data

i. National Identification Certificate number was recorded as proof of nationality
ii. Age was recorded in years
iii. Weight was measured to the nearest 0.5 kilograms with mechanical weighing machine
iv. Height was measured to the nearest 0.5 centimeter with height measurement scale
v. Body mass index was calculated using the formula weight in kilograms divided by height in meter square
vi. Dominant lower limb was determined by the leg of choice to kick a ball
vii. True length of both extremities was measured from the anterior superior iliac spine till the medial malleolus in centimeters, once confirming both limbs are positioned with a squared pelvis
viii. Intercondylar or intermalleolar distance was measured in centimeters with the subject standing and both heels leveled on a line on the prayer mat
ix. Abdominal girth was measured at the level of umbilicus in centimeters