



Knee Problems in Young Adults

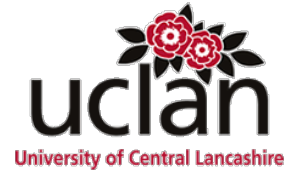
By

Chukwuemeka Onyebuchi Ibeachu

**A thesis submitted in partial fulfilment for the requirements for the
degree of Doctor of Philosophy at the University of Central
Lancashire**

June 2016

STUDENT DECLARATION FORM



Concurrent registration for two or more academic awards

I declare that while registered for the research degree, I was with the University's specific permission, a registered candidate for the following award:

-Certification in Graduate Research Skills-

Material submitted for another award

I declare that no material contained in the thesis has been used in any other submission for an academic award and is solely my own work

Collaboration

Where a candidate's research programme is part of a collaborative project, the thesis must indicate in addition clearly the candidate's individual contribution and the extent of the collaboration. Please state below:

Signature of Candidate:

Type of Award Doctor of Philosophy

School Dentistry

Acknowledgements

Thanks to God Almighty for helping me throughout this endeavor. I would like to thank my wonderful understanding wife Emma and my beautiful, gorgeous daughter Amara for supporting, encouraging and putting up with me whilst I complete my PhD programme. I would also like to thank my mother Katherine for her unwavering encouragement of my studies.

It has been a long journey and I have been very fortunate to have made such a journey with an excellent supervisory team (Professor Paola Dey; Professor James Selfe and Dr. Chris Sutton) from the start to submission. I would like to give special thanks to my director of studies Professor Paola Dey; she has been the best supervisor I or anyone else could have wished for. I have learned so much and am still learning from her as a mentor and a valued friend. I will forever be indebted to her. I would like to thank the other members of my supervisory team, Professor James Selfe and Dr. Chris Sutton to whom I am also grateful for their constant support with all aspects of the PhD programme.

I would like to thank Dr. Margaret Hurley who pointed me in the right direction during the application process for this programme. I would like to thank Dr. Svetlana Tishkovskaya, Neil Cook, Dr. Anne Milston, Nicola Gaskins and key administrative staff in UCLan's Research student Registry, particularly Claire Altham, for their support. Thanks to staff who made study recruitment possible and to all the participants in this research for their support. Thanks to fellow PhD candidates: Dan

Bahadur Baidwar-Kshetri, Joy Gana, and Victoria Appleton who could always be relied upon for conversation and sharing of moments of my academic and non-academic life.

Abstract

Obesity and physical inactivity have been identified as risk factors for knee pain in elderly populations. There has been an increase in the prevalence of obesity and physical inactivity in younger adults. Therefore, it is important to investigate whether they are risk factors for knee disorders among young adults. This thesis explored the epidemiology of knee problems in young adults.

A literature review, using systematic methods, identified 19 studies reporting on the incidence of and/or risk factors for knee disorders in young adults. Knee disorder incidence varied across studies (0.07% to 42.0%), because of the different knee conditions and study populations (military and sports) investigated. There was conflicting evidence on whether obesity and physical activity were risk factors for knee disorders; and physical inactivity had not been investigated.

A longitudinal study was undertaken to estimate the incidence of knee problems in young adults and explore whether physical activity, physical inactivity and obesity were risk factors. It was designed as a feasibility study to inform a large-scale cohort study in the general population. Three hundred and fourteen staff and students of the University of Central Lancashire, Preston campus were recruited and followed up for 12 months. Data was collected through self-report questionnaire and where possible direct measurement of weight and height was taken. Logistic regression was used to investigate any plausible relationship between knee problems and body mass index (BMI), physical inactivity, and physical activity levels.

The mean (SD) age was 22 (5.2) years. There were more men (n=176, 56.1%) than woman (n=138, 43.9%). At baseline, the mean (SD) score for the Hopkins Symptoms Checklist-10 (mental distress) was 1.5 (0.4); mean (SD) BMI was 24.3 (4.1) and mean (SD) total hours spent sitting per day was 5.6 hours (2.6). Over half of the participants (n=165, 52.9%) reported low physical activity with similar proportions reporting moderate (n= 75, 24.0%), and high (n= 72, 23.1%) physical activity levels. The prevalence of knee problems was high (31.8% [95% CI 26.9% to 37.2%]); knee pain was the most prevalent symptom. Multivariate logistic regression analysis on cross-sectional data showed that high physical activity levels (OR 2.6 [95% CI 1.4-4.9]) and mental distress (OR 2.3 [95% CI 1.2-4.6]) were independent risk factors. Only 126 (40.1%) participants responded to the follow up at 12 months: 76.9% still had knee problems and 11.5% had a new knee problem.

Knee problems are common in young adults. The study provided an estimate of incidence to inform the design of a large-scale population based study but attention needs to be paid to ensure lower attrition. The study suggests that more attention may need to be paid towards prevention of knee problems and that further work on the economic burden of knee problems among young adults is warranted. This is particularly important as there is increasing emphasis in public health policy on promoting physical activity.

List of abbreviations

ACL= Anterior Cruciate Ligament

AUC = Area Under the Curve

BMI = Body Mass Index

CI = Confidence Interval

DF= Degrees of Freedom

HSCL-10= Hopkins Symptoms Checklist- 10

HSE= Health Survey for England

ICC = Intra-class Correlation Coefficient

ICF = International Classification of Functioning, Disability and Health

IKDC = International Knee Documentation Committee

IPAQ-Long = International Physical Activity Questionnaire- Long form

IQR = Interquartile range

KNEST = Knee Pain Screening Tool

KOOS = Knee Injury and Osteoarthritis Outcome Score

NOS = Newcastle Ottawa Scale

NZPAQ = New Zealand Physical Activity Questionnaire – Long

OA = Osteoarthritis

OKS = Oxford Knee Score

OR = Odds Ratio

PCL = Posterior Cruciate Ligament

PFP = Patellofemoral Pain

ROC = Receiver Operating Characteristic

SD = Standard deviation

SNAPPS = Studies of the Prevalence Natural History & Aetiology of Patellofemoral
Pain syndrome

WHO = World Health Organisation

Table of Contents

STUDENT DECLARATION FORM.....	i
Acknowledgements	ii
Abstract	iv
List of abbreviations.....	vi
Table of Contents	viii
List of tables and figures	xiv
List of Tables.....	xiv
List of Figures	xvi
Chapter 1: Introduction	1
1.1 Background	1
1.2 Knee disorder	1
1.2.1 <i>Economic burden of knee problems</i>	2
1.3 Knee disorder in young adults.....	3
1.4 Obesity and physical activity and their relationship with knee disorder.....	5
1.5 Temporal changes in obesity, physical activity, and physical inactivity in young adults	7
1.6 Summary	10
Chapter 2: Risk factors of knee disorders among young adults: a review using systematic methods	12
2.0 Introduction	12
2.1 Objectives of the review	12
2.2 Methods	13
2.2.1 <i>Study inclusion and exclusion criteria</i>	13
2.2.2 <i>Search strategy</i>	14
2.2.3 <i>Assessment of methodological quality</i>	15
2.2.4 <i>Data extraction</i>	16
2.2.5 <i>Approach to analysis</i>	17
2.3 Results	17
2.3.1 <i>Description of eligible studies</i>	19
2.3.2 <i>Measurement of knee disorders</i>	25
2.3.3 <i>Incidence of knee problems reported in eligible studies</i>	26
2.3.4 <i>Risk factors reported in eligible studies</i>	28
2.3.5 <i>Weight related factors</i>	28
2.3.6 <i>Physical activity</i>	31
2.3.7 <i>Gender</i>	33
2.3.8 <i>Age</i>	35

2.3.9 <i>Psychological factors</i>	37
2.3.10 <i>Biomechanical risk factors</i>	38
2.4 Methodological quality of the selected articles	39
2.5 Discussion	40
2.5.1 <i>Strengths and weaknesses of the review</i>	42
2.6 Conclusion.....	43
Chapter 3: Development of a definition of outcomes for this study	44
3.1 Introduction	44
3.2 Overview of findings.....	44
3.3 Clinician perspective of knee disorders.....	47
3.3.1 <i>A perspective based on symptoms</i>	48
3.4 Understanding knee disorder from an ICF perspective.....	52
3.5 Perspective of Knee disorder for this thesis	53
3.6 Thesis aim.....	55
3.6.1 <i>Thesis objectives</i>	56
Chapter 4: Review of measurement instruments for the feasibility study	57
4.1 Introduction	57
4.2 Background	58
4.3 Objective	59
4.4 Methods	59
4.4.1 <i>Selection of the instrument</i>	59
4.5 Findings	60
4.5.1 <i>Selection of the instrument used to screen for the presence of knee problems</i>	64
4.5.2 <i>Selection of the instrument used to measure symptoms, functional impairments and quality of life associated with knee problems</i>	65
4.6 Summary	71
Chapter 5: Epidemiological study of knee problems in young adults - methods	72
5.1 Introduction	72
5.2 Objectives of this study	72
5.3 Study population.....	73
5.3.1 <i>Inclusion criteria</i>	73
5.3.2 <i>Exclusion criteria</i>	73
5.4 Study Design	74
5.5 Recruitment	75
5.5.1 <i>Study period for study recruitment</i>	78
5.6 Sampling.....	80

5.6.1 Sampling methods	80
5.6.2 Theoretical underpinning of the sampling approach.....	80
5.7 The assessment of participants	82
5.7.1 Baseline assessment	82
5.7.2 Follow up assessment.....	83
5.7.3 Methods used to promote response to follow up assessment	83
5.8 Data collection instrument: Baseline Assessment.....	85
5.8.1 Knee problems	86
5.8.2 Impact of knee problems	86
5.8.3 How the knee problem developed	87
5.8.4 Risk factors: obesity, physical activity and physical inactivity.....	89
5.8.5 How obesity was measured in this study.....	89
5.8.6 Methods used in direct measurement of height and weight	92
5.8.7 How physical activity was measured	95
5.8.8 How physical inactivity was measured	96
5.8.9 Measuring confounding variables	97
5.8.10 Measuring sports participation.....	98
5.9 Data collection: Follow-up assessment	99
5.10 Outcomes:.....	100
5.11 Ethical and Data Protection	101
5.11.1 Potential Risk.....	103
5.12 Study Management.....	103
5.13 Quality assurance of the data collection process.....	104
5.14 The data management.....	104
5.15 Data cleaning	105
5.15.1 The screening phase.....	106
5.15.2 Diagnostic phase.....	107
5.15.3 Treatment phase.....	108
5.16 Theory underpinning data quality assurance	109
5.17 Estimation of sample size	110
5.18 Statistical Analysis	111
5.18.1 Descriptive analysis of the characteristics of the cohort	111
5.18.2 Inferential analysis.....	113
5.18.3 Exploring risk factors for knee problems.....	114
Chapter 6 Result of the epidemiological study of knee problems in young adults – Recruitment and Prevalence data.	118
6.1 Introduction	118

6.2 Recruitment	118
6.2.1 Demographic and other participant characteristics at baseline assessment.....	120
6.3 Investigating the potential effect of cluster sampling on confidence interval estimates for knee problems, knee pain and traumatic onset of knee problems at baseline assessment	122
6.3.1 The prevalence of knee problems at baseline assessment.....	124
6.3.2 Severity of the knee problem measured by KOOS at the baseline	125
6.3.3 Prevalence of knee pain among the participants reporting knee problems at the baseline	129
6.3.4 How the knee problems developed among the participants reporting knee problems at the baseline	130
6.4 Examining the relationship between the prevalence of knee problems and gender	131
6.5 Age of participants at the baseline	131
6.6 Prevalence of mental distress at baseline	132
6.6.1 Comparison of mental distress in those with and without knee problems	133
6.7 Comparison of the nature of sport participation in those with and without knee problems at the baseline	135
6.8 BMI at baseline	135
6.8.1 Estimating the missing values of directly measured BMI	137
6.8.2 Comparison of BMI in those with and without knee problems at the baseline...	145
6.8.3 Examining the relationship between the prevalence of knee problems and BMI at the baseline	146
6.9 Physical inactivity (sedentary behaviour) in the cohort at the baseline	149
6.9.1 Comparison of physical inactivity in those with and without knee problems at the baseline	149
6.9.2 Examining the relationship between the physical inactivity level and BMI at the baseline	152
6.10 Physical activity levels in the cohort at baseline	154
6.10.1 Comparison of physical activity levels in those with and without knee problems at the baseline	155
6.10.2 Examining the relationship between the physical activity level and physical inactivity at the baseline	157
6.10.3 Examining the relationship between the physical activity level, physical inactivity and BMI at the baseline	159
6.11 Examining the relationship between risk factors for knee problems and confounding factors	161
6.11.1 Explanatory factors of knee problems in the cohort at the baseline.....	164
6.11.2 Evaluating the performance of Model E.....	165
6.12 Summary of key findings from the prevalence study.....	166

Chapter 7 Result of the epidemiological study of knee problems in young adults- Follow up data.....	168
7.1 Introduction	168
7.2 Follow up of participants at one year	168
7.2.1 <i>Investigating the potential effect of a cluster sampling on confidence interval estimates for knee problems, knee pain and trauma at follow up</i>	171
7.2.2 <i>Prevalence of knee problems at follow up</i>	172
7.2.3 <i>Prevalence of knee pain as predominant symptoms among the participants at follow up</i>	173
7.2.4 <i>Source of knee problems among the participants reporting knee problems at follow up</i>	174
7.2.5 <i>Changes noted at follow up among the participants with knee problem at the baseline</i>	175
7.3 Incidence of knee problems after 12-month follow up	177
7.3.1 <i>Investigation of the relationship between the incidence of knee problems and other variables</i>	180
7.4 Summary of key findings from follow-up.....	183
Chapter 8. Discussion	185
8.1 Introduction	185
8.2 Findings from the systematic review.....	186
8.3 Knee problems in the cohort.....	187
8.3.1 <i>Measurement of knee problems in the cohort</i>	188
8.3.2 <i>Prevalence of knee problems in the cohort</i>	189
8.3.3 <i>Knee related predominant symptoms</i>	191
8.3.4 <i>The instruments used to measure the prevalence of knee problems</i>	192
8.3.5 <i>Measurement of how knee problem developed</i>	194
8.3.6 <i>Gender and Age in knee problems</i>	195
8.4 Inter-relationship between knee problems and obesity, physical inactivity and physical activity.....	197
8.4.1 <i>BMI as a risk factor for knee problems</i>	197
8.4.2 <i>Physical inactivity as a risk factor for knee problems</i>	198
8.4.3 <i>Physical activity as a risk factor for knee problems</i>	199
8.4.4 <i>Psychological factors as a confounding factor of knee problems</i>	201
8.5 Incidence of knee problems.....	202
8.6. The impact of knee problems among those reporting knee problems.....	203
8.7 Strengths of the findings of this study	205
8.8 Limitations of the findings of this study	209
8.9 Implications of the findings for Public Health Specialists	213

8.10 Implications of the findings for Clinicians.....	215
8.11 Implications of the findings for Researchers.....	216
Chapter 9.0 Summary.....	218
9.1 Conclusion.....	220
10.0 References	222
Appendix A: Final search strategy and results for CINAHL database using EBSCO platform	259
Appendix B: Newcastle-Ottawa Quality Assessment Scale	264
Appendix C: Data Extraction Form for Systematic Review on Risk factors for Knee Problem.	266
Appendix D: List of articles excluded from the review and the rationale	269
Appendix E: Letter of approval and amendment of this study from the university Ethic committee	273
Appendix F: Poster used in recruitment of this study	276
Appendix G: Information sheet.....	278
Appendix H: Consent form	281
Appendix I: AU Outlook Poster.....	282
Appendix J: Newsletter send to the participants to maintain their interest in the study and increase retention.....	283
Appendix K: Email send to participants during follow up study.....	284
Appendix L: Questionnaire used at baseline assessment.....	285

List of tables and figures

List of Tables

Table 1.1 BMI with a valid height and weight measurement by age from 1993 to 2012.	8
Table 1.2 Changes in reported physical inactivity, by survey year (2008 and 2012) across age group and gender.	9
Table 1.3 Comparison of levels of physical activity, by survey year (2008 and 2012), age group and gender.	9
Table 2.1 The summary of the characteristics of the reviewed studies.	21
Table 2.2 Incidence of different types of knee disorders reported in the eligible studies.	27
Table 2.3 Weight as a risk factor.	30
Table 2.4 Relationship between gender and knee disorders.	34
Table 2.5 Age as risk factor for knee disorder.	36
Table 2.6 Relationship between psychological factors and knee disorders.	38
Table 3.1. Variations in case definition in studies reviewed in the systematic review that investigated knee disorders among young adults.	45
Table 3.2. Different forms of knee problems, symptoms, and possible sources.	50
Table 4.1 Characteristics of the Instruments.	62
Table 4.2: The list of potential possible instruments considered for the measurement of symptoms and functional impairments associated with knee problems.	68
Table: 5.1 The test- retest reliability of KOOS questionnaire across the domain it measures in patients with knee injury.	87
Table 6.1 Nature of sport participated by the participants at least weekly.	121

Table 6.2 List of cluster units recruited into the study.	123
Table 6.3 Estimation of the inflation factor for the standard error estimate of prevalence of knee problems, knee pain as dominant symptom, and knee problems due to trauma at baseline due to clustering.	124
Table 6.4 Severity of the symptoms measured by KOOS (n= 100).	126
Table 6.5 Comparison of prevalence of knee problems between different age group.	132
Table 6.6 Comparing self-reported and directly measured height and weight.	136
Table 6.7 Description of the participants' BMI after replacing missing values with imputed values compared to self-reported and directly measured BMI.	144
Table 6.8 Demonstrating risk and odds of knee problems across different categories of BMI.	147
Table 6.9 Demonstrating risk and odds of knee problems across different categories of physical inactivity.	151
Table 6.10 Effects of physical activity level and physical inactivity on the prevalence of knee problems at the baseline.	158
Table 6.11 Effects of the risk factors on the prevalence of knee problems at baseline.	160
Table 6.12 Using Percent Correct Predictions to compare regression model performance across different logistic regression results for the risk factors.	160
Table 6.13 Effects of different confounding factors on the effect of the three risk factors on the prevalence of knee problems at baseline while adjusting for other variables.	162

Table 6.14 Using Percent Correct Predictions to compare regression model performance across different logistic regression results of the risk and confounding factors.	163
Table 6.15 Effects of demographic variables on the prevalence of knee problems at baseline while adjusting for other variables.	164
Table 7.1 Characteristics of participants at the baseline and follow up.	169
Table 7.2 Estimation of the inflation factor for the standard error estimate of prevalence of knee problems, knee pain as dominant symptom, and knee problems due to trauma at follow up due to clustering.	171
Table 7.3 Knee Pain and Trauma at baseline and follow up.	174
Table 7.4 Physical activity levels, physical inactivity, KOOS score, and knee pain as predominant symptom at the baseline compared to follow-up for those with knee problems at both the baseline and follow-up (n= 30).	176
Table 7.5 Estimation of the inflation factor for the standard error estimate of the incidence of knee problems and of knee pain, aching or stiffness due to clustering.	177
Table 7.6 Characteristics of those without knee problems at the baseline.	179
Table 7.7 Univariate analysis of the effects of baseline factors on incidents of knee problems at follow up.	181
Table 7.8 Effects of baseline factors on incidents of knee problems at follow up adjusting for other variables.	182

List of Figures

Figure 2.1 Flow chart of the process used to select the eligible studies.	18
Figure 2.2 Showing gender distribution and the nature of participants in the eligible studies.	24

Figure 3.1 Interactions between the components of International Classification of Functioning, Disability and Health (WHO 2001).	53
Figure 3.2 Framework used in defining of a knee problem.	55
Figure 5.1 Flow chart showing the administrative processes of the project.	79
Figure 5.2 Flow chart of the follow up strategy.	85
Figure 5.3 Research student demonstrating how the height variable was taken.	93
Figure 5.4 Research student demonstrating how the weight variable was taken.	94
Figure 5.5 Histogram of self- reported BMI to check distribution of data.	107
Figure 6.1 Percentage of participants per course recruited into the study.	119
Figure 6.2 The percentage of participants that reported knee problems and the knee affected at baseline.	125
Figure 6.3 Distribution of KOOS score for pain subscale among those who reported knee problems (n= 99).	127
Figure 6.4 Distribution of KOOS score for severity of symptoms subscale among those who reported knee problems (n=99).	127
Figure 6.5 Distribution of KOOS score for Activities of Daily living subscale among those who reported knee problems (n=100).	128
Figure 6.6 Distribution of KOOS score for quality of life subscale among those who reported knee problems (n= 100).	128
Figure 6.7 Distribution of KOOS score for sports and recreational activities subscale among those who reported knee problems (n= 100).	129

Figure 6.8 Proportions of participants reporting different predominant symptoms of knee problems in the study cohort. There were seven missing values.	130
Figure 6.9 Distribution of HSCL-10 score of those who reported a knee problems.	133
Figure 6.10 Distribution of HSCL-10 score of those without knee problems.	134
Figure 6.11. Scatterplot showing the imaginary line of agreement between BMI measured through direct measurement and self-reporting.	138
Figure 6.12 Bland & Altman plot demonstrating the agreement between the BMI measured by self-report and direct measurement.	140
Figure 6.13. A scatterplot of self-reported and directly measured BMI with best fit line and 95% CI showing how self-reported BMI explains directly measured BMI.	141
Figure 6.14 Distribution of participants' BMI which includes the imputed BMI for every missing directly measured BMI.	143
Figure 6.15 The distribution of participants' mean imputed BMI across the three categories.	145
Figure 6.16 The proportion of the participants with knee problems across the BMI categories.	146
Figure 6.17 A scatterplot of the BMI category against the logit of the odds of knee problems.	148
Figure 6.18 Boxplot demonstrating average sitting time per day in hours across genders.	150

Figure 6.19 A scatterplot of the physical inactivity category against the logit of the odds of knee problems showing a quadratic relationship.	152
Figure 6.20 A scatterplot showing the relationship between the BMI and Physical inactivity.	153
Figure 6.21 Distribution of reported physical activity levels across genders.	155
Figure 6.22 Physical activity levels among the participants without knee problems compared to the participants with knee problems at the baseline.	156
Figure 6.23 Boxplot showing the distribution of average sitting time per day in hours across different categories of physical activity levels. Participants that reported low, moderate, and high activity were 165, 75, and 72 respectively.	157
Figure 6.24 The ROC Curve of modified screening question for knee problems.	166
Figure 7.1 Flow chart showing on-going cases and new cases of knee problems at follow up.	170
Figure 7.2 Percentage of the participant reporting affected knee at follow up.	173
Figure 7.3 ROC curve plot showing the trade-off between sensitivity and specificity.	183

Chapter 1: Introduction

1.1 Background

Musculoskeletal disorders are an important public health problem as they are one of the major causes of work-related disability, sickness absence, long-term pain and physical disability, across all continents and economies (WHO 2003). Musculoskeletal disorders also have a significant impact on the psychosocial status of affected individuals and the loss of independence can affect family and carers (Woolf and Akesson 2001). Musculoskeletal disorders consist of a diverse group of conditions which are associated with pain and/or impaired physical function. The conditions can be of acute or gradual onset and can last for a short duration or can be chronic. In the course of a year in the United Kingdom (UK), an estimated 20% of adults consult their general practitioner with a musculoskeletal disorder (Jordan et al. 2007a; RCGP 2007). Recent findings show that musculoskeletal disorders account for 1 in 7 general practice consultations (Jordan et al. 2010), and more than 30% of years lived with physical disability (Murray et al. 2013).

1.2 Knee disorder

One of the most common sites for musculoskeletal disorder is the knee with 6% of the population over the age of 30 reporting frequent episodes of knee disorders and 25% of the population of over 50 years old (Urwin et al. 1998; Jinks et al. 2004; Peach et al. 2005). Knee disorders can lead to a reduction in functional ability, increased dependency, reduced participation in major daily activities and substantial health

service costs, due to management of the disorders (Felson et al. 1987; WHO 2003; Jinks et al. 2004; van der Waal et al. 2006; Grotle et al. 2008).

In the UK, of the 63.2 general practice consultations per 1000 person years attributable to musculoskeletal disorders, the highest incidence was for knee disorders: 21.4 per 1000 person years in men and 22.8 per 1000 person years in women (van der Waal et al. 2006).

Osteoarthritis (OA) of the knee, has been suggested to be the largest single cause of knee pain (Felson et al. 1987; Miranda et al. 2002; Brooks 2006) with the prevalence of knee OA being 23.9% (Pereira et al. 2011). Knee OA is common in older people (prevalence ranged from 10% to 44%) (Felson et al. 1987; Peat et al 2001; Miranda et al. 2002; Nguyen et al. 2011; Pereira et al. 2011; Singh et al. 2014), but some younger adults also suffer from symptomatic knee OA. It has been estimated that between 1 - 4.9% of those aged 35 years or more (Petersson et al. 1997) have asymptomatic radiological evidence of knee OA, whereas 6.7 – 16.7% of those aged 45 years or more (Jordan et al. 2007b) have symptomatic evidence of knee OA. In the UK, there has been an increase in the number of young patients seeking general practice consultation due to symptoms related to OA of the knee (NICE 2008). Therefore it is important to understand the risk factors for knee disorder in younger people.

1.2.1 Economic burden of knee problems

There is some information about the cost of treating knee problems. The cost per GP consultation is estimated at £36 for a 12 minute consultation (Curtis 2009). The cost

of arthroscopic treatment for patients with mechanical symptoms such as locking or giving way has been calculated at £1.3 million per annum in 2010 (Hamilton et al. 2009; Chen et al. 2012). Osteoarthritis remains the most frequent cause for knee replacement (96% of primary knee replacement in 2014/15) (National Joint Registry 2015). The national tariff in 2010 for uncomplicated total knee replacement was £5198, which leads to estimated cost of £426 million per year.

The literature has demonstrated that younger people aged 20 to 55 years old with knee osteoarthritis in Australia experience substantial personal burden in terms of lower income, lower productivity, worse quality of life and increased dependency (Ackerman et al. 2015). In a systematic review (Agaliotis et al. 2014), a number of high quality studies consistently demonstrate that chronic knee pain or knee osteoarthritis is associated with reduced work productivity. However, in the UK the indirect cost of knee disorders has not been identified (Chen et al. 2012). There is lack of costing studies in the UK and therefore the overall economic burden will be largely underestimated if it is limited to health service costs.

1.3 Knee disorder in young adults

A number of studies have suggested a high prevalence of knee disorder among younger adults with rates between 19 – 33.7% (Fairbank et al. 1984; Vahasarja 1995; Majewski et al. 2006; Louw et al. 2008; Selfe et al. 2015). Knee disorders in younger adults usually occur following an injury (Majewski et al. 2006). High incidence rates of knee injuries in young adults have been reported (2.2% to 32.0%) but these are

mainly in studies of athletic and military populations (Fairbank et al. 1984; Witvrouw et al. 2000; Van Tiggelen et al. 2009; Boling et al. 2010; Engebretsen et al. 2011). These are individuals with high levels of physical activity and it could be suggested they are not truly representative of the general population. It has been suggested that there are few studies which have estimated the incidence of knee disorders in younger adults in the general population (Dey et al. 2012; Gelber et al. 2000).

Many studies suggest that rates are higher in females than males, although this may be related to the condition or sports activity being studied (Engstrom et al. 1991; de Loes et al. 2000; Moustaki et al. 2005; Majewski et al. 2006; Giugliano and Solomon 2007; Sliver and Mandelbaum 2007; Louw et al. 2008; Ingram et al. 2008;). For example, females were at more risk of knee injuries in certain sports, e.g. downhill skiing, team handball, volleyball, basketball, gymnastics compared to males (de Loes et al. 2000; Ingram et al. 2008). Knee joint laxity has been suggested as a potential risk factor for non-contact anterior cruciate ligament injury (Woodford-Roger et al. 1994; Loudon et al. 1996). Sex differences in knee joint laxity has been demonstrated to be menstrual cycle dependent, coinciding with significant elevations in estradiol levels in females (Shultz et al. 2005), which could explain the higher rate of injury among females. The anterior cruciate ligament (ACL) and patellar tendon is made up of collagen, a protein and this is what enables the knee to withstand mechanical loading of knee joint and, hence, response to injury. There have been differences found in the proteome of the ACL and patellar tendon between males and females (Little et al. 2014).

Knee disorders related to injury may be of gradual or traumatic onset. In a population based prevalence study, gradual onset of knee disorder was more common than

traumatic onset (Selfe et al. 2015). Gradual onset of knee disorders, such as that seen in conditions like patellofemoral pain, may be explained by chronic overloading of the knee joint (Dye 1996). Traumatic onset of knee disorder is related to multidirectional forces imposed on the knee joint complex as occurring in conditions such as rupture of the anterior cruciate ligament (ACL) or posterior cruciate ligament (PCL) (Yang et al. 2005; Parkkari et al. 2008). Although, there is conflicting evidence in the literature of the effectiveness of the management of these conditions (deLoes et al. 2000; McAllister et al. 2003; Carey et al. 2006), many still seek and undergo treatment (Gobbi et al. 2003; Feller et al. 2003; Smith et al. 2004). The short and long-term problems associated with knee disorder in young adults and the consequent burden on health services as discussed under section 1.2 above suggest that there is a need to identify preventable risk factors in young adults (Hewett et al. 1999; deLoes et al. 2000; Myklebus and Bahr 2005; Wright et al. 2010).

1.4 Obesity and physical activity and their relationship with knee disorder

Obesity is one of the lifestyle factors which has been identified as a risk factor for knee OA in elderly populations (McLellan 2002; Jink et al. 2006; 2008; Nguyen et al. 2011). The lifetime risk of developing knee OA has been estimated to be 60% in those whose body mass index (BMI) increased to above 30 kg/m² or higher during adult life (Murphy et al. 2008). In their study, almost two-thirds (63.5%) of the sample were overweight or obese as measured at baseline, only one-tenth (10.4%) reported to be so at age 18 years (Murphy et al. 2008).

A number of studies of young adults with knee injuries, such as ACL injury, have identified a high prevalence of knee OA in this group - 12 to 36 years post knee injury (Gelber et al. 2000; von Porat et al. 2004; Lohmander et al. 2004). In the John Hopkins Precursor Study which followed a cohort of medical students, with an average age of 22 years, in the United States, for 36 years, the incidence of knee OA was 13.9% in individuals who self-reported a knee injury at entry to the study or during follow-up (within young adulthood) compared to 6.0% in those without such a history (Gelber et al. 2000). Evidence from this study also suggested an association between “heavier” participants and increased risk of knee OA (Gelber et al. 2000). However, there were considerable limitations to their study. Women, who have a higher incidence of knee OA, were under represented and other important risk factors associated with osteoarthritis were not accounted for in the analysis. In addition, the method of classifying “heavier” participants was not clear.

A recent systematic review explored whether joint injury, sport activity, physical activity, obesity or occupational activities are risk factors for knee OA. This systematic review confirmed that obesity and joint injury at a young age are important risk factors, but suggested the evidence supporting high or low levels of physical activity and sports injury as risk factors is less conclusive (Richmond et al. 2013). An association between high physical activity in young adulthood and increased risk of knee OA has been confirmed in some studies (Urquhart et al. 2008; Urquhart et al. 2011), while other studies have shown no association or that physical activity has a protective role (Urquhart et al. 2008; Chapple et al. 2011; Urquhart et al. 2011). These overall inconsistencies in results might be explained by different definitions for OA and physical activity and by different study designs.

1.5 Temporal changes in obesity, physical activity, and physical inactivity in young adults

There appears to have been an increase in the reported uptake of physical activity over time (Health and Social Care Information Centre 2014), although, this finding is based on self-reported physical activity. In a systematic review that compared direct versus self-report measurement methods as a way of assessing physical activity in adults, findings suggest that self-report measurements of physical activity levels can be higher than directly measured levels of physical activity. This poses a problem for the reliance on the self-report measurements of physical activity levels (Prince et al. 2008).

Paradoxically, over the last two decades, there has been an increased prevalence of obesity and physical inactivity among younger adults (Butland et al. 2007; Sutton 2012). The Health Survey for England (HSE) (2012) shows that 24% of men and 25% of women are currently obese, and the proportion of adults with a normal Body Mass Index (BMI) decreased between 1993 and 2012, from 41.0% to 32.1% among men and from 49.5% to 40.6% among women (HSE 2012). In the survey, obesity was measured by BMI which was calculated as weight of an individual in kilograms (kg) divided by the square of his/her height in meters (m) = kg/m^2 . Individuals with BMI higher than 29.9 were classified as obese. The decrease in normal BMI stated above and the increase in obesity was also observed across younger adults as demonstrated in Table 1.1. It should be noted that Table 1.1 does not include the percentage of other categories of BMI (like underweight, overweight and superobese) and therefore does not equal 100%. Most recent estimates suggest that by 2030, 41% to 48% of men and 35% to 43% of women could be obese if this trend continues (HSE 2012).

Table 1.1 BMI with a valid height and weight measurement by age from 1993 to 2012.

Age Group	Normal BMI %		Obese %	
	1993	2012	1993	2012
16 – 24	69.1	58.7	4.9	12.1
25 – 34	49.6	44.3	10.0	14.7
35 – 44	37.5	27.5	14.3	25.1
Body mass index (BMI)				

Physical inactivity has been defined as circumstances when energy expenditure is very low, as seen in sitting or lying or where physical activity is below recommended levels (WHO 2010). The physical activity recommendation considered here is based on 150 minutes of moderate intensity physical activity or 75 minutes of vigorous physical activity or equivalent to the combination of these per week (WHO 2010). Physical inactivity has been said to contribute heavily to the development of obesity and secondary aging of various metabolic systems and reduction of average life expectancy (Booth et al. 2011). Again paradoxically, although physical activity has increased, physical inactivity has also increased over time among some age groups 16 years and over (Table 1.2). This is reflected in the fall in the percentage of the national recommendations for physical activity over time (HSE 2012) (Table 1.3).

Table 1.2 Changes in reported physical inactivity, by survey year (2008 and 2012) across age group and gender.

Age Group	Low activity in Men %		Low activity in Women %	
	2008	2012	2008	2012
16 - 24	12	10	25	28
25 - 34	13	14	20	26
35 - 44	19	18	23	21

Table 1.3 Comparison of levels of physical activity, by survey year (2008 and 2012), age group and gender.

Age Group	Meeting Recommended physical activity for men %		Meeting Recommended physical activity for women %	
	2008	2012	2008	2012
16 – 24	81	83	61	57
25 - 34	78	76	64	61
35 - 44	71	71	63	66

According to the Health Survey for England (2012), men were more likely than women to spend an average of six or more hours of total sedentary time on both weekdays (31% and 29% respectively) and weekend days (40% and 35% respectively). Over half of men and women spent four or more hours in sedentary time per weekday and weekend day, regardless of their BMI category. Among women, the proportion averaging more than four hours of sedentary time on both weekdays and weekend days increased as BMI category increased, and among men, sedentary time per weekday was significantly higher in participants who were obese (HSE 2012).

Studies conducted among young people suggest that obesity and physical inactivity are associated, although the direction of the association is unclear (Petersen et al. 2004; Tammelin et al. 2004).

1.6 Summary

Obesity has been identified as a risk factor for osteoarthritis of the knee, which is the main cause of knee pain in elderly people (Felson et al. 1987; Miranda et al. 2002; Jinks et al. 2006; Jinks et al. 2008; Nguyen et al. 2011). Physical inactivity is associated with obesity. Over the last two decades, there has been an increase in the prevalence of obesity and physical inactivity in younger adults (Butland et al. 2007; Sutton 2012). Physical activity has increased as well in the same age group (HSE 2012). However, there has been little research on whether obesity, physical activity and physical inactivity are common risk factors in the development of knee disorders in younger adults. Knee disorder in younger adults is associated with knee injury

(Majewski et al. 2006; Louw et al. 2008) and knee injuries are associated with knee OA in younger adults (Muthuri et al. 2011).

Because of the short and long term burden related to knee OA, it is important to investigate the relationship between obesity, physical activity, physical inactivity and knee disorders in younger adults. If there is a relationship between the increasing prevalence of obesity and physical inactivity, an increase in functional limitations and early onset of osteoarthritis in younger adults might be expected. This knowledge will inform strategic planning, and the development and implementation of preventative interventions geared towards the reduction of the public health burden of knee disorders and their complications in the population.

A preliminary search of the literature has suggested research to date has been devoted to the study of knee disorders among young adults, many of the studies have been limited to athletic or military cohorts and the peer-reviewed literature lacks a comprehensive epidemiological analysis of risk factors for knee disorders among young adults. In order to assess the current evidence on obesity, physical activity and physical inactivity as risk factors for the incidence of knee disorders among younger people and to inform the design of an incidence study, a review using systematic methods was conducted. This literature review is reported in the next chapter.

Chapter 2: Risk factors of knee disorders among young adults: a review using systematic methods

2.0 Introduction

This review, using systematic methods, was conducted following a preliminary search of the literature, which suggested a lack of a comprehensive epidemiological analysis of possible risk factors for knee disorders among young adults. This systematic review has particularly focussed on the current evidence about obesity, physical inactivity and physical activity as potential risk factors for the incidence of knee disorders among young adults. The review was undertaken to help inform the development of the protocol for a feasibility study which explores the incidence of knee disorders among young adults and the relationship between knee disorders and obesity, physical activity and physical inactivity.

2.1 Objectives of the review

The objectives of the review were to ascertain:

- the evidence for BMI, physical activity and physical inactivity as risk factors for knee disorders in young adults
- the evidence for other risk factors for knee disorders in young adults
- the incidence of new knee disorders among young adults reported in the studies identified by the review

2.2 Methods

2.2.1 Study inclusion and exclusion criteria

The inclusion and exclusion criteria used in the selection of eligible abstracts are outlined below:

Inclusion criteria were:

- Studies that have investigated risk factors for knee disorders that affect young adults using either case-control or cohort (retrospective/prospective) designs
- Participants included in this review were young adults within the age bracket 18 – 40 years of age
- Studies with participants outside 18 to 40 years old, but which have an analysis of participants aged 18 to 40 years old
- Studies that have 25% of their participants less than 18 or above 40 years old

Exclusion criteria were:

- Studies focusing on people with established knee pathologies
- Studies with participants who have undergone any form of treatment for their knee disorder before the commencement of the study or participants in a treatment comparative study were excluded
- Randomised controlled trials were excluded as they investigate mainly the effectiveness of an intervention
- Studies with participants that have a systemic disease that affect their knee

2.2.2 Search strategy

The review was conducted through a search of the following databases: EMBASE, CINAHL, MEDLINE, AMED and SPORTDIScus, undertaken by the research student in June 2012.

Cohort and case-control studies were identified by using keywords and subject headings for these types of studies and using the Boolean operator 'or' to connect the terms. For the condition, keywords or subject headings for general and specific terms for knee disorders were identified and connected using the Boolean operator 'or'. The searches on study designs and knee disorders were then combined using the Boolean operator 'and' to retrieve articles which were cohort or case-control studies of knee disorders. As this produced too many abstracts, search terms for established knee pathologies which are not eligible for inclusion in this review (see exclusion criteria in section 2.2.1) were identified and studies on these disorders removed from the search by using the Boolean operator 'not' to the combination of study design and condition terms to give the final output filtered by the research student. This process was applied in all databases (MEDLINE, EMBASE, CINAHL, AMED and SPORTDIScus).

Each database had different subject subheadings used to identify articles. Therefore, different search strategies were constructed for each of the other databases to accommodate these differences. Appendix A contains the final search strategy for all databases. Searches were restricted to those in the English language; time limitation was not applied.

The research student performed an initial filtering of articles from the databases based on the title and abstract using the pre-defined inclusion and exclusion criteria outlined above. Thereafter, the research student retrieved the full text of the articles which appeared to be eligible identified by the search. Two reviewers (the research student and the Director of Studies) independently reviewed the identified articles based on the inclusion and exclusion criteria. If there was a disagreement on inclusion of any article, discussions continued until a consensus was reached or if a consensus could not be achieved, the opinion of a third reviewer (another member of the supervisory team) was sought. Reference lists of the eligible articles were hand-searched by the research student to identify eligible articles missed by the electronic search.

2.2.3 Assessment of methodological quality

The Newcastle Ottawa Scale (NOS) for assessing the quality of the nonrandomised studies (which includes case-control and cohort studies) in meta-analyses was used to assess the methodological quality of the included studies (Wells et al. 2009). Cohort and Case-Control studies quality assessment is very important as it will aid in the understanding of the studies through acknowledgement of their strengths and weaknesses, which will help in decision making. The NOS was developed in such a way that it assesses the design and content of these studies. It judges these studies based on 3 main areas: selection of the study groups; comparability of the groups; and exposure (Case-Control studies) or Outcomes (Cohort studies). It uses a scale of 0 -9 stars. It operates by awarding stars to the item under each of the main areas. In Selection of the study groups and Outcomes or exposure a maximum of one star is awarded to each item under them, whereas a maximum of two stars is awarded to the

item under comparability of the groups. The face and criterion validity, inter-rater reliability, and evaluator burden of the NOS has been evaluated (Wells et al. 2003). Face validity has been evaluated as strong by comparing each individual assessment item to their stem question. NOS has shown an intra-class correlation coefficient (ICC) of 0.88 on a series of 10 cohort studies evaluating hormone replacement therapy in breast cancer. Inter-rater reliability for the NOS on cohort studies was high with an ICC of 0.94 and evaluator burden was shown to be significantly less than another well-established tool developed by Downs and Black (1998) (Wells et al. 2003). NOS has been endorsed for use in systematic reviews of non-randomized studies by the Cochrane Collaboration (Higgins et al. 2009).

2.2.4 Data extraction

Having selected the relevant articles, it is necessary to locate and synthesize the relevant information from within these selected articles. Hence, a data extraction form was constructed which was tailored to the question the review was trying to answer. A copy of the form is included in appendix C. The data extraction form ensures consistency in the extraction of data from the articles. The following data was extracted from selected studies: author and year of publication; information on the study design; description of study population (setting, country, gender distribution and age distribution); the number of participants enrolled; the definition of knee disorder and the exposure(s) investigated. The Exposures included: BMI; physical inactivity; physical activity; participant characteristics e.g. age, gender; psychosocial factors and biomechanical factors such as jumping, climbing stairs, etc.

2.2.5 Approach to analysis

Performing a statistical meta-analysis of results from a systematic review is not always possible or appropriate (Arai et al. 2007). This might be due to the diversity of the selected studies which makes it difficult to pool the data. In such cases, a narrative synthesis of the findings of selected studies as opposed to a statistical summary is typically adopted. Narrative synthesis can be used to incorporate diverse forms of evidence within a systematic review (Arai et al. 2007) although there are cases when both statistical summary (meta-analysis) and narrative synthesis are used together (Rodgers et al. 2009). In this review, the analytical approach adopted was essentially narrative as this review was conducted using a systematic method and there is a need to incorporate a diverse form of evidence.

2.3 Results

A total of 14,415 abstracts were identified through the search of the five databases (Figure 2.1). This includes abstracts which were identified in more than one database. After reviewing the 14,415 abstracts the research student excluded 14,374 following screening of the title and abstract. Based on the abstract and title of the paper, a total of 41 abstracts were considered as possibly eligible and the full text retrieved for more information. An additional three studies were identified from the reference list of the 41 papers and the full text retrieved.

Following the independent review of the full text and discussion with the Director of Studies, a consensus for inclusion was reached on 21 papers. A third researcher was

consulted concerning one other study, after which it was excluded. The 21 papers were related to 19 studies as Boling et al. (2009; 2010) and Milgrom et al. (1991; 1996) each published two papers on the same study population. The combined information from each pair was used for the assessment of risk of bias and for data extraction.

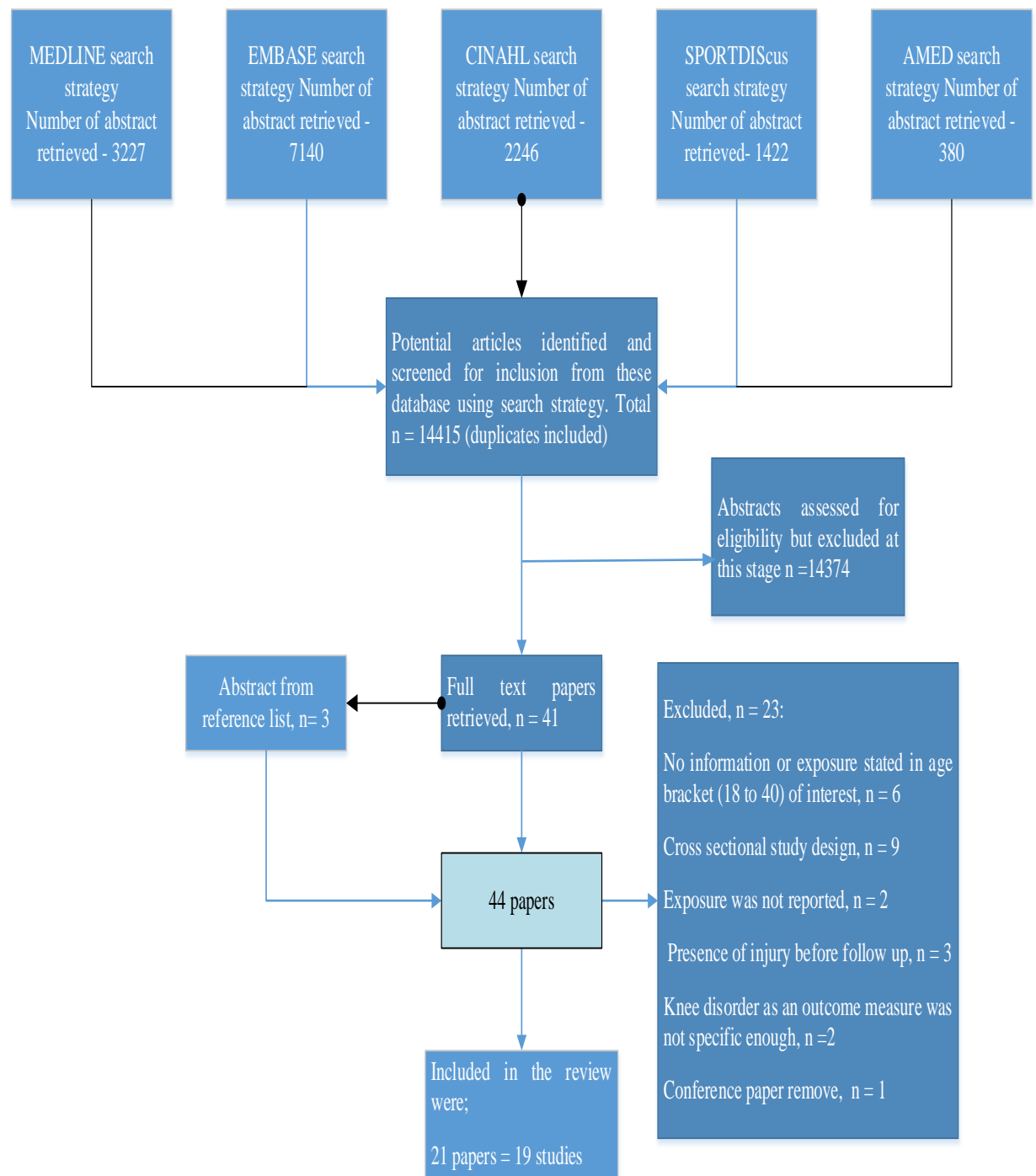


Figure 2.1 Flow chart of the process used to select the eligible studies.

Twenty-three papers were excluded (Figure 2.1). Of the excluded papers, six studies lacked information on outcomes and exposures on young adults aged 18 to 40 years. Knee disorder was not reported in two studies and nine studies were cross-sectional studies. Knee injuries were present before follow up of participants in three studies and knee disorder as an outcome is not specific enough in two studies. A conference paper was excluded as the main paper had already been included. Appendix D contains the list of excluded articles and the reasons they were excluded.

2.3.1 Description of eligible studies

All the studies were cohort studies of which three had a longitudinal design and 14 had a prospective design (Table 2.1). None of the studies had a case-control study design. The number of participants included in these eligible studies ranged from 24 to 128,584, and the mean age ranged from 18 to 37 years old. Studies with mean age of 18 were included as only less than 25% of their participants were less than 18 years old. Seven studies (eight papers) (see Figure 2.2) examined military cadets, infantry or soldiers of both genders (Wilson et al. 1983; Uhorchak et al. 2003; Hestroni et al. 2006; Thijs et al. 2007; Boling et al. 2009; 2010; Hsiao et al. 2010; Jones et al. 2012). Two studies investigated only military females (Duvigneaud et al. 2008; Rauh et al. 2010). Only male cadets, male infantry recruits or male conscripts were included in three studies (four articles) (Milgrom et al. 1991; 1996; Van Tiggelen et al. 2009; Kuikka et al. 2011). Two studies looked at college students and included both males and females who were engaging in either sports or physical education classes (Witrvrouw et al. 2000; Mountcastle et al. 2007). Four studies were conducted in sports populations, among these studies one was on male football players only

(Engebretsen et al. 2011), another on sportswomen only (Vauhnik et al. 2011), and the two other studies included both genders with one study on elite footballers (Walden et al. 2011) and the other on novice runners (Thijs et al. 2008). Only one study investigated knee disorders in the general population (Jones et al. 2007); both genders were included in this analysis.

Table 2.1 The summary of the characteristics of the reviewed studies.

Author	Study design	Country	Setting	Mean age or Range (years)	Exposure	Outcome	Follow up	NOS award
Boling et al. 2009; 2010	Prospective	USA	Military	17 - 23	Gender and Biomechanical factors	PFP	2.5 years	8
Duvigneaud et al. 2008	Prospective	Belgium	Military	18 - 34	BMI; sport participation (hour/week); Biomechanical factors	PFP	6 weeks	7
Engebretsen et al. 2011	Prospective	Norway	Sport	24	Age; BMI; Level of play; Players' position; Matches played;	Knee injury	1 year	8
Hetsroni et al. 2006	Prospective	Israel	Military	18	Biomechanical factors	PFP	14 weeks	7
Hsiao et al. 2010	Prospective	USA	Military	<20 ≥ 40	Gender, Age, service and rank	Patellar dislocation	9 years	8
Jones et al. 2007	Prospective	England	Community	23	Age; gender; BMI; Physical activity and Psychological factors	Knee pain	2 years	6
Jones et al. 2012	Prospective	USA	Military	<20 ≥ 40	Age and gender	Meniscal tears	8 years	8
Kuikka et al. 2011	Prospective	Finland	Military	20	Age; BMI; length at military service	Hospitalization due to knee injuries	4 years	8

Author	Study design	Country	Setting	Mean age or Range (years)	Exposure	Outcome	Follow up	NOS award
Milgrom et al. 1991; 1996	Prospective	Israel	Military	17 – 25	Biomechanical factors; Weight	PFP	6 years	8
MountCastle et al. 2007	Prospective	USA	Military	>18	Gender and Sport participation	ACL injury	4 years	8
Rauh et al. 2010	Prospective	USA	Military	19	Biomechanical factors	PFP	1 year	8
Thijs et al. 2007	Longitudinal	Belgium	Military	19	Age; Weight; Biomechanical factors	PFP	6 weeks	8
Thijs et al. 2008	Longitudinal	Belgium	Novice runners	37	Age; BMI; Biomechanical factors	PFP	10 weeks	8
Uhorchak et al. 2003	Prospective	Belgium	Military	18.4	BMI; Biomechanical factors	ACL injury	4 years	8
Van Tiggelen et al. 2009	Longitudinal	Belgium	Military	17 – 27	Biomechanical factors; Weight	PFP	6 weeks	8
Vauhnik et al. 2011	Prospective	Slovenia	Sport	18.1	Nature of sport participation	ACL injury	1 year	7
Walden et al. 2011	Prospective	Sweden	Sport	24.3	Age; Match played	ACL injury	8 years	7
Wilson et al. 1983	Prospective	England	Military	>17	Pre-service sport participation	PFP	3 years	8

Author	Study design	Country	Setting	Mean age or Range (years)	Exposure	Outcome	Follow up	NOS award
Witvrouw et al. 2000	Prospective	Belgium	College	18.6	External sport activity; Biomechanical factors; Psychological factors	PFP	2 years	8
Anterior cruciate ligament (ACL), Body mass index (BMI), Patellofemoral Pain (PFP)								

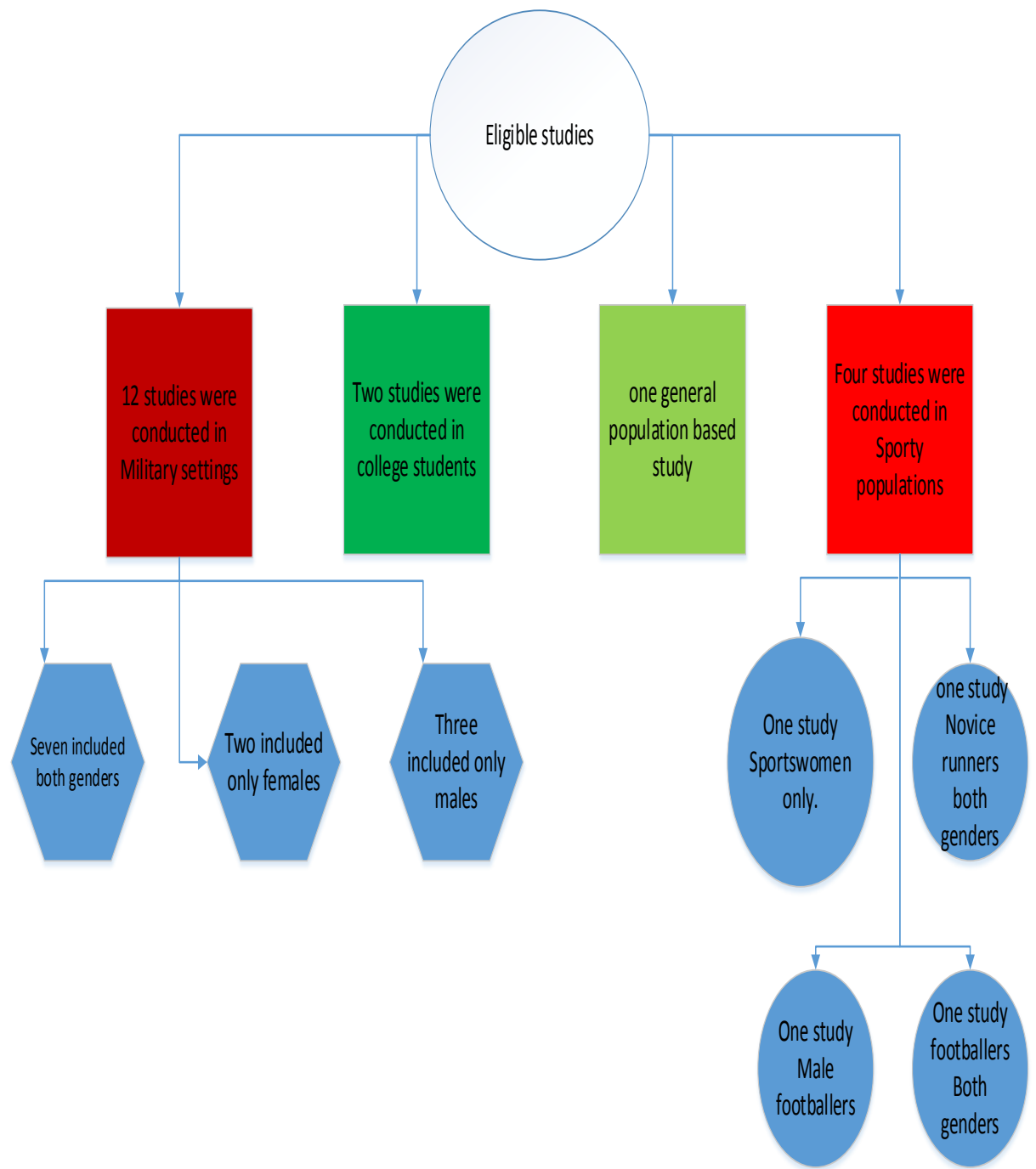


Figure 2.2 Showing gender distribution and the nature of participants in the eligible studies.

Five of the eligible studies were conducted in the USA, two in Israel, two in England (one within the general population [Jones et al. 2007] and another in the military

setting [Wilson et al. 1983]), six in Belgium and the rest elsewhere in other European countries (see Table 2.1).

2.3.2 Measurement of knee disorders

The follow up period reported in the eligible studies ranged from six weeks to nine years. The included studies looked at different types of outcomes. Sixteen studies reported on specific knee disorders. The most investigated knee disorder was patellofemoral pain (PFP) (Wilson et al. 1983; Milgrom et al. 1991; Witvrouw et al. 2000; Hetsroni et al. 2006; Thijs et al. 2007; Duvigneaud et al. 2008; Thijs et al. 2008; Van Tiggelen et al. 2009; Boling et al. 2010; Rauh et al. 2010). Four studies reported on anterior cruciate ligament injury (Uhorchak et al. 2003; Mountcastle et al. 2007; Vauhnik et al. 2011; Walden et al. 2011). One study reported on meniscal tears (Jones et al. 2012) and one on patellar dislocation (Hsiao et al. 2010). There were three studies that had a generic outcome measure: one reported on knee pain defined as any pain in the past month that had lasted for a day or more (Jones et al. 2007) and two reported on knee injuries. One of these studies defined knee injury as an acute injury of the knee ligaments, menisci, bone or joint cartilage, or hemarthrosis as a result of knee sprain (Engerbretsen et al. 2011). The others' definition was hospitalization due to knee injury using ICD-10 codes to identify anterior cruciate ligament (ACL) injury, posterior cruciate ligament (PCL) injury, patellar dislocation and meniscal tear, and overall knee injury (Kuikka et al. 2011).

These outcomes were measured in a variety of ways across the different studies. This included use of a self-administered knee pain questionnaire in one study (Jones et al.

2007); medical records in three studies (Hsiao et al. 2010; Rauh et al. 2010; Jones et al. 2012); a questionnaire and medical records in one study (Boling et al. 2010); a knee injury and osteoarthritis outcome score (KOOS) tool used as a screening questionnaire and physiotherapist examination in one study (Engebretsen et al. 2011) and self-administered questionnaire and surgeon examination in one study (Vauhnik et al. 2011). Six studies used orthopaedic surgeon examination alone (Milgrom et al. 1991; Witvrouw et al. 2000; Uhorchak et al. 2003; Hetsroni et al. 2006; Mountcastle et al. 2007; Walden et al. 2011). The remaining six studies were not clear on the method of measurement of knee disorders (Wilson et al. 1983; Thijs et al. 2007; Duvigieaud et al. 2008; Thijs et al. 2008; Van Tiggelen et al. 2009; Kuikka et al. 2011).

2.3.3 Incidence of knee problems reported in eligible studies

Nineteen studies reported on the incidence of different types of knee disorders. The incidence ranged from 0.07% to 42% (Table 2.2). The incidence reported for studies that were conducted in military cohorts ranged from 0.07% to 42% and for studies in sports cohorts from 2.1% to 10.4% (Table 2.2). For studies investigating specific knee disorders, the incidence reported ranged from 2.1% to 3.3% for ACL injury and 2.2% to 42% for PFP (Table 2.2). For studies reporting a follow-up period less than 20 weeks, the incidence reported ranged from 7% to 42% and for those who reported a follow-up period of 4 years and above from 0.07% to 3.3% (Table 2.2).

Table 2.2 Incidence of different types of knee disorders reported in the eligible studies.

Author	Outcome	Incidence (%)	Follow up	Population
Mountcastle et al. 2007	ACL injury	3.2	4 years	Military
Vauhnik et al. 2011	ACL injury	2.1	1 years	Sport
Uhorchak et al. 2003	ACL injury	3.3	4 years	Military
Walden et al. 2011	ACL injury	3.3	8 years	Sport
Boling et al. 2010	PFP	2.2	2.5 years	Military
Rauh et al. 2010	PFP	7.5	13 weeks	Military
Wilson et al. 1983	PFP	9.0	3 years	Military
Witvrouw et al. 2000	PFP	9.0	2 years	College
Milgrom et al. 1991	PFP	15.0	14 weeks	Military
Hetsroni et al. 2006	PFP	15.0	14 weeks	Military
Thijs et al. 2008	PFP	16.7	10 weeks	Novice runners
Thijs et al. 2007	PFP	20.0	6 weeks	Military
Van Tiggelen et al. 2009	PFP	32.0	6 weeks	Military
Duvigneaud et al. 2008	PFP	42.0	6 weeks	Military
Kuikka et al. 2011	Knee injury	1.1	4 years	Military
Engebretsen et al. 2011	Knee injury	10.4	1 year	Sport
Jones et al. 2007	Knee pain	10.2	2 years	General population
Jones et al. 2012	Meniscal tears	0.8	8 years	Military
Hsiao et al. 2010	Patellar dislocation	0.07	9 years	Military

*Patellofemoral pain (PFP), Anterior cruciate ligament (ACL) injury.

There is inconsistency in the incidence of the same knee disorder reported within a similar population with the same follow-up period (Table 2.2). For example, the incidence of PFP was high in the military population according to Duvigneaud et al. (2008) whereas a lower percentage was reported by Thijs et al. (2007). In contrast, there were two studies that reported the same incidence (Milgrom et al. 1991; Hetsroni et al. 2006). Studies investigating the incidence of knee disorders as knee pain (Jones et al. 2007) or injury (Engebretsen et al. 2011) report a higher incidence compared to some of the studies that focus on a specific knee disorder (Wilson et al. 1983; Witvrouw et al. 2000; Uhorachak et al. 2003; Mountcastle et al. 2007; Boling et al. 2010; Hsiao et al. 2010; Rauh et al. 2010; Vauhnik et al. 2011; Walden et al. 2011; Jones et al. 2012) but some studies of specific knee disorders with shorter follow-up period have a higher incidence.

2.3.4 Risk factors reported in eligible studies

The 19 studies included 12 studies that reported on weight-related and 8 studies of physical activity (including sports activity and general activity). None of the studies investigated physical inactivity as a risk factor. Other exposures reported on included: age (eight studies), gender (five studies), biomechanical factors (ten studies) and psychological factors (two studies).

2.3.5 Weight related factors

Of 12 studies that reported on participants' weight, only nine studies reported on the relationship between weight-related factors and knee disorders, and compared this

factors between groups (Milgrom et al. 1991; Uhorchak et al. 2003; Jones et al. 2007; Thijs et al. 2007; Duvigneaud et al. 2008; Thijs et al. 2008; Van Tiggelen et al. 2009; Engebretsen et al. 2011; Kuikka et al. 2011) (Table 2.3). Of the nine studies that compared this factor between groups, seven measured it directly (Milgrom et al. 1991; Uhorchak et al. 2003; Thijs et al. 2007; Duvigneaud et al. 2008; Thijs et al. 2008; Van Tiggelen et al. 2009; Kuikka et al. 2011) and two studies were self-reported (Jones et al. 2007; Engebretsen et al. 2011). Two studies compared the risk of knee disorders with increasing weight related factors (Jones et al. 2007; Kuikka et al. 2011) (Table 2.3).

Only two studies suggested an increase in knee disorders with increased weight (Uhorchak et al. 2003; Kuikka et al. 2011) In the study by Uhorchak et al (2003), the relative risk for ACL injury associated with BMI was 2.0 and adjustment for other risk factors, for example Notch width of knee joint, increased the relative risk to 8.5 (Uhorchak et al. 2003). Kuikka et al (2011) reported that participants whose BMI was $\geq 30 \text{ kg/m}^2$ were up to 1.6 times (95% CI 1.03 to 2.5) more likely to develop knee disorders compared to those whose BMI were $< 25 \text{ kg/m}^2$ (Kuikka et al. 2011).

Table 2.3 Weight as a risk factor.

Authors	Measures	Knee disorders		Risk of knee disorders (OR / RR	P- value
		Present	Absent		
		Mean (SD)	Mean(SD)		
Duvigneaud et al. 2008	BMI	21.6 (2.8)	22.2 (2.7)		0.42
Uhorchak et al. 2003	BMI	25.0 (2.7)	23.2 (2.6)	RR 2.0*	0.002
Van Tiggelen et al. 2009	Height	180.6 (6.12)	180.5(6.2)		0.96
	Weight	72.1 (9.0)	70.5 (8.5)		0.25
Milgrom et al. 1991	Height	177.8 (7.3)	177.0 (6.3)		
	Weight	70.2 (9.7)	69.3 (9.5)		
Thijs et al. 2008	BMI	24.9 (3.5)	25.1 (2.8)		0.80
Thijs et al. 2007	Height	175.9 (7.5)	179.3 (7.7)		0.054
	Weight	67.6 (8.4)	67.4 (7.6)		0.91
Engebretsen et al. 2011	BMI	23.6 (1.4)	23.7 (1.7)	OR 0.94 (95%CI 0.69- 1.27)	0.42
Jones et al. 2007	BMI				0.30
	<21.3	8 (5.8%)	129 (94.2%)		
	21.3 – 22.8	15 (12.6%)	104 (87.4%)		
	22.9 – 25	16 (12.3%)	114 (87.7%)		
	>25	12 (9.7%)	112 (90.3%)		
Kuikka et al. 2011	Normal			1	
	Overweight			OR 1.0 (95%CI 0.8 – 1.3)	
	Obesity			OR 1.6 (95%CI 1.03 - 2.5)	

*adjusted for other risk factors. Odds ratio (OR), Body mass index (BMI), Standard deviation (SD)

2.3.6 Physical activity

There were eight studies that compared some type of physical activity. However, levels of physical activity were measured differently in all these studies. Vauhnik et al. (2011) measured physical activity as the types of sport participated in by their participants, which were basketball, volleyball and handball. Participation in sport was measured as the level of the sport was played at and physical education courses and activities (Mountcastle et al. 2007), while the number of hours of participation in sport per week was used in another study (Duvigieaud et al. 2008). One study used sport activities participated in beside the school activities (Witvrouw et al. 2000), another matches played, and a player's position (Engebretsen et al. 2011; Walden et al. 2011) whilst pre-service sport participation was used in one study (Wilson et al. 1983). In one study, participants were asked if they frequently took part in sports, activities, or other physical activities such as gardening or other hobbies (Jones et al. 2007). Their responses were categorised into high or low. Grouping of the participants was not clarified neither was there any justification given for the choice of method of measurement of physical activity.

The Jones et al. (2007) study found that being physically active was not significant in the reporting of knee pain among their cohort (Jones et al. 2007). This could be because the majority of their cohort was young and physically active, and those who were not active had a lower risk of knee pain. It could also be as a result of the grouping of their participants' physical activity level. Witvrouw et al. (2000) found no difference in external sports activities participation other than in the physical education classes between those who reported PFP and those without PFP. Of students

without, PFP 217 of 258 participated in competitive sports and 16 of 24 with PFP participated in competitive sports. However, there was a variety of sports among their cohort, the number of participants that reported PFP was small, which make statistical comparison of the group difficult (Witvrouw et al. 2000). One study reported a 3.4% incidence of ACL injury (Mountcastle et al. 2007). Of those that reported new cases of ACL injury, 11% reported them to have occurred during free-time activities, 13.9% during physical education instruction, 25.2% playing intercollegiate sports and 35% intramural sports (Mountcastle et al. 2007). However, one study found that participating in a sport before military basic training was protective against PFP (Wilson et al. 1983). The strength of the quadriceps muscle in individuals that participate more in a sport could explain the protection afforded by participation in sport against PFP (Duvigneaud et al. 2008).

Despite this advantage of sport participation, the nature of the sport participated in was found to be a risk factor for ACL injury, as a higher incidence was reported among those participating in basketball (p-value 0.04) (Vauhnik et al. 2011). It should be noted that the Vauhnik et al. (2011) study cohort consisted of females only, hence it could be suggested this could have influenced the outcomes reported by their study. However, in a cohort of professional footballers that consisted of both genders, three quarters of the ACL injuries were reported to have occurred during match play, and the overall match-to-training incidence ratio was significantly higher (Relative risk 20.8 (95%CI 12.4 to 34.8) (Walden et al. 2011).

The findings demonstrate that participating in physical activity increase knee disorders. However, as a result of the variations in the measurement of physical

activity and the cohorts in which these studies were conducted, the relationship between physical activity and knee disorders need further exploration.

2.3.7 Gender

There were five studies which examined gender as a risk factor for knee disorders (Jones et al. 2007; Mountcastle et al. 2007; Boling et al. 2010; Hsiao et al. 2010; Jones et al. 2012) (Table 2.4). Four studies found gender to be a risk factor for knee disorders (Mountcastle et al. 2007; Boling et al. 2010; Hsiao et al. 2010; Jones et al. 2012) whereas one suggested no association with a knee disorder (Jones et al. 2007).

It may be that females are more susceptible to certain types of knee disorders than males and vice versa and for some disorders there are equal risks. Boling et al. (2010) found that females had a higher incidence of PFP compared to males. Hsiao et al. (2010) found that women experienced a significantly higher rate of patellar dislocation than men, and were 61% more likely to sustain patellar dislocation, when adjusted for other factors in the model (Table 2.4).

Jones et al. (2012) reported in their study that males were more likely to develop meniscal tear than females (rate ratio (RR), 1.18 [95%CI 1.15 – 1.20]). Mountcastle et al. (2007) found that the overall proportion ratio (PR) for ACL injuries was similar in men and women (IPR, 1.09 [95%CI 0.80 to 1.47]). Jones et al. (2007) reported no gender difference when investigating knee pain (Relative risk of 0.64). The findings suggest that females are just as susceptible to knee disorders as males but the risk

varies across specific knee disorders. Hence the need to include gender in a study exploring knee disorders among young adults.

Table 2.4 Relationship between gender and knee disorders.

Authors	Outcome measured	Rate ratio / Relative risk / Proportion ratio / Odds ratio
Boling et al. 2010	PFP	
<i>Female compared to male</i>		OR 2.3 (95% CI 1.16 – 4.10)
Jones et al. 2012	Meniscal injury	
<i>Male compared to female</i>		RR1.18 (95%CI 1.15 – 1.20)**
Mountcastle et al. 2007	ACL injury	
<i>Female compared to male</i>		PR1.09 (95%CI 0.80 – 1.47)
Jones et al. 2007	Knee pain	
<i>Female compared to male</i>		RR 0.64
Hsiao et al. 2010	Patellar Dislocation	RR1.61 (95%CI 1.53 – 1.69)*
<i>Female compared to male</i>		

*adjusted for age, gender, race, service, and rank. ** adjusted for age, race, service, and rank. Patellofemoral pain (PFP), anterior cruciate ligament (ACL) injury, Odds ratio (OR).

2.3.8 Age

Eight studies examined age as a risk factor for a knee disorder (Jones et al. 2007; Jones et al. 2012; Kuikka et al. 2011; Hsiao et al. 2010; Engebretsen et al. 2011; Walden et al. 2011; Thijs et al. 2007; 2008) (Table 2.5).

The incidence rate of patellar dislocation was reported to be higher among participants 20 to 24 years old (Hsiao et al. 2010). Participants 20 to 24 years old were 56% more likely to sustain a patellar dislocation injury compared to those at 35 to 39 years old (incidence rate ratio, 1.6 [95%CI 1.4 to 1.7]). With an increase in age the risk of sustaining knee disorders like patellar dislocation decreases. This might be associated with the higher rate of participation in younger service members compared to older ones.

In contrast to the decreased risk of sustaining a patellar dislocation with age, an increase in age was found to be associated with an increase in the risk of hospitalisation due to a specific knee disorder - meniscal injury (Kuikka et al. 2011). The oldest group (21 to 30 years old) had a 2.4 times (95%CI 1.5 to 3.6) greater risk of hospitalisation due to meniscal injury compared to the younger group (18 to 19 years old). However, Kuikka et al. (2011) went further to suggest that an increase in age is associated with all knee injuries leading to hospitalization (OR 1.7 [95%CI 1.3 to 2.2]). The risk of different types of knee disorders changes with an increase in age, hence age is an important factor to be considered when investigating knee disorders among young adults.

Table 2.5 Age as risk factor for knee disorder.

Author	Outcome	Unadjusted OR (95%CI) / Proportion	Adjusted OR (95%CI)	P- value	Direction of effect
Kuikka et al. 2011	Knee injury	1.7 (1.3 – 2.2)			Increasing
Hsiao et al. 2010	Patellar dislocation		1.8 (1.6 – 2.1)*		Increasing
Jones et al. 2012	Meniscal injury	2.4 (2.4 – 2.5)	3.2 (3.1 – 3.3)**		Increasing
Kuikka et al. 2011	Knee disorder***		2.4 (1.5 – 3.6)		Increasing
Engebretsen et al. 2011	Knee injury	1.1 (0.8 -1.4)			Increasing
Walden et al. 2011	ACL injury				
<i>Female</i>		2.4 (1.3– 4.2)			Increasing
<i>Male</i>		2.1 (1.0 – 4.2)			
Jones et al. 2007	Knee pain				Increasing
<i>Age 21–23</i>					
<i>24 – 27</i>		14 (9.7%)			
<i>>27</i>		13(12.3%)			
		15 (10.9%)			
Thijs et al. 2008	PFP	-		0.49	Increasing
Thijs et al. 2007	PFP	-		0.92	Increasing

* Gender, race, service, and rank. * *Race, gender, service, and rank. ***Hospitalisation due to specific knee disorder- meniscal injury. Patellofemoral pain (PFP), anterior cruciate ligament (ACL) injury, Odds ratio (OR).

2.3.9 Psychological factors

Only two studies reported on the risk of psychological factors amongst those that had a knee disorder and those that did not (Witvrouw et al. 2000; Jones et al. 2007) (Table 2.6). Both these studies showed a higher level of psychological distress among participants with a knee disorder. Witvrouw et al. (2000), using the Utrecht Coping Test and Amsterdam Biographic questionnaire in their study, measured seven psychological parameters for coping-behaviour mechanisms in their participants. They showed participants with PFP were less likely to ‘seek social support’ (mean difference, -1.78 [95%CI -3.44 to -0.12]), and these participants found it difficult to relax when confronted with a knee disorder compared to healthy controls. In investigating a plausible relationship between knee pain and psychological factors, Jones et al. (2007) measured general psychological distress using the General Health Questionnaire. They reported a relative risk of 1.5 (95% CI 0.9 – 2.3) and 1.6 (95% CI 1.02 – 2.6) for medium and high psychological distress compared to low psychological distress among their cohort. The latter confidence interval is consistent with an association between the reporting of knee pain and high psychological distress. These findings suggest that psychological status is an important variable to be considered when investigating knee disorders among younger people.

Table 2.6 Relationship between psychological factors and knee disorders.

Authors	Relative risk*of psychological distress	Mean difference**between Psychological parameter of participants with PFP and those without
Jones et al. (2007)	Low – 1.0 Medium – 1.5 (95%CI 0.9 – 2.3) High – 1.6 (95%CI 1.02 – 2.6)	
Witvrouw et al. (2000)		-1.78 (95%CI -3.44 - -0.12)

*Adjusted for age, sex, occupational group, BMI, physical activity

**Significant difference between groups ($P < 0.05$). Patellofemoral pain (PFP).

2.3.10 Biomechanical risk factors

Physical fitness described as strength in knee extension, quick reaction time, jumping ability, muscle strength, and explosive force were measured in three studies (Milgrom et al. 1991; Witvrouw et al. 2000; Duvigneaud et al. 2008; Boling et al. 2009). Increased Q-angle, altered kinematics and kinetics were reported to be associated with PFP (Boling et al. 2009), while the other studies reported strength of the quadriceps (Milgrom et al. 1991; Duvigneaud et al. 2008), vertical jump performance and lower explosive strength capacity (Witvrouw et al. 2000) as a statistically significant physical fitness variable for predicting PFP. For the posture variables which were the anatomical features of the knee joint, a larger medial tibial intercondylar distance (Milgrom et al. 1991) was associated with the development of PFP while Notch width was associated with the development of ACL injury (Uhorchak et al. 2003) compared to controls.

Hip and knee angle variables were not associated with knee disorders (Milgrom et al. 1991; Witvrouw et al. 2000). Thijs et al. (2007) in their study to investigate gait-related risk factors for a knee disorder measured 37 variables for plantar pressure measurement during barefoot walking as possible causes of PFP using a footscan pressure plate. However, only two of these variables (maximal pressure on the fourth metatarsal and slower maximal velocity in lateromedial direction of the centre of pressure) were associated with PFP. Witvrouw et al. (2000) measured five variables which were reflective of general joint laxity: a greater range of motion for thumb-forearm and knee extension mobility, and a lower range of motion for elbow extension mobility were significantly associated with PFP. Hetsroni et al. (2006), investigating foot pronation as risk factor for a knee disorder, measured five variables of dynamic movement. The five variables were; bilateral maximal foot pronation angle during stance phase, the pronation range of movement, the time to maximum pronation from heel strike, the pronation mean angular velocity and stance duration. Only pronation mean angular velocity was statistically significant in relation to anterior knee pain, (Hetsroni et al. 2006) although, the association was not consistent between feet. Biomechanical factors are important variables to be considered when exploring knee disorders in young adults.

2.4 Methodological quality of the selected articles

The NOS scale of zero to nine stars was used to assess the selected studies, with nine stars being awarded to studies with outstanding quality. Following assessment by the research student the 19 studies received a star award ranging from six to eight (see

Table 2.1). Fourteen studies received eight stars that demonstrating the reviewed studies were of good quality.

2.5 Discussion

This review, using systematic methods, set out to identify independent risk factors for knee disorders in young adults aged 18 to 40 years old with a particular focus on BMI, physical activity and physical inactivity. This discussion focuses on the implication of the findings of this review on the development of an epidemiological study of obesity, physical activity and physical inactivity as risk factors for knee disorders.

Most studies investigated different knee disorders, of which PFP was the most common. Only three studies had a more generic outcome (Jones et al. 2007; Engebretsen et al. 2011; Kuikka et al. 2011). There were marked variations in the incidence of knee disorders such that an adequate sample size estimate is not possible. Population, type of measure, and follow up also varied across reviewed studies. Unsurprisingly therefore, the incidence of knee disorder varied from 0.07% to 42% (Table 2.3). Incidence was inconsistent in studies which examined the same disorder. In addition, there was only one study which investigated the incidence of knee disorders in a general population. Therefore, there is a need for a feasibility study to estimate incidence in a more general population.

There was conflicting evidence on weight-related factors as a risk factor for knee disorders. Only two studies found it to be a risk factor for knee disorders (Uhorchak et al. 2003; Kuikka et al. 2011). However most of these studies were in athletic or

military populations with participants mainly with normal weight or BMI. Even in the community based study, there were relatively few participants within the obese group (Jones et al. 2007). This suggests that further exploration of the relationship between BMI and knee disorders is warranted.

There were no studies that looked at physical inactivity which is an increasing problem in contemporary societies as a risk factor for knee disorders. The evidence around physical activity in this review is conflicting. Levels of physical activity were investigated as an independent risk factor using various definitions and mainly relating to sports participation, the nature of the sport, and the level of sports participation. However, the risk of cruciate ligament injury was found to increase with an increase in the frequency of participation in physical activity (Mountcastle et al. 2007; Kuikka et al. 2011) and the highest risk of knee disorders was observed among participants that played basketball compared to other sports (Vauhnik et al. 2011). None of the studies looked into the risk of knee disorders for activities during leisure time, for example, walking, cycling etc. among younger people in the general population and most of the studies were in physically active cohorts. Therefore, further exploration of the relationship between physical activity and knee disorders and physical inactivity and knee disorders in a general population with different levels of activity is warranted.

Most of the evaluated risk factors in the studies were biomechanical and neuromuscular risk factors, which require direct measurement (Milgrom et al. 1991; Witvrouw et al. 2000; Hetsroni et al. 2006; Thijs et al. 2007; Duvigneaud et al. 2008; Thijs et al. 2008; Boling et al. 2009; Van Tiggelen et al. 2009; Kuikka et al. 2011;

Engebretsen et al. 2011). Biomechanical factors were found to be risk factors for different knee disorders, but the proposed study would be undertaken in the general population looking at generic knee disorders from a public health perspective and measuring of biomechanical factors in such large study is not feasible and, more importantly, as it varies with different conditions, may be inappropriate.

Most studies were of specific knee disorders. Risk factors may vary for different types of knee disorders, for example, age and gender. The focus on knee disorders is very clinically focused and does not encapsulate less defined knee disorders which may be present in the general population. Therefore a broader definition of knee disorders may be needed. Only three studies looked at this and each had a different definition. There is a need to further define knee disorders for a study in the general population. .

2.5.1 Strengths and weaknesses of the review

The review had a clear objective, inclusion and exclusion criteria, search strategies on what it set out to achieve, as well as the study group of interest. Five databases were separately searched and reference lists manually searched.

However, the review's weaknesses lie in the selection of studies to be included. Usually two independent researchers would have separately performed the review of abstracts after which consensus would have been reached. In this review, the selection of abstracts retrieved by the search strategy was performed by the research student only, because of time and resource constraints, although a consensus on which articles to include was reached between two researchers independently following the

screening of abstracts. The assessment of the quality of selected studies for the review using NOS and the data extraction would also normally be carried by two researchers independently, with the difference resolved by dialogue as stated earlier. This was performed only by the research student because this is a piece of work done as a partial fulfilment of the requirements for the award of Doctorate in Public Health and Epidemiology and there were insufficient resources and time constraints. This introduced bias in the assessment of quality of the reviewed studies.

2.6 Conclusion

This review suggests that an epidemiological study examining the relationship between obesity, physical activity and physical inactivity in the general population is warranted. However, as the incidence of knee disorders in the population is not clear, a feasibility study on a convenience sample should be undertaken first to inform a large scale study. Furthermore, as the outcomes considered by most studies were clinically focused, for example, on ACL and PFP, a clear definition of outcomes that will encapsulate all knee disorders is needed. The next chapter reports on the development of a definition of outcomes for this study.

Chapter 3: Development of a definition of outcomes for this study

3.1 Introduction

In an epidemiological study, there is a need for a clear definition of the condition under investigation to ensure that an appropriate measurement tool is used for the purpose of identification of those with the condition (Sharma 2011). A clear definition will ensure: consistency in data collection, comparison and replication of the study findings, quantification of condition occurrence within a population, and reduction of measurement bias (Sharma 2011; Centre for Disease Control 2015). This was followed by a consultation of the International Classification of Functioning, Disability and Health (ICF) to investigate its perspective on the classification of knee disorders. The perspective of knee disorder for this thesis was defined followed by the thesis aim and objectives.

3.2 Overview of findings

It is necessary here to clarify exactly what is meant by ‘knee disorder’ for this thesis. The need for a definition of knee disorders is imperative for an epidemiological study. It should be noted that the problem with investigating knee disorders is that different authors from different backgrounds have different concepts of knee disorders as demonstrated in the systematic review (see Chapter 2). It is clear a wide variety of different definitions have been used in the investigation of knee disorders among young adults (Table 3.1).

Table 3.1. Variations in case definition in studies reviewed in the systematic review that investigated knee disorders among young adults.

Author	Definition of case	Outcome measured
Rauh et al. 2010	Overuse injuries	PFP
Witvrouw et al. 2000	Present of the characteristic history of PFP syndrome, Negative findings in the examination of knee ligaments, menisci, bursae, synovial plicae, Hoffa's fat pad, iliotibial band, the hamstrings, quadriceps and patellar tendons and their insertions, For more than 6 weeks.	PFP
Boling et al. 2009; 2010	Negative findings in the examination of knee ligaments, menisci, bursa, and synovial plica. Retropatellar knee pain during at least two of the following activities: ascending/descending stairs, hopping/jogging, prolonged sitting with flexed knees, kneeling, and squatting. Pain on palpation of medial or lateral patellar facets / Pain on palpation of the anterior portion of the medial or lateral femoral condyles.	PFP
Thijs et al. 2008	Characteristic history of PFP syndrome. Negative findings (no symptoms) in the examination of knee ligaments, menisci, bursae, synovial plicae, Hoffa's fat pad, iliotibial band, the hamstrings, quadriceps and patellar tendons and their insertions.	PFP
Thijs et al. 2007	The same as in Thijs et al 2008	PFP
Van Tiggelen et al. 2009	The same as in Thijs et al 2008	PFP
Duvigneaud et al. 2008	The same as in Thijs et al 2008	PFP
Milgrom et al. 1991; 1996	Pain around the patellofemoral joint	PFP
Wilson et al. 1983	Pain induced on extension of knee against resistance. Pain on gentle manipulation of patella over the femoral condyles and resistance of this movement. Pain on quadriceps contraction against mild, distally directed pressure on the patella. Pain on stair walking. Pain or stiffness associated with rest and after sport. Patellar dislocation. Feeling of giving way of the knee or instability.	PFP

Author	Definition of case	Outcome measured
Hetsroni et al. 2006	Exertional anterior knee pain.	Anterior knee pain
Vauhnik et al. 2011	ACL injury	ACL injury
Uhorchak et al. 2003	Injury to the ACL	ACL injury
MountCastle et al. 2007	Complete or partial tears of ACL	ACL injury
Walden et al. 2011	ACL injury: First-time or recurrent partial or total rupture of the ligament either isolated / associated with other concomitant injuries to the knee joint or absence of any physical contact at the time of injury. Knee sprain: an acute non bone distraction injury to the connective tissue, i.e., joint capsule and ligaments, of the knee joint.	ACL injury & Knee sprain.
Engebretsen et al. 2009	An acute injury of the knee ligaments, menisci, bone or joint cartilage, or if hemarthros had occurred as a result of knee sprain.	Knee injury
Kuikka et al. 2011	Knee injuries including: ACL & PCL tears, Fresh & Old meniscal tears, MCL & Lateral collateral tears, traumatic chondral lesion, and patellar dislocations.	Knee injury
Hsiao et al. 2010	First occurrence of patellar dislocation	Patellar dislocation
Jones et al. 2012	Tear of lateral cartilage or meniscus of knee	Meniscal tears
Jones et al. 2007	Presence of knee pain	Knee pain
Patellofemoral pain (PFP), anterior cruciate ligament (ACL) injury, Posterior cruciate ligament (PCL), Medial collateral ligament (MCL)		

3.3 Clinician perspective of knee disorders

From a clinician's perspective, patients will present to the clinician because of damage to the '*moving parts*' of the knee joint which may result in an unpleasant sensational feeling such as pain around the joint area (Dye 1996), and/or because of an impact on the level of performance of the knee over a period of time (Felson et al. 2007). The clinician will want to diagnose the underlying disorder so that they can treat the condition appropriately.

This is why most of the studies in the review examined risk factors for specific disorders and in the populations which are thought to have more of those problems e.g. military and sports cohorts. However, even when the studies investigated specific disorders the definitions differed. For example, in the 10 studies investigating PFP there were 7 different definitions (Table 3.1 above). In the two studies that investigated injury to the knee joint, there was evidence of differences in definition, as one study included occurrence of hemarthrosis as a result of knee sprain as knee injury (Engebretsen et al. 2011), while the other study did not (Kuikka et al. 2011). Both included different specific knee disorders (Table 3.1). Furthermore, focus on knee injury may underestimate the scale of knee disorders in the population as a significant proportion do not come on suddenly (Selfe et al. 2015), and may not be considered traumatic by patients.

3.3.1 A perspective based on symptoms

An individual patient's perspective of his / her health condition may vary from the clinician's perspective. This is demonstrated by the existence of different pain thresholds across different individuals and the degree of influence it has on their daily living activities (Merskey & Bogduk 1994). One study in the review focussed on knee pain which is one of other possible symptoms present in knee disorders.

Knee disorders do not involve only pain around the knee joint. Different types of knee conditions can present themselves in different ways with the symptoms including pain, instability, swelling, and stiffness of the joint (Table 3.2). There are knee disorders which do not mainly present with knee pain but which can still affect the patient's quality of life. Felson et al. (2007) found in their study of knee buckling with a sample size of 2,351 men and women aged 36 to 94 years old (median 63.5 years), that knee buckling occurred in 2.1% of knees with no pain at any time in the past 30 days. The prevalence of buckling was 26.7% among knees with pain rated as severe compared with 9.9% among knees with pain rated as mild.

A focus on knee symptoms however, does not encompass the impact of knee disorders on the individual. Another important consideration is the function of the knee. In this context, the level of function of the knee is defined by the level of activities at which the knee can perform, interacting with components of its internal and external environment. According to Dye (1996),

“The knee is a complex assemblage of living asymmetrical moving parts whose purpose is to accept, transfer, and ultimately dissipate often high loads generated at the ends of the long mechanical lever arms of the femur and tibia”.

These activities performed by the knee are as a result of the working together of the different parts that make up the knee joint complex. Different parts that make up the knee complex include: cruciate ligaments, meniscus, cartilages, tendons, patella and muscles. The phrases from the above statements ‘*moving parts*’ and ‘*working together of different parts*’, could lead to the deduction that damage to any part of the knee would result in dysfunction of the joint. The deficiencies in the medical model which focuses on dysfunction within the individual rather than within the context of social, economic, and political domains led to the development of the ICF (WHO 2001). The ICF recognises the central role played by environmental and personal factors in a person’s functioning and disability.

Table 3.2. Different forms of knee problems, symptoms, and possible sources.

Condition	Natural History	Symptoms			
		Pain	Instability	Swelling	Stiffness
Anterior Cruciate Ligament Rupture (ACL Knee Injury and Reconstruction)	It is common in sport/physical exercise involving changing of direction and running; landing on bent or over extended knee then twisting and directed contact/hit on the knee joint.	√	√	√	√
Posterior Cruciate Ligament Tear (PCL Tear)	Results from a direct blow in front of the tibia.	√	√	√	√
Medial Collateral Ligament Injury (MCL Knee Ligament Injury)	Usually occur through direct hit on the knee or it twisting during physical activity.	√	√	√	√
Lateral Collateral Ligament Injury (LCL Knee Ligament Injury)	Result from twisting or direct hit on the knee during physical activity.	√	√		√
Meniscus Tear (Torn Cartilage Knee Injury)	Common in physical activity that involves bending of the knee.		√	√	
IlioTibial Band Friction Syndrome (Runner's Knee)	Common in runners and cyclists as a result of overuse of the knee that affects the outer part of the knee.	√		√	

Condition	Natural History	Symptoms			
		Pain	Instability	Swelling	Stiffness
Patellofemoral Maltracking/Anterior knee pain/ Chondromalacia Patella (Patellofemoral Pain Syndrome)	Dislocation of the knee cap from its path causing abnormal stresses under surface of the patella occurs during physical activity.	√	√	√	√
Patella Tendonitis (Jumpers Knee)	Common when jumping and landing activities are carried out more often.	√			√
Knee Fracture/Broken Knee cap (Patella Fracture)	Result from direct trauma on the knee cap that initial fracture which can be simple or complex.	√		√	√
Osteoarthritis of the knee (Knee arthritis)	It is a progressive degeneration of the knee as result of ACL injury or Meniscus tear in the past.	√	√	√	√
Loose Bone Fragment in the Knee joint (Osteochondritis Dissecans)	Result from direct trauma to the knee joint which leaves fragment of broken bone on the joint.	√		√	√
Osgoods (Osgood Schlatter)	Common in adolescence aged 9 – 14 years. Result from overuse of the knee.	√		√	

3.4 Understanding knee disorder from an ICF perspective

The ICF was also explored in order to further develop the definition for the proposed epidemiological study. It provides a systematic coding scheme for health information systems used in health outcome research, population surveys, and as an organizational basis for social policy (Imrie 2004). The ICF highlights that a person's functioning and disability (that is a Body functions and Body structures component and an Activity and Participation component) are a dynamic interaction between health conditions and contextual factors (that is Environmental and Personal factors) (Figure 3.1) (WHO 2001). Environmental factors are classified as factors not within a person's control that might have an impact on the person's functioning. Personal factors include; age, race, gender, educational level, coping styles, etc. The personal factors are not specifically classified in the ICF (WHO 2001), which could be due to wide variability among cultures.

The ICF measures participation as "the involvement in life situations" or "lived experience" of people in the actual context in which they live (WHO 2001) but does not take into account person-perceived participation. Some authors have criticised the theoretical and conceptual underpinnings of the ICF for a lack of clarity (Hemmingsson & Jonsson 2005). This lack of clarity on the theoretical and philosophical foundations of the ICF may lead to different interpretations by practitioners (Imrie 2004).

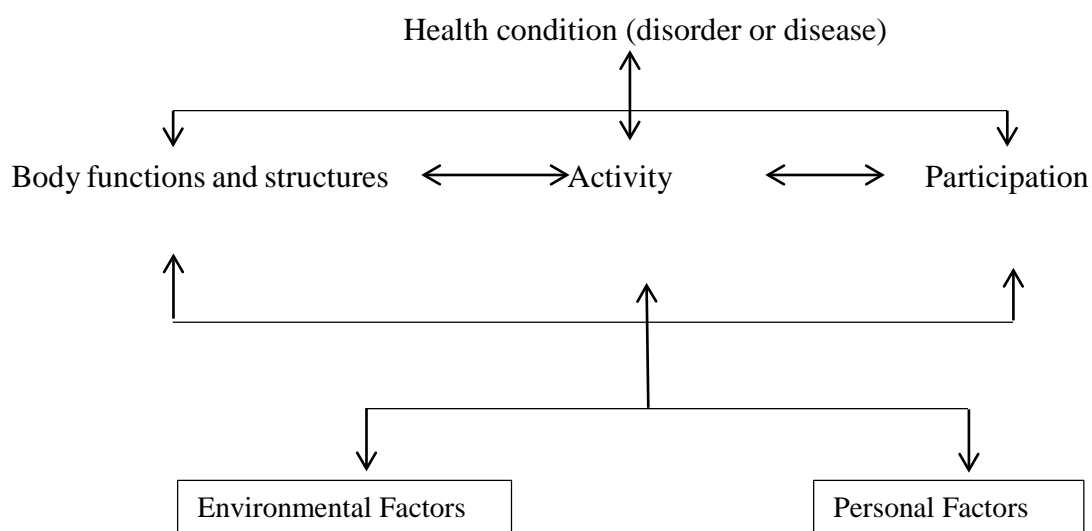


Figure 3.1 Interactions between the components of International Classification of Functioning, Disability and Health (ICF) (WHO 2001).

3.5 Perspective of Knee disorder for this thesis

The discussion above highlights that classification of the outcome measure in this thesis cannot focus solely on a clinical or symptomatic as this is too specific and may underestimate the condition at a population level. An ICF perspective may be more appropriate as it encompasses symptoms such as pain, functional activities and participation and is in line with a public health perspective which is concerned with the impact at a societal level. However, the ICF would be difficult to operationalise in a study.

In this study, the definition needs to cover any form of deviation from the normal anatomical function of the knee. This deviation from the normal anatomical function of the knee can present in a number of different ways such as stiffness and instability of the joint, the knee giving way when moving, difficulty walking on flat surfaces, the

need for support while walking or standing, difficulty in ascending or descending stairs, impact on sports, leisure or social participation etc. Joint laxity (discussed in chapter 1, section 1.3), malalignment and poor muscle control can lead to deviation from the normal function of the knee. These latter two factors have been discussed in chapter 2, section 2.3.10 (Milgrom et al. 1991; Witvrouw et al. 2000; Uhorchak et al. 2003; Duvigneaud et al. 2008; Boling et al. 2009). General ligamentous laxity has been shown to cause knee instability (Sharma et al. 1999). However, studies have shown that individuals with anterior knee laxity due only to anterior cruciate ligament deficiency report no symptoms of knee instability (Lephart et al. 1992). Deviation from normal function could result from mechanical factors (e.g. buckling, fracture as a result of direct or indirect trauma on the knee joint), injury to any part of the joint and biomechanical factors (e.g. overloading of the joint) (Figure 3.2). The thesis needs to cover all predominant knee symptoms which cause any sensation of unpleasant feeling indicating potential or actual damage to any structure of the knee joint felt in one or both knees (Merskey & Bogduk 1994).

Therefore, the term '*knee problem*' is used from now on in this thesis as it is able to incorporate all the issues above. **'Knee problem' is a deviation from the normal function of the knee joint with or without any unpleasant sensation around the joint area.** This definition has informed the selection of measurement instruments used for the feasibility study.

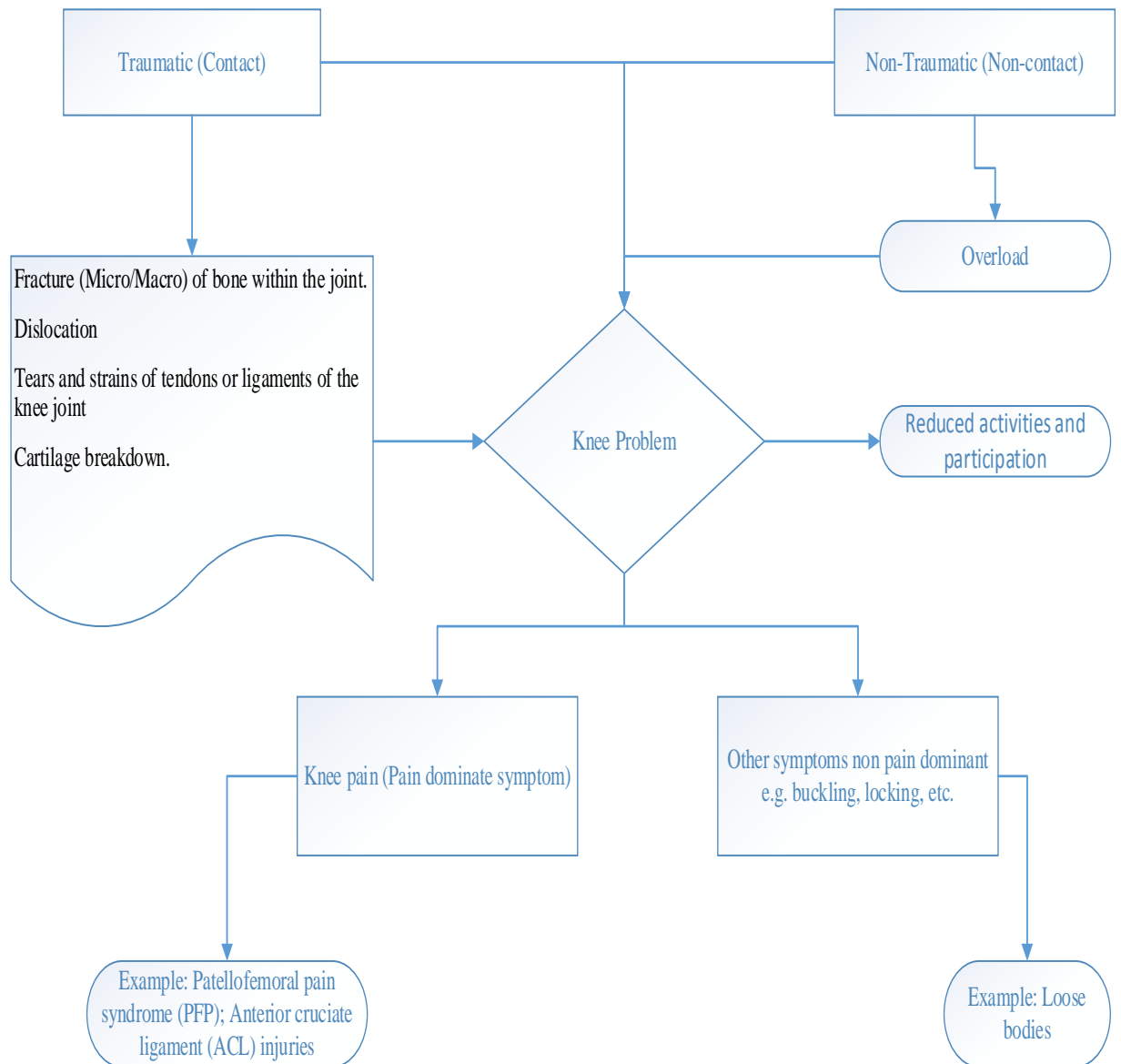


Figure 3.2 Framework used in defining a knee problem.

3.6 Thesis aim

The review (Chapter 2) showed that the incidence rate of knee disorders was inconsistent across reviewed studies due to the variations in the definition of outcomes

and because the populations studied were mostly athletic. The review also suggests that an epidemiological study examining the relationship between the risk factors obesity, physical activity and physical inactivity and knee problems in the general population is warranted. Hence, the aim of the thesis is to explore the epidemiology of knee problems in young adults.

3.6.1 Thesis objectives

- To estimate the prevalence of knee problems in young adults, and different types of knee problems (for example, those with and without knee pain, those of traumatic or non-traumatic origin)
- To explore the inter-relationship between knee problems, obesity, and physical inactivity in young adults
- To estimate the incidence rate of knee problems occurring in young adults over a 12- month period (overall and for different types of knee problems)
- To evaluate the feasibility of a larger incidence study

The next chapter describes the methods used to identify an appropriate measurement tool to identify knee problems (as defined in this chapter) which could be used to address these objectives in an epidemiological study of young adults.

Chapter 4: Review of measurement instruments for the feasibility study

4.1 Introduction

This chapter describes the method used to identify an appropriate measurement tool to identify knee problems which was defined in the previous chapter as: a deviation from the normal function of the knee joint with or without any unpleasant sensation around the joint area.

From the review in Chapter 2 it was noted that knee problems were measured in different ways across reviewed studies. Knee problems were measured through physical examination, medical records or a self-administered instrument. Physical examination needs specialist expertise, which was not available and requires substantial resources in large-scale epidemiological studies. Medical records would not be available and not all those with knee problems would have consulted a doctor (Rathleff et al. 2013).

This prompted a review of self-administered instruments used in incidence studies of knee disorders. This chapter reports on this review, which used systematic methods to identify different self-administered measurement instruments that have been used in incidence studies to measure knee disorders. These are then compared against the constructs of the case definition of a knee problem for this thesis (see Chapter 3).

4.2 Background

There has been an increase in the number of outcome measurement instruments available to both clinicians and researchers for assessing individuals with knee problems irrespective of underlying diagnosis or intervention (Johnson & Smith 2001; Davies 2002; Garratt et al. 2004; Fransen and van Riel 2009). In a research context, the participant's self-reported knee problem, their functional status and quality of life are important for the full assessment of musculoskeletal conditions, as this gives more in-depth information than assessment by a clinician (VanderZee et al. 1996; De Groot et al. 2008). However, there is no self-report instrument which is universally applicable across the spectrum of knee problems and groups of individuals (Garratt et al. 2004; Howe et al. 2012; Rodriguez-Merchan 2012).

Fitzpatrick et al. (1998) has suggested that before consideration of an instrument for an epidemiological study it is important to take into account the specific population and the feasibility of using the instrument for the proposed study (Howe et al. 2012). The instrument should also have the ability to detect change when used over a number of times (Streiner & Norman 2008).

Therefore, before proceeding to a study of knee problems, as previously defined, there was a need to identify an instrument which reflects the constructs to be measured in a young population (Mokkink et al. 2010) and which has good reliability and validity (Davies 2002).

4.3 Objective

The objective was to identify an instrument that fulfilled the constructs of the case definition of knee problems described in this thesis.

4.4 Methods

The systematic search strategy described in chapter 2 was extended to identify studies of self-reported questionnaire-based measurement tools used to classify adults of any age into those with a knee problem and those without. The following databases were searched: MEDLINE, EMBASE, AMED and CINAHL from inception to June 2012 using the same search terms as described in the systematic review in chapter 2, but also including words relating to osteoarthritis to identify population-based epidemiological incidence studies which have used a questionnaire-based measurement tool to identify adults of any age with knee problems. The inclusion and exclusion criteria used in the systematic review of risk factors of knee disorders (chapter 2, section 2.2.1) were applied to identify eligible studies. All titles and/or abstracts generated by the searches were screened by the PhD student for relevant instruments.

4.4.1 Selection of the instrument

The full text of relevant articles was retrieved from the search and assessed for eligibility. The instruments used in the eligible epidemiological studies were identified and a full copy obtained. When it was not possible to access the instrument online, the

principal investigator was contacted for a full copy of the instrument. For each tool published, data on its validity and reliability was identified; where published data was not available, the principal investigator was contacted for any unpublished data on its validity and reliability.

The constructs for knee problems used in each instrument were mapped against the case definition of knee problem in this thesis (see chapter 3, section 3.5) to identify an instrument (or some questions within an instrument) that best met study requirements. Other criteria for selection include: the instrument had to be self-reported, easy to understand by lay people, and available to use without payment (given the resource constraints of the PhD programme).

The characteristics of the instruments included in this review are provided in Table 4.1. The following data was extracted from studies:

- In what setting was the instrument developed or evaluated?
- What type of knee problems does it measure?
- What is the mean age of the sample in which the instrument was evaluated?

The primary study which tested each of these instruments was considered and is reported on in this review (Table 4.1).

4.5 Findings

Twelve relevant instruments were identified from these studies. The majority of the instruments were developed or evaluated in the USA, with one instrument developed and evaluated in the UK that is the Oxford Knee Score (OKS). (Table 4.1). Health

outcomes measured by these instruments included; symptoms, mobility, physical activity, activities of daily living and quality of life (Table 4.1). These instruments were developed and evaluated in individuals aged from 23 to 77 years old.

Table 4.1 Characteristics of the Instruments.

Instrument	Setting	Population (n)	Mean age or Range (years)	Time taken to complete	What is measured	Reliability (Design)
Knee Injury and osteoarthritis Outcome Score (KOOS). Roos et al. 1998	USA out-patients, Sweden out-patients	21 142	32 39.6	8 – 12 minutes	Swelling, symptoms, stiffness, the pain, function, activities, sport, quality of life.	See chapter 5, table 5.1
The knee pain screening tool (KNEST). Jinks et al. 2001	UK out-patients	240	55	5 minutes	A survey of knee injuries, pain, consultation, services used.	ICC> 0.60 91% agreement between baseline (Test-retest)
International Knee Documentation Committee (IKDC) Subjective Knee Form. Irrgang et al. 2001	USA, Japan, France out-patients	590	37.5	5 – 8 minutes	Pain, stiffness, swelling, giving away, sport activities, function.	ICC = 0.94
Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC). Bellamy et al. 1997	USA out-patients	30	61.5	5 - 7 minutes	Pain, function, and Stiffness.	Pain r= 0.90, Stiffness r = 0.76, Physical function r = 0.92 (Intra-subject)
America Academy of Orthopaedic Surgeons (AOOS) Outcomes Instruments Marx et al. 2003				Unclear	Pain, function, stiffness and swelling, and giving way.	ICC = 0.92 (Test-retest)
Lysholm knee score. Lysholm & Gillquist 1982	Sweden out-patients	130		5 minutes		ICC = 0.94 (Intra-subject)

Instrument	Setting	Population (n)	Mean age or Range (years)	Time taken to complete	What is measured	Reliability (Design)
Tegner activity scale. Briggs et al. 2009.		1783	37	3 – 5 minutes	Limp, pain, function, locking, instability, support, and squatting.	ICC = 0.80 (Intra-subject)
Western Ontario Meniscal Evaluation Tool (WOMET). Kirkley et al. 2007		78		5 minutes		ICC = 0.78 (Intra-subject)
Anterior Knee Pain Scale (AKPS). Crossley et al. 2004	Australia out- patients	71	12 - 40		Level of current function	ICC = 0.81 (Test-retest)
Oxford Knee Score. Dawson et al. 1998	UK out-patients	117	73	5 minutes	Activity level currently, before, and after surgery.	Person separation index = 0.924
PFPS severity Scale. Laprade and Culham 2002		29	32	5 minutes	Pain, sports, recreation, work, emotion.	Spearman rank correlation coefficient= 0.95 (Intra- tester)
Studies of Prevalence, Natural history and Aetiology of Patellofemoral Pain Syndrome (SNAPPS) questionnaire. Callaghan et al. 2009; Dey et al. 2016	UK general population	101	30	5 -10 minutes	A survey of knee problems, traumatic and non-traumatic knee problems.	Cohen's kappa (κ) = 0.74 (Test-retest)

r = Pearson product moment correlation coefficient, ICC = Intra-class Correlation Coefficient

There are eight instruments developed for specific conditions of the knee. Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) was developed to measure osteoarthritis; Lysholm, Tegner for ligament injuries; Western Ontario Meniscal Evaluation Tool (WOMET) for meniscal lesions; Anterior Knee Pain Scale (AKPS) and Patellofemoral Pain Syndrome Severity Scale (PFPS) for patellofemoral pain; Oxford Knee Score (OKS) for patients undergoing total knee replacement to assess their knee-related health status and benefit of treatment; American Academy of Orthopaedic Surgeons (AOOS) was developed to measure musculoskeletal condition in the lower limbs of the body (Collins et al. 2011; Howe et al. 2012). There are two instruments that could be applied to a wide range of knee conditions: Knee Injury and osteoarthritis Outcome Score (KOOS) and International Knee Documentation Committee (IKDC). The knee pain screening tool (KNEST) questionnaire was designed for screening of individuals who visit general practice for knee problems.

Consensus on the instrument to be used was reached after meeting with experts within the supervisory team (Professor James Selfe and Professor Paola Dey). From examining the identified instrument it was concluded that there was not one tool which covered all aspects of knee problems as described in the thesis case definition of knee problem in Chapter 3.

4.5.1 Selection of the instrument used to screen for the presence of knee problems

KNEST: The KNEST questionnaire was developed to measure General Practitioner consultation visits due to knee problems and the use of different services, but it also has the ability to discriminate between the presence and absence of knee problems

(Jinks et al. 2001). For the identification of individuals with knee problems, two screening questions incorporated in the KNEST questionnaire were used to identify people with a knee problem in the last 12 months (Jinks et al. 2004). These questions are:

- Have you ever injured your knee badly enough to see a doctor about it?
- Have you had pain in the last year in or around the knee? (Jinks et al. 2004)

These questions were modified to measure not just knee injury and knee pain, but knee problem as defined in the case definition. The modified questions are:

- Have you ever been to a doctor as a result of knee problems? “Yes” or “No”
- Have you had pain or problems in the last year in or around the knee? “Yes” or “No”

For measure of knee pain and consultation of general practice reliability, scores exceeded 0.6 (Jinks et al. 2001). The main question about knee pain showed good internal reliability, with an agreement score of 91% between baselines. Re-test assessment showed good ability to discriminate between an individual with a knee problem and those without (Jinks et al. 2001). The KNEST questions are easy to understand, have 12 months recall time, and have been used in UK populations (Jinks et al. 2004).

4.5.2 Selection of the instrument used to measure symptoms, functional impairments and quality of life associated with knee problems

For the identification of symptoms and functional impairments associated with knee problems, the list was narrowed down to three instruments, through mapping the

construct used in the instrument against the construct of the case definition of a knee problem and consultation with experts in the field (Professor James Selfe and Professor Paola Dey). The list comprised of three instruments: Knee Injury and Osteoarthritis Outcome Score (KOOS) questionnaire (Roos et al. 1998); International Knee Documentation Committee (IKDC) questionnaire (Irrgang et al. 2001); and Oxford Knee Score (OKS) questionnaire (Dawson et al. 1998) (see Table 4.2).

The OKS and IKDC include items relating to role limitation (Garratt et al. 2004). The OKS seemed like the best instrument to select for this study as it was developed and evaluated among the UK population (Dawson et al. 1998). However, the construct to be used in measuring knee problems in this study (Chapter 3, section 3.5) is not entirely covered by OKS as it does not measure quality of life. OKS was developed and evaluated for an individual who has undergone knee surgery / treatment. OKS was rejected because it had been designed for individuals undergoing knee surgery and was not felt to be appropriate for the population to be studied (Table 4.2). IKDC was developed by clinicians and it has been tested systematically and demonstrated a high level of discrimination (Howe et al. 2012). Although IKDC has face validity, content validity cannot necessarily be assumed due to lack of patient contribution to item selection (Higgins et al. 2007; Collins et al. 2011).

Although IKDC and KOOS can be used to measure a wide range of knee conditions, KOOS was felt to better fit the case definition of knee problems as it also measures the quality of life. According to Roos et al. (1998), KOOS was developed for young and middle-age people (18 – 46 years old) with post-traumatic knee osteoarthritis, and

those with injuries that may lead to it (e.g. an anterior cruciate ligament, meniscal, or chondral injury).

Table 4.2: The list of potential possible instruments considered for the measurement of symptoms and functional impairments associated with knee problems.

Instrument	“Pros”	“Cons”
Knee Injury and osteoarthritis Outcome Score (KOOS)	It contains questions that investigate the deviation from normal function (like overload) of the knee and presence or absence of sensational feeling (in the form of pain). It investigate buckling and locking of the knee. It investigates the quality of life for individuals with knee problems. Easy for the layman to understand.	It has a short recall period.
Oxford Knee Score	It investigates deviation from normal function (locking or buckling) and the presence or absence of sensational feeling in the form of pain in the knee area. Easy for the layman to understand. It was developed in the UK. Its context can easily be understood by the population I am using it in.	It has a short recall period. The question seems to be directed to an individual who has undergone knee surgery / treatment or is experiencing knee pain.

Instrument**“Pros”****“Cons”**

International Documentation Committee (IKDC) Subjective Knee Form.	Knee	It contains questions investigating deviation from normal function (like locking, buckling or overload of the knee) as well as the presence or absence of the sensational feeling around the knee area. Easy for the layman to understand.	It has a short recall period. It does not investigate risk factors for knee problem. It was developed in America.
Studies of Prevalence, Natural history and Aetiology of Patellofemoral Pain Syndrome (SNAPPS)		It contains questions investigating how knee problem developed. Easy to for the layman to understand. It was developed in the UK. Its context can easily be understood by the population I am using it in.	It has a short recall period. It explores how knee problems developed.

The KOOS is used to assess the symptomatology and severity of knee symptoms. Items of concern like emotional health and quality of life are included in the KOOS (Garratt et al. 2004). The purpose of developing KOOS was to measure the individual's opinions about their knee and associated problems over short and long term follow-up.

It is easy for laymen to understand it, and does not have any emotional impact on the individual completing the questionnaire, as it contains only questions around signs and symptoms of their knee function and how it affects everyday life. There is published evidence for its reliability, sensitivity, and construct validity (Roos et al. 1998; Collins et al. 2011; Salavati et al. 2011) see Chapter 5 for detail of its reliability and validity. Using the scoring spread-sheet takes approximately 5 minutes (Collins et al. 2011). Training is not required for its administration or scoring as it is easy and self-explanatory. KOOS can be obtained online at www.koos.nu, and is completely free with associated documentation.

The KOOS questionnaire lacks the ability to identify different types of knee problems. There was no instrument that was able to differentiate between the traumatic and non-traumatic knee problem among those who report a knee problem. Hence, questions from the Studies of Prevalence, Natural history and Aetiology of Patellofemoral Pain Syndrome (SNAPPS) questionnaire developed by the supervisory team, which consists of 32 questions, were adopted, as they have the ability to differentiate between traumatic and non-traumatic knee problems (Selfe et al. 2015). Test-retest reliability estimates of the overall SNAPPS questionnaire suggest good agreement (N=51, Cohen's kappa (κ) = 0.74, 95%CI 0.52 – 0.91) (Dey et al. 2016). Although the

psychometric property of the question that differentiates between traumatic and non-traumatic knee problems has not been validated on its own, it has demonstrated a high sensitivity and specificity (over 90%) (Dey et al. 2016). See Chapter 5 for details on these questions.

4.6 Summary

There is no instrument that is universally applicable to the measurement of all knee problems. The KNEST questionnaire was modified for screening and grouping of participants with or without knee problems. Based on the information available on the measurement of symptoms and functional impairment associated with knee problems the recommended instrument was KOOS. Although the KOOS can be used to measure symptoms and functional impairment for the proposed cohort, the outcomes measured warrant the use of other instruments that identify how knee problems occurred, hence the addition of questions adopted from SNAPPS which discriminate among those who reported knee problems of traumatic or non-traumatic origin.

Chapter 5: Epidemiological study of knee problems in young adults - methods

5.1 Introduction

This chapter describes the methods of an epidemiological study to estimate the prevalence and incidence of knee problems among a convenience sample of young adults and explore the association between obesity, physical inactivity, physical activity and knee problems. It describes the study design, the study population, sampling and recruitment methods, how assessments were undertaken and the approach to analysis. It also describes the quality assurance procedures undertaken in the study.

5.2 Objectives of this study

- To estimate the 12-month period prevalence of knee problems in a group of young adults
- To estimate the 12-month period prevalence of different types of knee problems (those with and without knee pain as the predominant symptom, those of traumatic or non-traumatic origin)
- To estimate the incidence rate of knee problems occurring in young adults over a 12-month period
- To estimate the incidence rate of those with and without knee pain as the predominant symptom, those of traumatic or non-traumatic origin occurring in young adults over a 12-month period

- To explore inter-relationships between knee problems and obesity, physical activity, and physical inactivity

5.3 Study population

The study population was staff and students at the University of Central Lancashire, Preston.

5.3.1 Inclusion criteria

The sample was aged between 18 years and 39 years (inclusive). The potential participants could have a current knee problem, a previous history of knee problems or no current or past history of knee problems. The potential participant had to be willing and available to be contacted by the research student for a follow-up study 12 months from the date of recruitment.

5.3.2 Exclusion criteria

Potential participants with doctor-diagnosed lower limb osteoarthritis, inflammatory arthritis, or other disorders which severely affected their walking were excluded. Students in their final year of study were excluded because they would not be available for follow-up. There was no specific question in the questionnaire used specifically to identify participants who might be suffering from hypermobility syndrome or generalised joint laxity. However, participants with known pathology that affected their ability to walk were excluded see screening question below in section 5.5.

5.4 Study Design

The study incorporated both a cross-sectional and a prospective cohort study design.

Cross-sectional studies are used to study the prevalence of disease and one of the thesis objectives was to investigate the prevalence of knee problems among young adults. Cross-sectional study designs have been used to investigate risk factors for disease (Glasziou et al. 2001). However, as they measure the risk factor and outcome at the same time, they cannot be used to establish the direction of the association. For example, a survey can demonstrate the prevalence of diabetes among an obese group in general population, but cannot determine if it was the diabetes that lead to obesity or the other way round.

Therefore a cohort design was used to estimate the incidence of knee problems and to explore the relationship with the risk factors, which were other thesis objectives. In a cohort study design participants without the condition at baseline are followed up to explore the relationship between presence of risk factors at baseline and the outcome of interest at follow up. The prospective nature allows the identification of new cases and hence incidence of disease. It also establishes that the risk factor was present before the outcome and therefore temporality, an essential criteria for causality (Bhopal 2002). A cohort study is still susceptible to bias because of losses to follow up, confounders, and inadequate follow up time (Carr et al. 2007).

5.5 Recruitment

The recruitment was conducted on the university campus. The study was advertised on both student and staff AU lookout - a weekly electronic newsletter delivered by email to all staff (2,666) and students (26,585) registered at the University of Central Lancashire (Appendix I). A simple, easy to read poster (more than 45 copies) containing information about the study and the research student's contact details (email, office phone number, and office location) was posted on notice boards across the university (Appendix F). In addition, a leaflet (more than 100 copies) was given out to staff and students at the library, canteens, the university sports centre, and other appropriate locations within the university (Appendix F).

Potential participants were able to contact the research student through email, telephone or could drop in at the research student's office. Those who expressed an interest in taking part were screened for eligibility before scheduling a meeting. The screening questionnaire consisted of seven questions to which the responses were *yes* or *no*. The participants were asked the following questions to determine their eligibility for the study:

1. *Are you a student / staff of UCLan? Yes /No.*
2. *Are you at least 18 years of age and under 40 years old? Yes / No*
3. *Are you willing to be contacted for a period of 12 months? Yes / No*
4. *Has your doctor ever told you that you have arthritis? Yes / No*
5. *Do you have any other known condition that affects you walking other than a knee problem? Yes/No*

The participants who answered *no* to either question 1, 2, 3, or all of the above and *yes* to either question 4, 5, or all of the above were declared ineligible for the study. They were informed immediately and it was explained why they could not participate and thanked for their interest in the study. Those participants that answered *yes* to questions 1, 2, 3, and *no* to questions 4 and 5 were declared eligible for the study. The screening were undertaken face-to-face, by telephone or by email at the potential participant's convenience. Arrangements were in place for participants with further concerns to discuss these with a member of the supervisory team, but no participant requested this.

Those eligible to participate in the study were provided with a copy of the consent form (Appendix H) and a time provided for an assessment at their convenience. For participants who were not eligible, the screening questionnaire was immediately destroyed (see Figure 5.0). The assessments at baseline were undertaken in the research student's office in Greenbank building or in a screened off area within the university buildings at Preston Campus, whichever the participant was comfortable with, to ensure privacy.

After two months of recruitment, only 32 (29%) participants were recruited. However, the necessary target was to recruit 300 participants (see subsection 5.18). Hence, there was a need for the evaluation of recruitment strategies to identify ways to improve the response. The strategies were evaluated by the research student.

Following review, the following was noted:

- Several of the interested participants did not respond to the email that asked them to book for assessment.

- The majority of the interested potential participants did not turn up for the assessment either because they were too busy or they forgot about it.
- The majority of participants preferred to enrol on the study at the first point of contact and undergo assessment and favoured less the arrangement of booking an appointment for an assessment.

Evaluation of the recruitment strategy suggested that depending on the original sampling method, it could be difficult to recruit enough participants within the time available. Hence, there was a need to improve the efficiency of the recruitment strategy. Following discussion with the supervisory team, the following change was agreed: that the research student should discuss going into class sessions with lecturers to discuss the study and arrange a time to recruit as many of those interested in taking part after the same or another class session. Ethical permission was sought and gained for this change in the recruitment processes.

Some Heads of School at the university were approached directly, others recommended by the supervisory team, asking for assistance to reach out to their staff and students. Those who agreed used their administration office to send out emails (which included the poster and information sheet) to their academic staff asking them to liaise with the research student. In addition, lecturers in different schools were approached (directly or on recommendation either by their Head of School, divisional leader or colleague) by telephone. A total of 14 course leaders across schools agreed access to their class sessions to raise awareness of the study and, possibly, recruit participants after the class. Students were emailed the information sheet by their course leaders before the research student visited the class sessions.

The research student attended class sessions within the different schools at the university, with permission of the lecturers, to advocate the study to students. Individuals who expressed an interest were given the participant information sheet and at least 24 hours to decide on participation in the study, unless they wanted to be recruited immediately (see figure 5.0). (Appendix G). All other processes were the same.

5.5.1 Study period for study recruitment

The recruitment process lasted from 28th January 2013 to 14th June 2013, then from 9th September 2013 to 21th October 2013. This was because of the university summer break when the students were not available for recruitment.

To ensure the availability of the participants for follow-up assessment, apart from their university email address, they were asked to provide their personal email address and a mobile phone number (see Figure 5.1).

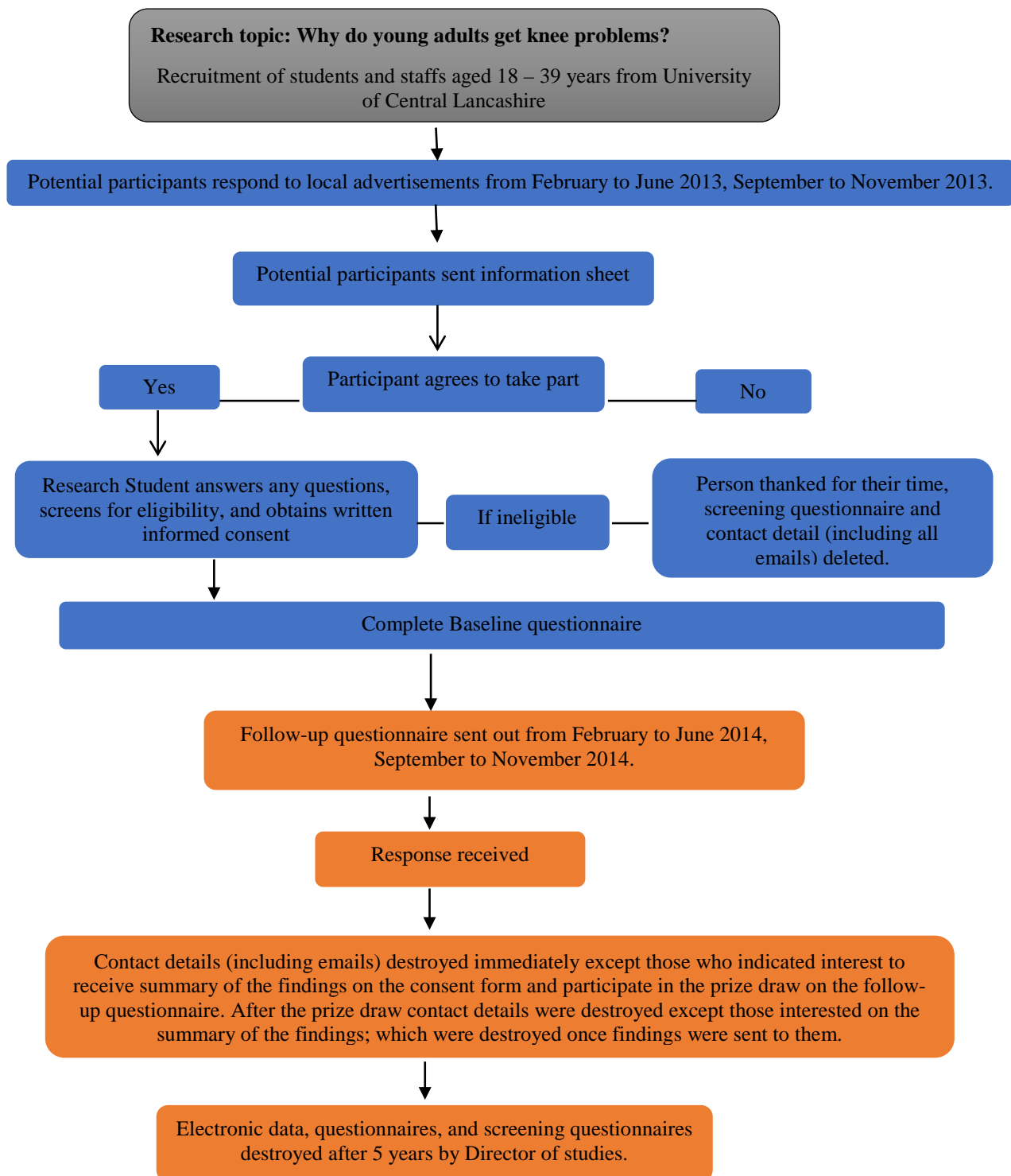


Figure 5.1 Flow chart showing the administrative processes of the project.

5.6 Sampling

5.6.1 Sampling methods

A convenience sample of staff and students was used. Initially, eligible staff and students were approached as individuals to take part in the study. The sampling method was supplemented by cluster sampling of student classes to increase sampling efficiency due to low recruitment early on in the study. Cluster sampling is recruitment of a naturally occurring group, or artificially created group for research study (Galbraith et al. 2010). Each of the groups (units or clusters) contains multiple observations of individuals nested within the group. Students were recruited as groups from the following courses: sport coaching, pharmacy, physiotherapy, nutrition, dentistry, business studies, foreign languages and postgraduate research.

5.6.2 Theoretical underpinning of the sampling approach

For the investigation of knee problems among young adults aged 18 to 40 years old, it would be ideal to recruit all individuals from the general population within that age range (Bowling 2014). However, the population of young adults is too large for each individual within it to be investigated and it is not possible to recruit everyone in the whole population. There would never be enough resources or time to recruit the whole population, hence, such a study is unfeasible. Instead, a sample of the population was selected from the university community. The rationale is if a large enough sample is selected, one that is representative, then the findings from the sample may be used to apply the findings to the overall population of young adults within that age group with

some degree of caution (Bowling 2014). Selecting participants from the university community is not without its shortcomings. Although the university community might consist of individuals of different genders, socioeconomic backgrounds, cultures, geographical locations, and ethnic origins, it might not reflect the overall characteristics of the population as it excludes subsets of this population (for example, the unemployed, those in other occupations) which are neither enrolled in nor work in the university. This restricts the recruitment of individuals who might have an increased risk of knee problems such as those whose work is manual labour (Jones et al. 2007).

The university community consists of 2,666 staff and 26,585 students. To achieve a sample that is a representative sample of young adults within the university community, an ideal approach would be a random sample of young adults. However, such an approach was not possible as the university policy on Data Protection restricts access to names of staff and students. Instead a convenience sample of staff and students of the University community was recruited (Bowling 2014).

Although convenience sampling is often applied in public health surveys, (Bowling 2014), it can introduce selection bias because it involves a selection of a sub-section of the population which is simply available and willing to take part (Small 2009; Lucas 2014a). One could argue that because it was a convenience sample, certain individuals would be more willing to volunteer than others. For example, those with knee problems would be more likely to volunteer than those without, since the study was about knee problems among young adults. An attempt to address this problem was employed during the design of the media resources used to advertise the study. The

main message carried by the advert was “volunteers needed”, “aged between 18 and 39 years”, and “with or without knee problems” (Appendix F contains a sample of the poster used in advertising the study).

This study supplemented individual sampling with a cluster sampling of students in order to increase response rates. The data generated from cluster sampling has a unique feature: within each cluster, data (individuals) are more alike than data (individuals) from a different cluster. Such similarities within each cluster reduce the variability of responses in a cluster sample. This variation is referred to as intra-cluster correlation (Kerry & Bland 1998). Homogeneity among individuals (data) within the clusters inflates the standard error (Campbell & Grimshaw 1998, Galbraith et al. 2010). This has an effect on the estimated confidence intervals and p-values, and this effect is known as clustering effect (Galbraith et al. 2010) and needs to be accounted for in the analysis (see the statistical analysis section below).

5.7 The assessment of participants

Participants were assessed twice, at baseline after consent was obtained and at follow-up, 12 months later.

5.7.1 Baseline assessment

The format and mode of the collection of data was through a questionnaire (Appendix L) and direct measurement of height and weight. The baseline assessment lasted between 15 and 20 minutes. The data collected at the baseline is discussed in section 5.8.

5.7.2 Follow up assessment

Follow up assessment was undertaken 12 months after the baseline assessment for participants who responded. Participants were invited to attend the assessment to complete a questionnaire or to email the questionnaire back to the research student. Follow up assessment took 10-15 minutes to complete. The data collected at follow up is discussed in section 5.9.

5.7.3 Methods used to promote response to follow up assessment

Participants were contacted twice after the baseline assessment to maintain contact and increase the retention of participants. The first contact was made by emailing an electronic newsletter (Appendix J) to participants 6 months after the baseline assessment to update them on the progress of the study. The newsletter was used to remind them of the coming follow-up assessment and enquired about any foreseen changes in their contact details. The second contact was an invitation by email encouraging participants to make an appointment for follow-up assessment (Appendix K). Participants were given the option to complete the questionnaire over the telephone, complete the attached questionnaire and email it back to the research student, post it or drop off the completed questionnaire at the research student's office. A prize-draw incentive was included in this email. Ethical approval was obtained (Appendix E) from Science Technology Engineering and Medicine Ethics committee (section 5.11).

A prize-draw was used to reduce non-response at follow up. In this study the prize draw was an Amazon voucher. There were seven Amazon vouchers and three levels of award. The lowest prize of £10 was awarded to four participants, the second prize of £25 was awarded to two participants, while the highest prize of £50 was awarded to one participant. The prize draw was conducted after the follow-up study and was overseen by a member of the supervisory team. Free prize draws do not come under the 2005 Gambling Act, and are free from regulatory control (Gambling Commission 2009). Göritz (2006) and Brueton et al. (2014) highlighted that participants are more likely to complete a study if an incentive is offered, and Goritz (2006) further states, the effects of incentives are stable across participants. Spring et al. (2014) exploring factors affecting retention in a national weight management programme stated that the use of incentives/rewards was associated with 44% greater retention (OR=1.44, 95%CI=1.01 – 2.06).

After follow-up of the first 113 participants, only 39 (34.5%) responded. Participants who responded were asked what would have been the best way to contact and get them to complete the study. Their feedback was: increased contacts through emails and telephone calls as a reminder. These were incorporated into the protocol. Ethical approval was sought and gained for the amended protocol before it was put into place (Appendix E).

A reminder telephone call was made two days later after the initial email was sent out. Two subsequent telephone calls were made depending on the participant's responsiveness. I re-contacted the lecturers whose students were recruited in their class sessions at the baseline, requesting permission to attend classes and remind

students about the study. During follow up class visit participants still willing to take part in the study were assessed. Individuals (staff and students) other than those recruited from class sessions were directly approached to remind them to complete the final assessment. See flow chart for follow up strategy (Figure 5.2).

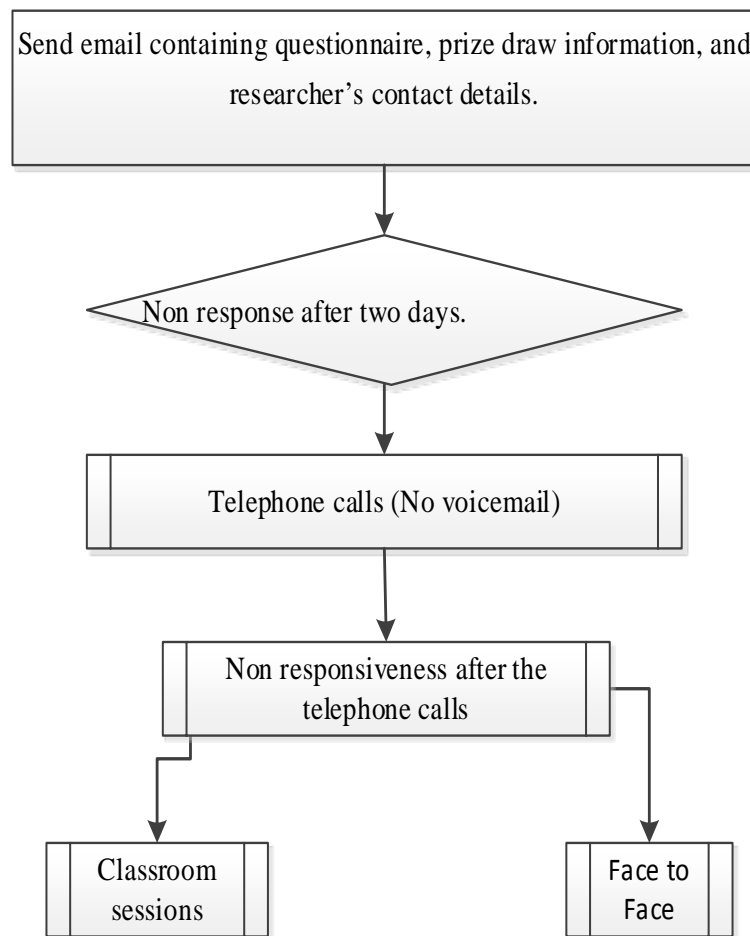


Figure 5.2 Flow chart of the follow up strategy.

5.8 Data collection instrument: Baseline Assessment

Participant assessment consisted of a self-administered questionnaire and direct measurement of height and weight. The questionnaire collected information on knee

problems; the risk factors under investigation (BMI, physical activity and physical inactivity) and other factors which were potential confounding factors in the review reported in Chapter 2 (age, gender, and level of psychological distress). Data was also collected on sporting activities to help describe the characteristics of participants compared to other studies. As much as possible, validated instruments were used in the study questionnaire as described below.

5.8.1 Knee problems

An adapted versions of the screening questions incorporated in the Knee Pain Screening Tool (KNEST) questionnaire were used to identify people with knee problems in the previous 12 months (Jinks et al. 2004) (Chapter 4). The questions were “*Have you ever been to a doctor because of knee problems?*” and “*Have you had pain or problems in the last year in or around the knee?*” The original questions were used in England with people over 50 years old (Jinks et al. 2004). The first question was included to collect information about participants who have consulted their doctors as a result of knee problems. The second question was used to differentiate participants with knee problems and those without, among the study population at the baseline.

5.8.2 Impact of knee problems

The Knee Injury and Osteoarthritis Outcome Score (KOOS) was applied to assess the symptomatology and severity of symptoms of those identified with knee problems (Chapter 4). The KOOS measures symptoms over the previous 7 days

(<http://www.koos.nu>). KOOS is a widely used self-reported questionnaire with 42 items in five separately scored subscales: Pain (nine items), Symptoms (seven items), Function in Daily Living (17 items), Function in sport & recreation (five items), and Quality of Life (four items) (Roos et al. 1998). The individual subscale score is transformed into a 0 – 100 scale. A score of 100 represents no knee problems and zero represents extreme knee problems. The subscales are analysed separately. Any score in a subscale less than 90 is considered clinically important (Ross and Lohmander 2003). The KOOS has been used to study populations with various knee conditions and age ranges between 13 – 79 years old (Roos et al. 1998; Roos and Lohmander 2003; Salavati et al. 2011). It has an estimated completion time of 8 – 12 minutes. There is published evidence highlighting its reliability in younger people (Roos et al. 1998; Collins et al. 2011; Salavati et al. 2011), see Table 5.1.

Table: 5.1 The test- retest reliability of KOOS questionnaire across the domain it measures in patients with knee injury (Collins et al. 2011).

No.	Domain measured	Reliability(Intraclass correlation coefficients [ICCs])
1	Pain	0.85 to 0.95
2	Symptoms	0.75 to 0.91
3	Activity of Daily living	0.75 to 0.91
4	Function of sport & recreation	0.61 to 0.89
5	Quality of Life	0.83 to 0.95

5.8.3 How the knee problem developed

Questions from a partially validated questionnaire – Studies of the Prevalence, Natural history & Aetiology of Patellofemoral Pain Syndrome (SNAPPS) developed by the

supervisory team was also included. SNAPPS consists of 32 questions (Callaghan et al. 2009). It has an estimated completion time of 5-10 minutes. These questions from the questionnaire were included because they help to differentiate between those with traumatic and those without traumatic-onset knee problems (Chapter 4). The reliability of SNAPPS questionnaire has been described in chapter 4 section 4.5.2 and table 4.1.

On the type of knee problem, SNAPPS asks the question: *Thinking about your **right** knee, did your current knee problem come on-*

- *Because of sudden injury e.g. twist, fall or accident that you needed to see a doctor about*
- *Gradually over a period of time*
- *Neither gradually nor because of a sudden injury*
- *Not sure, can't remember*
- *No problem in this knee*

The same question was asked for the left knee. Participants were asked to tick only one answer.

SNAPPS also identifies the predominant knee symptom. SNAPPS asks the question: *Thinking about your **right** knee, what do you consider your **main problems** with your knee?*

- *Pain or discomfort*
- *Locking*
- *Giving way or feeling like it will give way*
- *No problem in this knee*

The same question was asked for the left knee. Participants were asked to tick only one answer.

5.8.4 Risk factors: obesity, physical activity and physical inactivity

Information about height and weight, the level of physical activity and physical inactivity were collected through the questionnaire, where possible information on height and weight were collected through direct measurement.

5.8.5 How obesity was measured in this study

BMI is the most common method used to measure obesity. In this study, BMI was estimated from the participant's height and weight. BMI was calculated as weight in kilograms (*kg*) divided by the square of the height in meters (*m*) = ***kg/m²***. The World Health Organisation (WHO) International Classification was used to classify adults into BMI categories (WHO 2006): participants whose BMI was less than 18.5 kg/m² were classified as underweight, a BMI of 18.5 to 24.99 kg/m² was classified as normal, a BMI of 25 kg/m² to 29.99 kg/m² was considered to be overweight (pre obese), a BMI of 30 kg/m² - 39.99 kg/m² obese and 40 kg/m² and over as super obese (obese class III).

Height and weight were measured both by self-reporting and by direct measurement. For those who agreed to direct measurement, these measurements were taken by the research student after the participant had completed the self-report weight and height in the questionnaire. The measurements were performed only by the research student,

using the same equipment and adhering to the procedures described below to maintain consistency throughout the data collection phase and to minimise measurement errors. The completion of self-reporting of height and weight before direct measurement was used to ensure participants were not simply copying the value of their direct measurement. The rationale for the collection of height and weight using two different measurements was to enable the imputation of directly measured BMI from the self-reported BMI, when the former was missing.

The use of BMI calculated through self-reported height and weight is common practice among surveillance studies, due to its practical value and cost effectiveness compared to direct measurement of participants. However, the use of self-reported height and weight can lead to an erroneous assumption for the population under investigation (Vasan et al. 2005; Wada et al. 2005; Ezzati et al. 2006). Research has shown self-reporting tends to overestimate height and underestimate weight which results in an underestimation of BMI. Hence, it has been suggested that self-reporting should be avoided as a singular tool (Engstrom et al. 2003; Gorber et al. 2007; Griebeler et al. 2011).

Bias in self-reported data is suggested to be associated with different characteristics of the participants, including age, social and cultural values, and degree of obesity (Kuczmarski et al. 2001; Wada et al. 2005; Ezzati et al. 2006; Peixoto et al. 2006; Boucher & Maslach 2009; Granberg et al. 2009; Thruston et al. 2010). In contrast, individuals who are aware their height and weight will be measured have a tendency to report their weight more accurately (Shield et al. 2008). Griebeler et al. (2011) and Lois et al. (2011) demonstrated that there is no gender difference in the

underestimation of weight in self-reporting. Different authors have reported on the prevalence of obesity in recent years (Rowland 1990; Elgar et al. 2005; Ogden et al. 2006; Butland et al. 2007). Some studies have shown that heavier individuals are more likely to under report their weight (Rowland 1990; Elgar et al. 2005).

According to Yannakoulia et al. (2006) and Chiolerio et al. (2007) the relationship between obesity and related health conditions might be underestimated because of a reliance on self-reported BMI compared to BMI calculated from directly measured height and weight. In contemporary society, the awareness of obesity and its health conditions has increased, with weight discrimination increasing (Andreyeva et al. 2008). Tremblay et al. (2004) suggest a change in attitude towards obesity could greatly affect an individual's response to self-reported questions around weight.

An increase has been observed in the difference between self-reported and directly measured BMI in Canada over the past decade (Gorber et al. 2010). Previously in Canada, there was a 4% difference between self-reported and directly measured BMI when the prevalence of obesity using directly measures was 14% (95% CI 13% to 15%) (Gorber et al. 2010). Recently, an 8% difference has been reported and the prevalence of obesity using direct measures is 24% (95% CI 22% to 26%). However, a sustained 3% difference between self-reported and directly measured BMI was recorded in the United States (Gorber et al. 2010).

5.8.6 Methods used in direct measurement of height and weight

The procedures used to measure height and weight are described below:

Height: Height was measured in centimetres (cm) using a Seca 217 mobile stadiometer, Medical Scales and Measuring Systems, Seca gmbh & co.kg. Hammer Strindamm 9 – 25, 22089 Hamburg. Germany.

Procedure for height measurement (Figure 5.3)

1. The participant was asked to remove his / her shoes. The participant wore thin socks or was barefoot.
2. The participant was asked to step on Seca 217 and stand erect with his / her back to the vertical plastic mounted ruler.
3. The participant's heels were together and against the vertical ruler, both feet flat on the Seca 217 platform, with weight evenly distributed across both feet.
4. The participant faced straight ahead with his / her head positioned in the horizontal plane. His / her arms hung freely by the sides of the trunk with palms facing the thighs.
5. The measurement was taken as the participant maintained the above position.



Figure 5.3 Research student demonstrating how the height variable was taken.

Weight: Weight was measured in kilograms (kg) using Seca 813 scales, Medical Scales and Measuring Systems, Seca gmbh & co.kg. Hammer Strindamm 9 – 25, 22089 Hamburg, Germany.

Procedure for weight measurement (Figure 5.4)

1. Participants were asked to remove any heavy clothing. They removed their shoes before stepping on the scale.
2. The scale (Seca 813) was set to zero prior to asking the participant to step on it and the units adjusted to kg. The participant was asked to step on the Seca 813 facing the measurement beam.
3. The participant was instructed to stand in the middle of Seca 813 platform with head erect and eyes looking straight ahead. Weight was equally distributed on both feet with the participant not supporting him/herself.
4. The weight was read as the participant maintained the above position.



Figure 5.4 Research student demonstrating how the weight variable was taken.

5.8.7 How physical activity was measured

The questionnaire adopted to measure physical activity levels and physical inactivity was the International Physical Activity Questionnaire Long form (IPAQ-Long). The IPAQ-Long form was chosen because it was self-reported and developed to facilitate the measuring of the prevalence of physical activity levels and physical inactivity in large scale studies. It allows comparability of results across studies (Craig et al. 2003). It consists of 27 items which can be self-completed or administered over the telephone (The IPAQ group 2014). It is designed for those aged between 15-65 years old (Craig et al. 2003; The IPAQ group 2014). Its test-retest repeatability has an acceptable Spearman correlation coefficient of 0.8 and criterion validity of 0.3 which was comparable to most other self-reported validation studies (Craig et al. 2003; Ekelund et al. 2006; Maddison et al. 2007; Oyeyemi et al. 2014). It has an estimated completion time of 10 minutes (van Poppel et al. 2010; The IPAQ group 2014). It has been a widely adopted physical activity questionnaire for research that needs information on physical activity and sedentary behaviour (van Poppel et al. 2010; The IPAQ group 2014). The physical activity levels estimated by the questionnaires include physical activities engaged in solely for recreation, sport, exercise or leisure. Any physical activities that involve travelling from place to place, job-related activities, housework, house maintenance, and caring for a family are not included.

The IPAQ – Long was used to categorise the level of physical activity into 3 (The IPAQ group 2014 <http://www.ipaq.ki.se/scoring.pdf>). These were:

- High for individuals participating in higher levels of physical activity. Pattern of activity to be met before being classified as high include; participating in

vigorous-intensity activity on at least 3 days meeting a minimum of 1500 Metabolic Equivalent of Task (MET) - minutes / week, OR 7 or more days of any combination of walking, moderate-intensity or vigorous-intensity activities

- Moderate for individuals participating in what was classified as doing some activity, more than the low activity category. The pattern of activity should be 5 or more days of walking and/or moderate-intensity activity of at least 30 minutes per day OR 3 or more days of vigorous-intensity activity of at least 20 minutes per day
- Low was used to describe individuals whose activity level did not meet any of the criteria for either high or moderate

5.8.8 How physical inactivity was measured

Physical inactivity was also measured using the IPAQ- Long, using the question about sitting. Physical inactivity was estimated as the amount of time spent sitting while at work, at home, while doing coursework, during leisure time, sitting at a desk, visiting friends, reading or sitting or lying down to watch television. The estimated time excluded time spent sitting in a motor vehicle. The data was analysed and presented as a continuous variable using mean values of time spent sitting per hour. Both the number of days and daily time are required for the creation of categorical and continuous variables. All responses of duration (time) were converted into hours. Data that was considered to be unreasonably high was excluded. For example, when the sum total of all walking, moderate and vigorous time was greater than 960 minutes (16 hours), it was excluded from the analysis. This was under the assumption that on average an individual spends 8 hours per day sleeping (The IPAQ group 2014).

5.8.9 Measuring confounding variables

Data was collected on age, gender and psychological factors as these were found to be potential risk factors for knee disorders in chapter 2. Data on psychological factors was collected using a validated questionnaire, the Hopkins Symptom Checklist-10 (HSCL-10).

HSCL-10: The HSCL-10 is one of the screening instruments renowned and widely applied in epidemiological studies to measure mental distress (psychological distress) (Derogatis et al. 1974). There are different versions of the HSCL and they differ in length ranging from 5 – 90 items (Derogatis et al. 1974; Lipman et al. 1979; Strand et al. 2003) and are applied across a wide range of settings. The reliability and validity of the HSCL-10 measure, which is a shortened version of the widely used HSCL-25 measure (Strand et al. 2003) in young adults has been well established (Strand et al. 2003; Sogaard et al. 2003; Halvorsen et al. 2009; Haavet et al. 2011). HSCL-10 completion is shorter than HSCL-25. HSCL-10 asks questions regarding the following symptoms of mental distress during the last week:

“Suddenly scared for no reason

Feeling fearful

Faintness or dizziness

Feeling of worthlessness

Feeling tense or keyed up

Blaming yourself for things

Trouble falling asleep

Feeling blue

Feeling everything is an effort

Feeling hopeless about the future” (Strand et al. 2003; Halvorsen et al. 2009).

Each of the 10 items in HSCL-10 is scored on a Likert scale of one (not at all) to four (extremely). Taking the mean of each participant's responses, the cut-off point of HSCL-10 for a valid explanation of mental distress has been set as ≥ 1.85 (Strand et al 2003). The ≥ 1.85 threshold has good sensitivity (69%) and specificity (92%) for detecting psychological symptomatology and mental distress compared with the widely used HSCL-25 (Strand et al. 2003). For valid information of the total HSCL-10 score, six of the ten questions had to be completed, and missing values were replaced by the sample mean for each value (Strand et al. 2003). The overall score was classed as missing if more than six answers were missing.

5.8.10 Measuring sports participation

Sports participation was used as a measure of the characteristics of the participants for descriptive purpose only. The sport participated in by the participants was collected via a modified New Zealand Physical Activity Questionnaire- Long (NZPAQ) questionnaire.

The participants were asked at baseline to report any sports they participated in and how often they participated in these over the last year. The list of sports was adopted from Show card 1 – Sport and Physical Recreation Activities in NZPAQ-Long form questionnaire (<http://www.activenzsurvey.org.nz/Documents/validation-report-physical-activityquestionnaires.pdf>). The following is the list of sports: dancing,

gym, circuit training, cricket, cycling, badminton, football, rugby, hockey, running / jogging / cross country, tennis, squash, netball, basketball, aerobics, swimming, judo, karate, other martial arts. The response to each sport was categorised as never, more than once a year but less than once a month, at least once a month but less than weekly, at least weekly.

5.9 Data collection: Follow-up assessment

During follow up assessment participants were asked to complete a questionnaire similar to that completed at the baseline. However, questions about age, gender, psychological factors, and sport participation, height and weight characteristics were excluded from the questionnaire. The value of these variables at the baseline were used to investigate their relationship with the incidence of knee problems at follow up (Chapter 2). The questionnaire included the same questions about knee problems as at the baseline.

After the baseline assessment, the prevalence of knee problems was estimated and was found to be high (Chapter 6, section 6.3.1). Many of the other studies of prevalence have a definition focused on knee pain and have much stricter criteria such as aching, stiffness, swelling and pain (Zhai et al. 2006; Ling et al. 2010; Soni et al. 2012; Jhun et al. 2013). However, the question used in this study is more comprehensive and less stringent about the duration of symptoms. The question asks about knee pain or problems. However to see if the question may be overestimating problems, an additional question *“Have you had pain, aching, or stiffness lasting at least a month in or around the knee during the past 12 months?”* was added to the follow-up

questionnaire. This question was accepted as a measure for identification of knee pain in prevalence study as more than one study has used it (Ling J et al. 2010). It was added to enable comparison to the literature.

The impact of knee problems and its severity was measured with KOOS while the two questions from the SNAPPS questionnaire were used to assess the different types of knee problem. The level of physical activity and physical inactivity was assessed with IPAQ-long. These measurement tools were also used to measure the change between data collected at the baseline and follow-up.

5.10 Outcomes:

Knee problems were measured as pain or problems in the last year in or around the knee. The outcomes of interest of this study were:

- i. 12-month period prevalence of knee problems at baseline
- ii. 12-month period prevalence of traumatic and non-traumatic knee problems
- iii. Relationship and inter-relationship between physical activity levels, BMI and physical inactivity and knee problems
- iv. Incidence rate of knee problems over a 12-month period in those who did not have knee problems at baseline

- v. Incidence rate of traumatic knee problems and of non-traumatic knee problems over a 12-month period in those who did not have knee problems at baseline
- vi. Change in severity of knee problems in those that had knee problems at baseline and follow-up

5.11 Ethical and Data Protection

Every aspect of this study was approved by the University of Central Lancashire Science, Technology, Engineering and Medicine (STEM) Ethics Committee before the research student commencing any of the activities. Ethical approval to changes to the protocol was sought and obtained before they were implemented. The approval unique reference number is STEM 25 (Appendix E).

All the participants were provided with the participant information sheet (Appendix G) and written informed consent was obtained (Appendix H). Participants were given at least 24 hours to consider whether to take part in the study or not. Participants were informed about anonymisation of data on the participant information sheet. Participants were informed that only anonymised data from the study would be included in the thesis, publications and presentations at conferences. All participants were asked if they would like to receive a summary of the results of the study. The summary was sent to participants who indicated an interest in receiving the summary. Participants expressing concerns or issues emerging from their involvement with the

study were asked to direct their concerns to the Director of Studies. In this study there was no report of any concern.

The study sample was obtained from students and staff at the University, therefore, extra caution was required to ensure participants were not identifiable. This was in compliance with the Data Protection Act (1998) and the policy outlined by the University Data Protection policy and the conditions upon which this study was approved. As this was a follow-up study, participants' contact details were required. Participants' identifiable information was handled with care, and contact details only kept until the final follow-up. Contact details were linked by a unique code to the questionnaire data. The electronic data used only this unique code. Contact details were kept separate from the study data in a separate locked filing cabinet. Contact details were only kept on paper records and destroyed after the final assessment data was checked. The contact details of the participants who did not respond to the final assessment were destroyed within two months of the final assessment date. For participants who opted in to the cash prize draw, their contact details were destroyed after the prize draw. Consent forms were kept separate from the study data to reduce the likelihood of the information being linked to the manual or electronic data. All email communications were deleted.

Participants were able to withdraw from the study up to and until the time the contact details were destroyed, either after the last assessment or, if they failed to respond to the final assessment, within two months of the final assessment date. Participants withdrawing from the study had all identifiable information deleted and other data deleted as requested. Only two participants withdrew during the follow up.

All research documents were stored to ensure anonymity and confidentiality in line with university policies. Hard copies were stored in locked cabinets. Electronic data was held on a shared drive folder which was only accessible by members of the supervisory team. Datasets holding individual data were kept in an encrypted WinZIP folder until it was fully anonymised, that is the participants' contact details were destroyed. All members of the research team could access the folder. The Director of Studies is responsible for the deletion of the data within 5 years of the end of the study.

5.11.1 Potential Risk

The direct measurement of weight to estimate BMI might present itself as upsetting to some participants. However, to obviate any distress, this data was only collected if the participant found it acceptable. The screening questionnaire was used to ensure that direct measurement of height and weight was only offered to the participants that answered *yes* to the question - *Are you willing to have your height and weight taken for the research purpose? Yes / No*. A screen was in place to ensure privacy.

5.12 Study Management

Project meetings were held every six weeks to monitor study progress and address any issues. The research student and Director of Studies met once a week. When there was a prolonged absence of the Director of Studies, meetings were arranged with another member of the supervisory team. In case of emergency a meeting was to be held within 48 hours. In the course of this research, this was not required.

5.13 Quality assurance of the data collection process

The process used in the collection of data and how the collected data was handled to maximise quality is described below.

Following the signing of the consent form, the participants were informed as to the nature of the questionnaire and how to fill it in before it was handed out, to reduce errors in filling in. Each participant was given adequate time to fill in the questionnaire. Afterwards, the questionnaire was checked by the research student, while the participant was there to ensure all fields were filled in appropriately. However, in some cases, for example, during the class based recruitment when there were too many volunteers, these procedures could not be fully observed, because there was lack of adequate time. At follow up, after completion of a questionnaire (either during face-to-face assessment or through an email) the questionnaires were checked to ensure all fields were filled in appropriately.

5.14 The data management

A database was created in SPSS version 22.0 software. It was created in such a way as to mimic the questionnaire. Each column in data view within the database represented a question in the questionnaire. The data was inputted solely by the research student into the database (Winkler 2004).

Double data entry by an independent data checker was not performed because of a lack of resources (Barchard et al. 2008; Barchard et al. 2011). This re-entering of data after initial entering by a different person allows for identification of values that are

outside the allowable range and data that is not entered. Double entry is said to improve data accuracy and prevent human error (Reynolds-Haertle & McBride 1992; Kawado et al. 2003; Barchard et al. 2011; Barchard et al. 2013).

To reduce input errors in this study, the database was programmed to restrict entering of categorical variables outside the range of values. For example, for a question with a *yes or no* answer, it was programmed that *yes = 1 and no = 0*. To ensure the quality of the data entering, 20 minute breaks were taken every hour following complete input of data from the questionnaire. Visual checking, graphs and diagnostic statistics of data were used to correct human error incurred during data entering (Winkler 2004; Mavridis & Moustaki 2008).

5.15 Data cleaning

Data cleaning is a process whereby a database is systematically searched for error(s) with predefined rules for dealing with error(s) in order to improve the quality of the data (Van den Broeck 2005; Van den Broeck et al. 2013). Data cleaning in the past has been seen as unimportant (Van den Broeck 2005), Armitage and Berry (1987) almost apologised for including a chapter on data cleaning in their textbook on statistics in medical research. It is appropriate to state here that data cleaning can never be a cure for poor study design or study conduct (Van den Broeck 2005). The American Statistical Association recommend as a guideline that a description of data cleaning be included when reporting statistical methods of research (American Statistical Association 1999). The methods used to ensure data quality following data entry in this study are described below.

5.15.1 The screening phase

The screening phase is used to screen for suspect features such as outliers, etc. This phase is used to identify missing or excess data; outliers; and a strange pattern in data distributions (Van den Broeck 2005). The screening phase was carried out to ensure the total number of participants recruited corresponded to the number on the database. The code number, gender, and age on each completed questionnaire was cross-checked against those on the database.

This phase was used to identify continuous data, for example, age, outside the designed range values missed during data entering. This was achieved by a column to column check of age variable. Descriptive analysis was used to screen the continuous data, for example, a histogram of the distribution of BMI was plotted to check for outliers (Figure 5.5). Figure 5.5 shows that one participant self-reported a BMI of 12.5. This was checked again on the questionnaire. However, the directly measured BMI of the same participant was confirmed to be 16.7, which is the value used in further analyses (Chapter 6, table 6.6). When potential errors were detected, the questionnaire was retrieved to check whether a value was consistently the same. The outliers that were true values were discussed with the Director of Studies and the action taken was recorded. It should be noted that erroneous values below the highest value of any continuous variable were likely to escape detection.

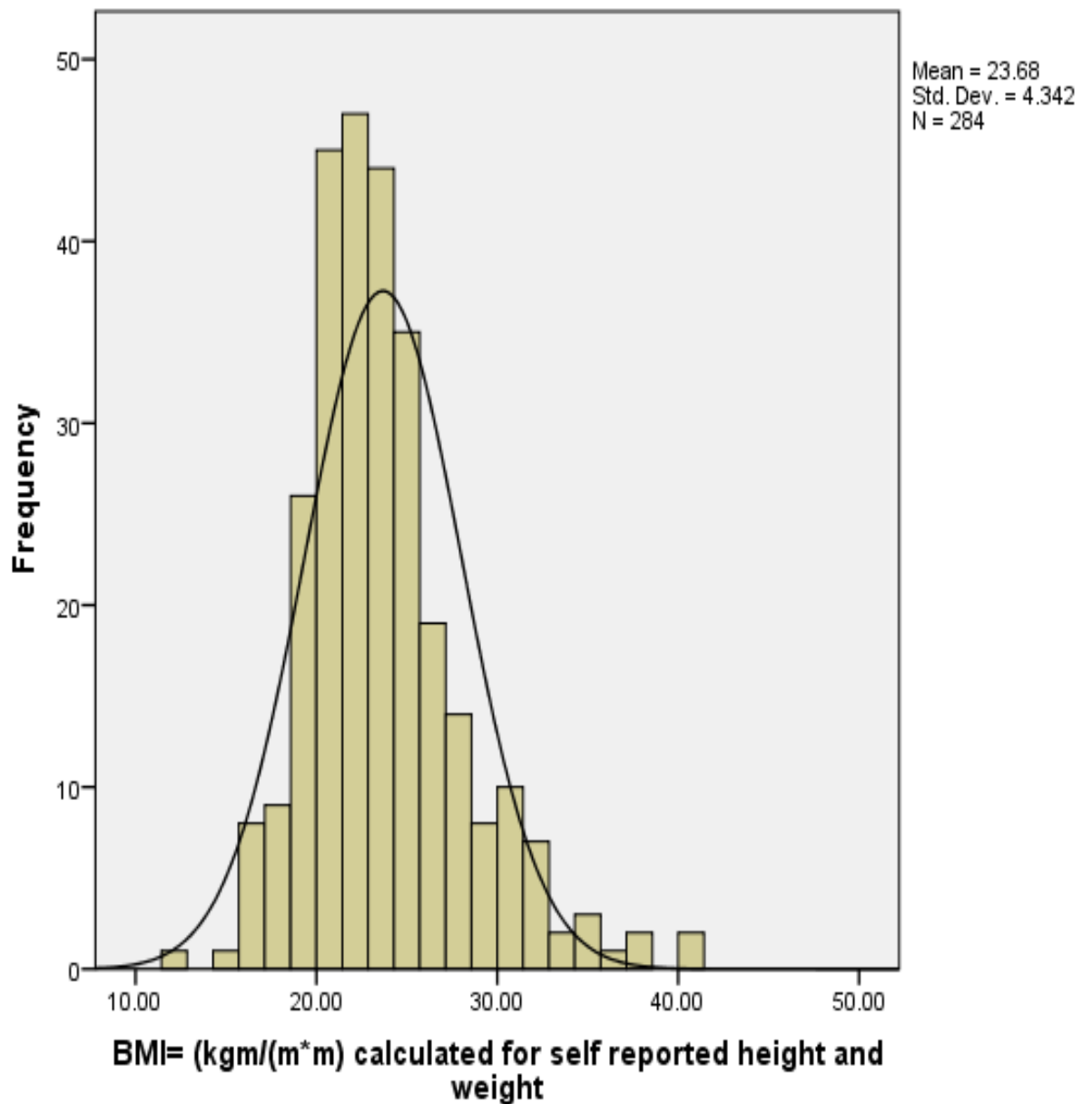


Figure 5.5 Histogram of self- reported BMI to check distribution of data.

5.15.2 Diagnostic phase

The diagnostic phase aimed at identification of any error missed during the screening phase (Van den Broeck 2005). The participant identification codes were arranged in

an ascending order. The data was divided into three sections – 1st (the first part of the database), 2nd (the middle of the database), and 3rd (the last part of the database). The research student went through the first 10% of the first section of the database row by row, checking for errors. This was repeated for the first 10% of the middle and of the last section of the database. An item error of 5 (0.02%) out of 25277 items was identified.

The questionnaire used to collect data consists of individual tools put together. Some of these questionnaires have documented procedures for handling missing values, true extreme or normal values. True extreme values were handled as outlined in the protocol of the individual questionnaire. The information on these procedures for IPAQ and KOOS is available on <http://www.ipaq.ki.se/scoring.pdf> and <http://www.koos.nu> respectively. True extreme values were retained. Overall, two errors (in a categorised variable) were identified and five anomalies in continuous variables on the IPAQ- long instrument were observed and were true extreme values. Erroneous data were sorted out immediately by replacing them with the actual value from the questionnaire. IPAQ – long protocol for true extreme values was adopted in handling the extreme values reported for physical inactivity, which was to exclude them from analysis.

5.15.3 Treatment phase

The treatment phase in data cleaning is when the researcher must decide how to handle problematic observations (Van den Broeck 2005). Missing values have the potential to reduce the effective sample size or precision of your prevalence and incidence

estimation in this study. Mean-substitution has been suggested as a possible way to avert the threat to the power of the statistical analysis (Dancey et al. 2012). In calculation of the HSCL-10 score, for valid information, six of the ten questions had to be completed, and missing values were replaced by the sample mean for each value (Strand et al. 2003). The mean-substitution can introduce serious biases into the analysis, if the number of missing values was high, say 30% of the collected data, using the mean-substitution would be underestimating or overestimating the overall mean (Dancey et al. 2012). However, linear / multiple regression rely on using data that are present to provide estimates for missing values. This is with the assumption that the actual values of the imputed variable are perfectly predicted by the other variable in the model, so they replicate the exact relationship between the two variables. It is the best technique suited to the investigation of naturally occurring phenomena (Dancey et al. 2012). The statistical analysis section has details of the procedure used in handling missing data for BMI using these techniques.

5.16 Theory underpinning data quality assurance

Errors do occur in epidemiological research regardless of careful planning and the strategic implementation of such a plan to prevent errors. Good prevention strategies can reduce the occurrence of error but can rarely eliminate it (Van den Broeck et al. 2013). These errors can occur in both experimental, clinical trials, and observational research (Ki et al. 1995; Horn et al. 2001). Uncleaned data could lead to false conclusions (Van den Broeck et al. 2013). Although data cleaning is a time consuming and tedious process, it should not be ignored (Van den Broeck et al. 2005).

The minimum acceptable data quality levels have not been established, and no freely available and sufficiently detailed standard currently exists to evaluate them (Ohmann et al. 2011). In this study, a field error of 0.02% was identified during data cleaning and the errors were corrected and documented ensuring traceability. These corrections were added to the database while retaining the original data in a separate field or fields so that there is always the chance of going back to the original information.

The rigorous process undertaken by the research student during data collection ensured high quality of the data. Direct measurements were undertaken by the research student only. The design of the database made it easy for data inputting, and minimised entering errors (only 0.02%).

5.17 Estimation of sample size

The sample size for the estimation of the prevalence of knee problems was calculated using the result from a pilot study, undertaken by the supervisory team, which suggested a 16% prevalence. It was proposed that a sample size of 300 staff and students would enable the estimation of the overall prevalence of knee problems within $\pm 4.5\%$ with 95% confidence, assuming a true prevalence of 20% or less. For an estimation of traumatic and of non-traumatic knee problems the precision would be $\pm 3.4\%$ with 95% confidence, assuming the true prevalence of each was 10% or less. The above estimation was undertaken before changes to the recruitment method and assumes that there is no clustering effect on the outcome of interest.

5.18 Statistical Analysis

The study design allows for two analytical approaches. A cross-sectional analytical approach was applied to data collected from participants at the baseline assessment. A longitudinal analytical approach was applied to data collected from participants at baseline and follow up. This sub-section discusses how continuous and categorical variables were summarised. It discusses steps taken to impute missing data of directly measured BMI before it was included in the analysis. Measures were taken to ensure minimal effect of the sampling method employed in this study. It outlines steps taken to arrive at the final regression model used to evaluate the inter-relationship between physical inactivity (average sitting time per day in hours), obesity (BMI), physical activity (as three categories low, moderate and high) and knee problems.

5.18.1 Descriptive analysis of the characteristics of the cohort

A central tendency measure (mean) and measure of dispersion (standard deviation (SD)) were calculated for variables: age, the HSCL-10 score (which measured psychological factors), BMI (continuous), physical inactivity, and the KOOS score variables. The percentage and frequency was calculated for categorical variables, for example: physical activity levels, BMI groups, types of sport participation, and gender.

The period prevalence and incidence (excluding participants with knee problems at the baseline to explore an onset of new cases of knee problems after 12 months follow up) is estimated by dividing the number of participants who reported ‘yes’ to the

question ‘*have you had pain or problems in the last year in or around the knee?*’ by the total number of participants responding to the question.

Self-reported BMI was classed as missing if height and/or weight were not reported. It was anticipated that more participants would self-report their height and weight, then used to calculate self-reported BMI, than have it established by direct measurement. Hence, Bland & Altman’s (1986) plot was used to explore the interchangeability of self-reported BMI and directly measured BMI. Bland & Altman’s method was used to assess the discrepancy between self-reported BMI and directly measured BMI as each has its own measurement error. The proposed Bland & Altman method calculates the mean difference between two methods of measurement (the bias) and 95% limits of agreement of the mean difference (± 1.96 SD) (Bland & Altman, 1986). Bland & Altman highlighted the difference in the two measurement methods against the mean for each participant, arguing that, if the new method (in this case self-reported BMI) agrees sufficiently well with the old (in this case directly measured), the old may be replaced. The presentation of the 95% limit of agreement is for visual judgement of how well the two methods of measurement agree, the smaller the range between these two limits the better the agreement.

Linear regression was used to impute missing values in directly measured BMI using self-reported BMI. In the regression model self-reported BMI was used as the explanatory variable and the BMI from direct measurement was the outcome variable. The imputed values were used to replace the missing values only. The resulting completed direct BMI measurement data was used in the analysis. BMI was initially categorised into: underweight, normal, overweight, obese and super obese. However,

as a result of the small number of participants in the underweight and super obese groups, the BMI was re-categorised into normal, overweight, and obese.

5.18.2 Inferential analysis

95% confidence intervals were estimated as appropriate. As a result of the cluster sampling method employed during the recruitment phase, the clustering effect needed to be accounted for in the analysis. Reducing the observation within a cluster into a single observation is another approach for dealing with clustering (Galbraith et al. 2010). In this study, class sessions (a cluster / unit) in different schools within the university were identified by lecturers, and groups of participants from these class sessions of 1st and 2nd year students were recruited (see Table 6.2). The number in each cluster is unequal, so taking the mean observation of each cluster will result in a cluster with more observations and variance contributing more to the outcome in the estimate of prevalence and incidence.

The impact of clustering effect on the estimate of prevalence and incidence was established by assessing the inflation factors. The inflation factor measures the degree to which the standard error (standard deviation) has been inflated due to clustering (Myers et al. 1994). The cluster robust standard error (Standard deviation after adjusting for clustering effect) allows for intragroup correlation which relaxes the usual requirement that the observation be independent. An inflation factor which is less or equal to one has been recommended as an acceptable level of no correlation, however, a value above one shows the level of a correlation which warrants adjusting for clustering (Hair et al. 1995; Kutner et al. 2004). If the result was less than or equal

to one there was no adjustment for clustering. This is with the assumption that all observations are independent (Galbraith et al. 2010). The outcome of this approach depends strongly on the nature of the extent of the correlation that exists in the data, that is, homogeneity within clusters and across clusters (Galbraith et al. 2010). If the result was above one, all the estimates (confidence intervals (CI) and p-values) of subsequent inferential analyses were adjusted for clustering. The same method was applied to trauma, pain as the dominant symptom amongst those with knee problems, and knee pain variables.

Inferential tests, for example, t-test, and chi-square test were used to test for change between the baseline and follow-up in mean KOOS scores and average sitting time per day in an hour. P-values <0.05 were considered statistically significant. The data were analysed using STATA 13.1 software

5.18.3 Exploring risk factors for knee problems

Here steps were taken to investigate variables affecting the prevalence of knee problems. Logistic regression was used to investigate any plausible relationship between knee problems and BMI, physical inactivity, and physical activity levels. Age, gender, psychological factors (mental distress) were considered potential confounding factors. Odds ratio (OR) are reported with 95% CI. Factors measured at baseline were used in the logistic regression to estimate the most plausible relationship to prevalence and to incidence of knee problems after 12 months follow up.

In these analyses, continuous variables (HSCL-10 score, age, BMI, and physical inactivity) were categorised.

Age was categorised into four groups to investigate if it revealed a relationship between age and knee problems. The HSCL-10 score was divided into two categories (i) those with a threshold less than 1.85 and (ii) those with a threshold greater than or equal to 1.85. Those who reported a HSCL-10 score greater than or equal to 1.85 were classified as mentally distressed, those reporting below this score were not mentally distressed. This was done to investigate any plausible relationship between being mentally distressed and knee problems.

Data collected using the IPAQ-Long questionnaire was fitted in to the regression model to investigate the relationship between knee problems and physical activity levels in this study. Sports participation was used for description of the participants' purpose only.

The nature of the relationship (linear or quadratic) between knee problems and crude BMI as a continuous variable was investigated by plotting the logit of the odds of knee problems against BMI categorised into nine groups. The same process was applied to the crude physical inactivity variable as well. BMI and physical inactivity were centred. Centring it means that one can interpret the intercept as the expected value of the outcome (knee problems) when the explanatory values (BMI and physical inactivity) are set to their means. Whereas, if not centred, the interpretation of the intercept may not be realistic or interpretable (as the expected value of the outcome would then be when the explanatory is set to 0). Physical inactivity and BMI were

centred before being fitted into the model based on the observed nature of their relationship with knee problems. When the nature of the relationship was quadratic, both linear and quadratic terms were included in the regression model instead of quadratic term only.

Physical activity levels and physical inactivity were treated as separate risk factors for knee problems. A low physical activity level indicates the absence of medium and high physical activity level, and logically an increase of physical inactivity. Therefore, to ensure that these could be both put in the model as independent variables to check for collinearity, the relationship between physical activity levels and physical inactivity was evaluated.

It is important to know how each variable independently explains knee problems while adjusting for confounding variables demonstrated to affect an outcome (Chapter 2). Irrespective of the significance; age, gender, and psychological factors (mental distress) were included in the final regression model as known confounding factors; and BMI, physical inactivity and physical activity levels as risk factors.

Multivariate logistic regression was performed as there is a single dichotomous outcome (presence or absence of knee problems) and more than one independent variable, which include the three risk factors (BMI, physical inactivity and physical activity) for knee problems in the absence of confounders (age, gender, psychological factor).

The performance of the model was investigated using ‘Percentage correct predictions’ (Hosmer et al. 2013). The best fitting model containing both risk factors and confounding factors of knee problems was used to analyse the effects of one potential risk factor, while adjusting for the effects of others (Alan 2007; Vittinghoff et al. 2012; Hosmer et al. 2013; Long and Freese 2014). This best fitting model’s ability to discriminate between participants with or without knee problems was estimated using Hosmer & Lemeshow’s goodness-of-fit test and Area Under the Curve (AUC) (Hosmer et al. 2013). Hosmer & Lemeshow goodness-of-fit test helped to decide whether the final model was correctly specified. The AUC measures the performance of the model in its ability to discriminate between presence and absence of knee problems or incidence of knee problems. $AUC = 0.5 - 0.6$ means discrimination was poor and no better than chance, $0.7 \leq AUC < 0.8$ means acceptable discrimination, and $0.8 \leq AUC < 0.9$ means excellent discrimination. (Hosmer et al. 2013) The Receiver Operating Characteristic (ROC) curve was plotted to identify a true condition state, given by the reported presence of knee problem variable.

Chapter 6 Result of the epidemiological study of knee problems in young adults – Recruitment and Prevalence data.

6.1 Introduction

This chapter presents details on recruitment and the characteristics of the recruited participants and discusses the prevalence of knee problems; the prevalence of different types of knee problems and the severity of knee problems in this study cohort. This is followed by an exploration of the association between the prevalence of knee problems and the participants' characteristics and an exploration of their relationship with knee problems. The chapter goes on to explore the association between the prevalence of knee problems, and risk factors (BMI, physical activity levels and physical inactivity levels). The relationship between risk factors and confounding factors identified from the systematic review (age, gender, and mental distress) in the explanation of knee problems is also explored.

6.2 Recruitment

Participants were recruited during two time periods. During the first recruitment period, 130 (41.4%) participants were recruited; 184 (58.6%) were recruited during the second period. A total of 314 participants were recruited to the study.

The percentage of staff and students who came forward as individuals after advertising was 41(13.1%) (Figure 6.1). The remaining participants 273 (86.9%) were recruited as groups from different classes and from the postgraduate research student's

induction sessions within the university. The types of courses from which they were selected is shown in Figure 6.1. There were seven courses and the number of the participants recruited from each course ranged from 10 to 88.

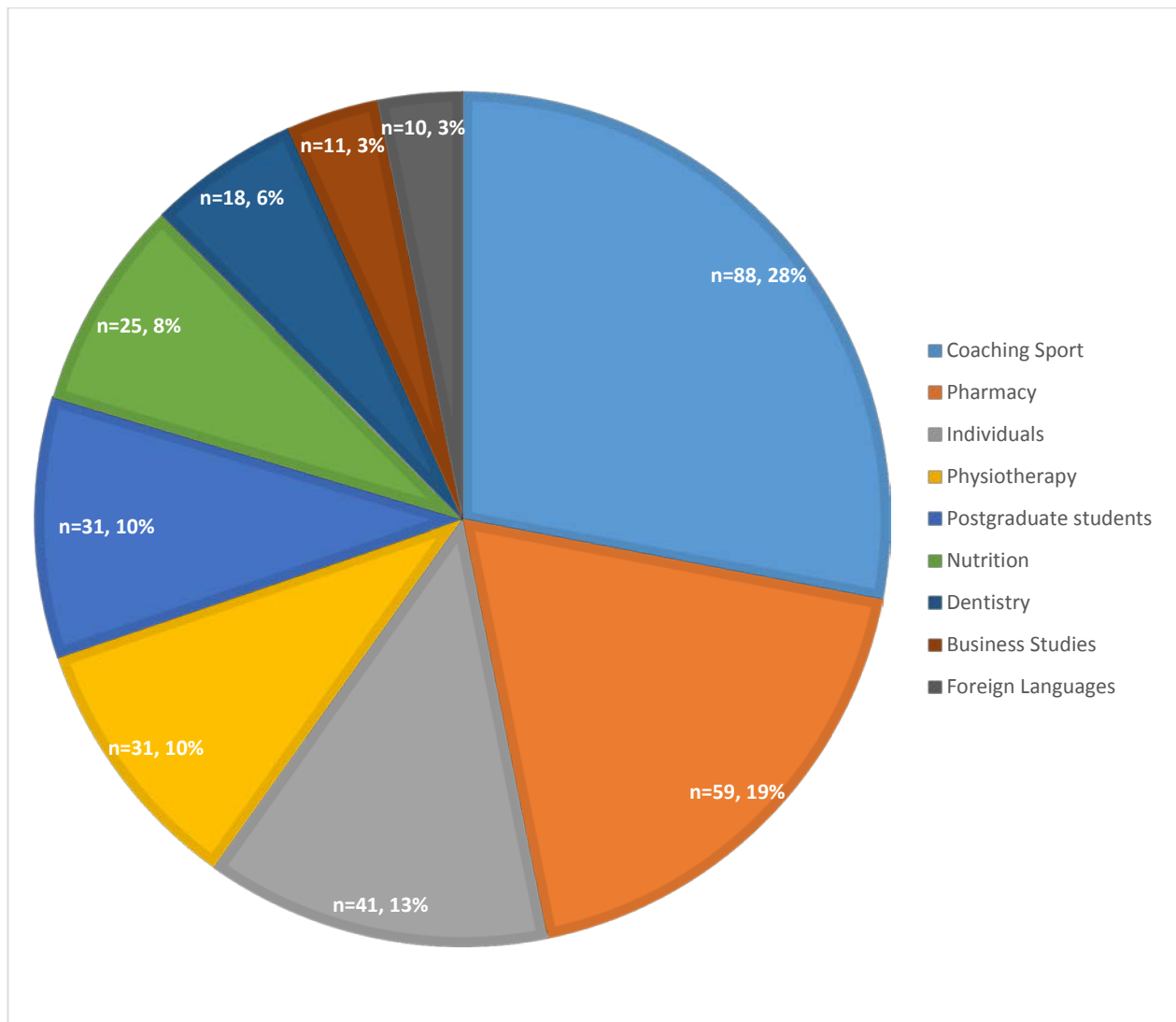


Figure 6.1 Percentage of participants per course recruited into the study.

6.2.1 Demographic and other participant characteristics at baseline assessment

There were more men (n=176, 56.1%) than women (n=138, 43.9%) recruited to the study. In the university, the student gender distribution is 46% male and 54% female. It should be noted that staff were also recruited to this study. The gender distribution of staff employed at the university is 42.8% male and 57.2% female. The mean (SD) age of the cohort was 22 (5.2) years. There was a small number of participants who were 30 years of age or over (n = 33, 10.5%). The mean (SD) score of Hopkins symptoms checklist-10 (HSCL-10) for the study population was 1.5 (0.4). There were missing values for 5 (1.6%) participants for the HSCL-10 score.

Of the 314 participants recruited to this study, a total of five (1.6%) participants did not take part in any sporting activity. Looking at 'at least weekly' sports participation measured with a modified New Zealand Physical Activity Questionnaire- Long (NZPAQ), the highest report was recorded for gym / circuit training (n = 113, 36.6%) (Table 6.1). This was followed by running/jogging/cross country (n= 95, 31.1%), football (n= 76, 25%), Dancing (n= 43, 14.2%), Cycling (n= 36, 11.8%) and others (n= 34, 21.7%) (Table 6.1).

Table 6.1 Nature of sport participated by the participants.

Sport participated	At least weekly	Prevalence of knee problem per sport
Dancing	43 (14.2%)	17 (39.5%)
Gym, Circuit Training	113 (36.6%)	37 (32.7%)
Cricket	9 (3.0%)	3 (33.3%)
Cycling	36 (11.8%)	18 (50.0%)
Badminton	11 (3.6%)	5 (45.5%)
Football	76 (25.0%)	28 (36.8%)
Rugby	15 (4.9%)	4 (26.7%)
Hockey	5 (1.6%)	1 (20.0%)
Running / Jogging / Cross Country	95 (31.1%)	38 (40.0%)
Tennis	8 (2.6%)	1 (12.5%)
Squash	1 (0.3%)	1 (100%)
Netball	7 (2.3%)	1 (14.3%)
Basketball	7 (2.3%)	6 (85.7%)
Aerobics	20 (6.6%)	7 (35.0%)
Swimming	22 (7.3%)	8 (36.4%)
Judo, Karate, other martial arts	10 (3.4%)	4 (40.0%)
Other	34 (21.7%)	11 (32.4%)

6.3 Investigating the potential effect of cluster sampling on confidence interval estimates for knee problems, knee pain and traumatic onset of knee problems at baseline assessment

The sampling method employed in this study included recruitment by clusters. The clusters were individuals recruited as a group from different class sessions. In total, 273 (86.9%) of the sample size were recruited as 14 cluster units across different schools in the university. The participants who were not recruited as a group ($n=41$, 13.1%) were treated as a single cluster unit in the analyses. Overall, there were 15 cluster units and the unit size ranged from 9 to 76 (Table 6.2).

The inflation factor for the prevalence of knee problems and of knee problems due to trauma suggested there were no clustering effects on the standard error as their inflation factors were less than 1 (Table 6.3). Therefore, confidence interval (CI) and P-values relating to the prevalence of knee problems and of knee problems due to trauma (Table 6.3) were not adjusted for clustering and all subsequent analysis, including logistic regression. However, the analysis of knee pain as a dominant symptom was adjusted for clustering as the inflation factor was slightly greater than one (Table 6.3).

Table 6.2 List of cluster units recruited into the study.

Schools (Course)	Cluster units	No. of participants
Sport, Tourism & Outdoors (Coaching Sport)	a. Class 1	12
	b. Class 2	76
Pharmacy & Biomedical sciences (Pharmacy)	a. Class 1	21
	b. Class 2	38
Individuals recruited as staff and students (School not recorded)		41
Sport, Tourism & Outdoors (Physiotherapy)	a. Class 1	20
	b. Class 2	11
Postgraduate students recruited at postgraduate induction	a. Batch 1	15
	b. Batch 2	16
Health (Nutrition)	a. Class 1	11
	b. Class 2	14
Medicine & Dentistry (Dentistry)	a. Class 1	9
	b. Class 2	9
Lancashire Business School (Business Studies)		11
Languages, Literature & International Studies (Foreign Languages)		10

Table 6.3 Estimation of the inflation factor for the standard error estimate of prevalence of knee problems, knee pain as dominant symptom, and knee problems due to trauma at baseline due to clustering.

Variable	Standard unadjusted clustering	error for	Robust standard error adjusted for clustering	Inflation factor
Prevalence of knee problems	0.0263		0.0250	0.95
Prevalence of knee pain as dominant symptom	0.0229		0.0241	1.05
Prevalence of knee problems due to trauma	0.0169		0.0118	0.70

6.3.1 The prevalence of knee problems at baseline assessment

Of the 314 participants at baseline, 100 (31.8%, 95% CI 26.9% to 37.2%) reported knee problems. Of the 100 participants with a knee problem, 33 (33%) had a problem in the left knee, 22 (22%) in the right knee, and 44 (44%) had problems in both knees; only one participant among those reporting a knee problem did not provide information on which knee had a problem (Figure 6.2). The total number of knees with problems was 143.

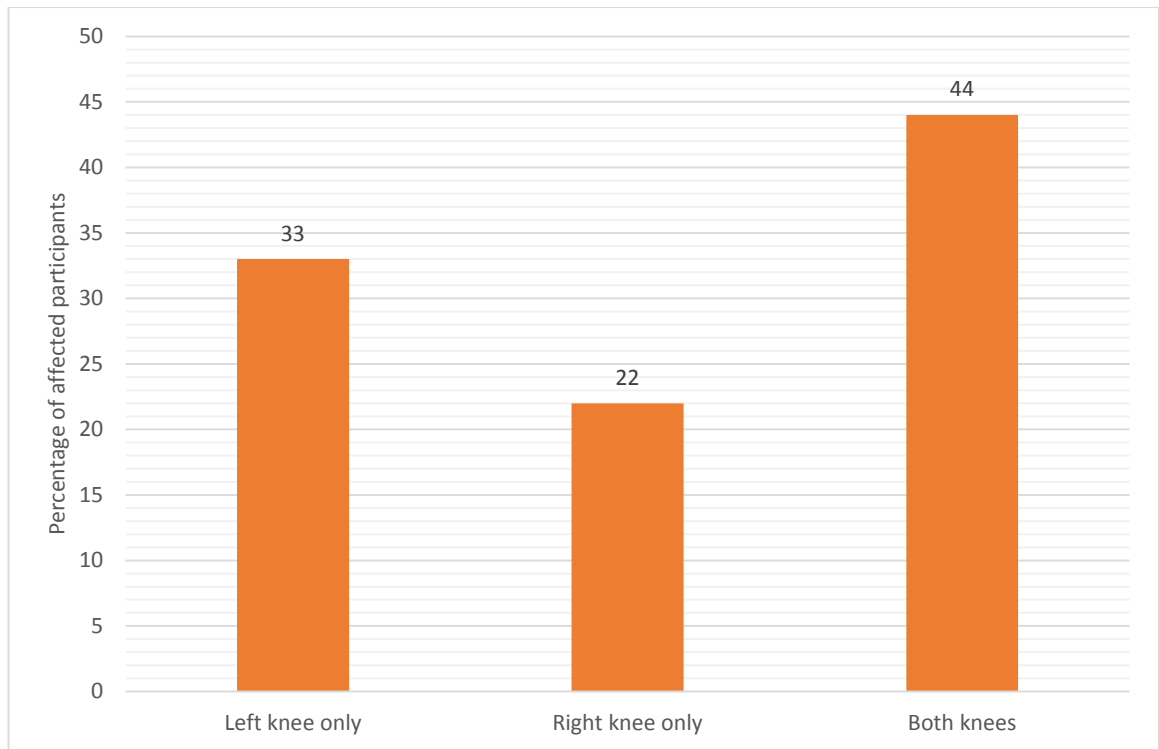


Figure 6.2 The percentage of participants that reported knee problems and the knee affected at baseline.

6.3.2 Severity of the knee problem measured by KOOS at the baseline

There were 78 (24.8%) participants out of 314 at the baseline who reported seeking medical care as a result of a knee problem. Twenty six participants who did not report a knee problem reported seeking medical care because of their knee problems. Of the 100 participants who reported knee problems, 52 (52%) participants reported seeking medical care because of the knee problem. Detail of medical care seek by the participants who reported knee problems was not explored at this study. Therefore, 26 participants must have had a previous problem with their knees.

Of the 100 participants that reported knee problems, 97 (97%) of those had a KOOS score of less than 100 on at least one subscale. The mean (SD) KOOS score on

subscale: pain, severity of symptoms, deviation from normal daily living, sports activities, and quality of life ranged from 71.1(21.4) to 90.8 (17.4) (Table 6.4). The distribution of the impact of knee problems reported on quality of life, function, sport and recreational activities, function, daily living and pain as reported by those who reported knee problem is shown in Figure 6.3 to 6.7.

Table 6.4 Severity of the symptoms measured by KOOS (n= 100).

Variable	Mean (SD)	Median	Interquartile range
KOOS score on pain	83.3 (18.6)	89.0	19.0
KOOS score on severity of symptom	80.8 (15.2)	82.0	14.0
KOOS score on function, daily living	90.8 (17.4)	96.0	35.0
KOOS score on function, sports and recreational activities	78.9 (25.5)	90.0	10.29
KOOS score on quality of life	71.1 (21.4)	75.0	32.0

More than 40% of the participants who reported knee problems reported pain as clinically important whereas 60% reported symptoms. Nearly half of the participants who reported knee problems reported a KOOS score of 90 or less for the subscale of function sport and recreational activities.

The majority of the participants who reported knee problems, reported an impact on the quality of life and up to 30% of the participants recorded a score less than 60 on this subscale. The activities of daily living appeared to be less affected.

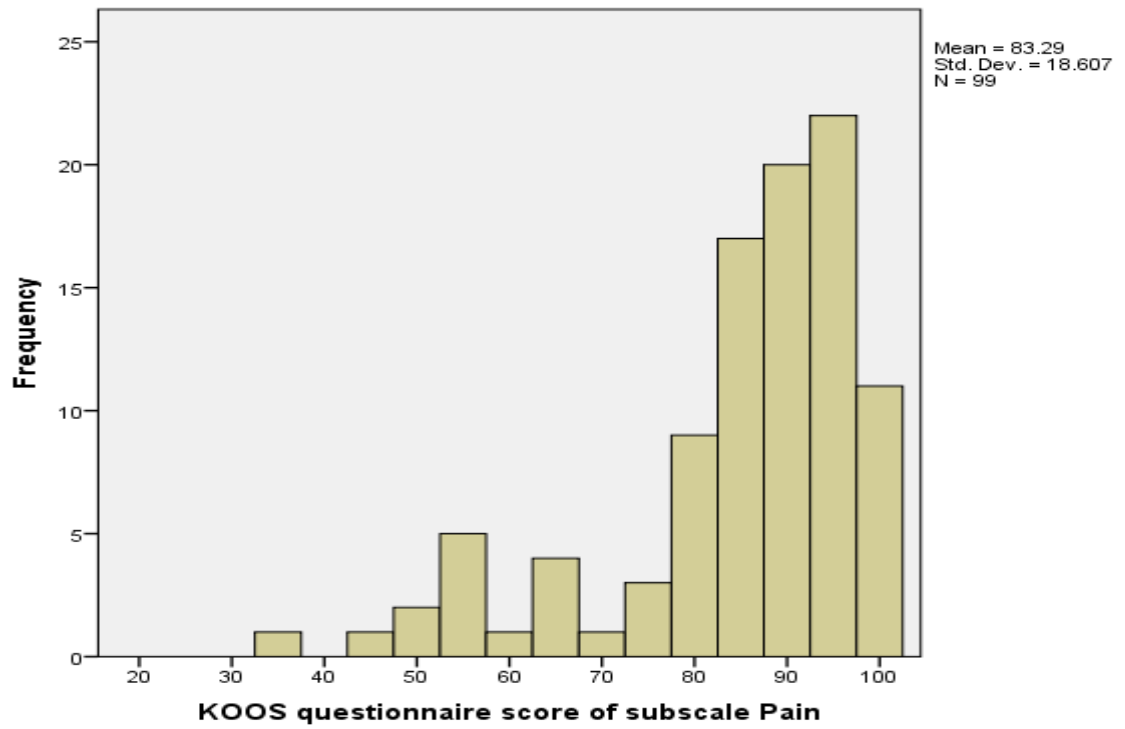


Figure 6.3 Distribution of KOOS score for pain subscale among those who reported knee problems (n= 99).

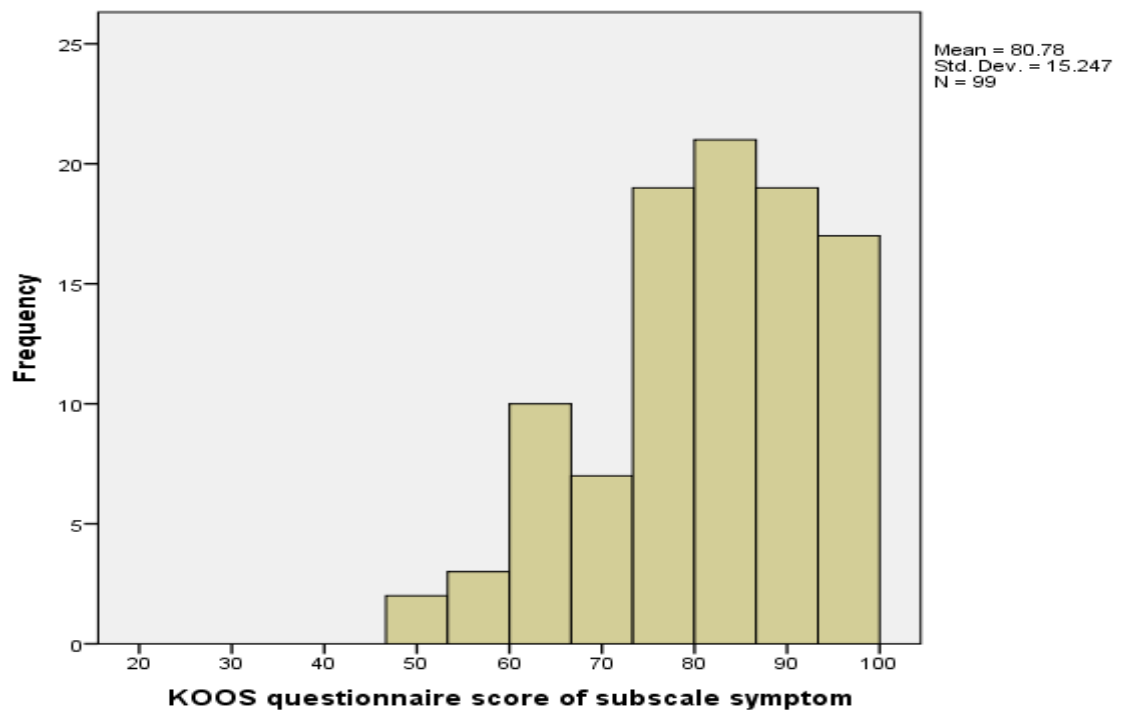


Figure 6.4 Distribution of KOOS score for severity of symptoms subscale among those who reported knee problems (n=99).

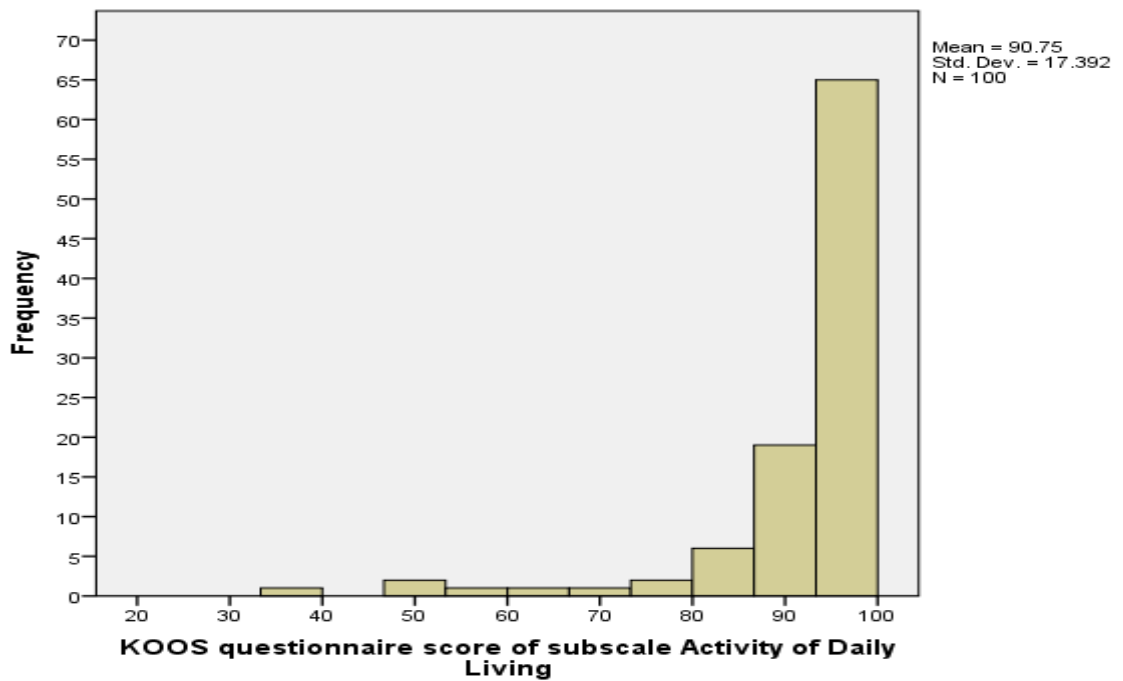


Figure 6.5 Distribution of KOOS score for Activities of Daily living subscale among those who reported knee problems (n=100).

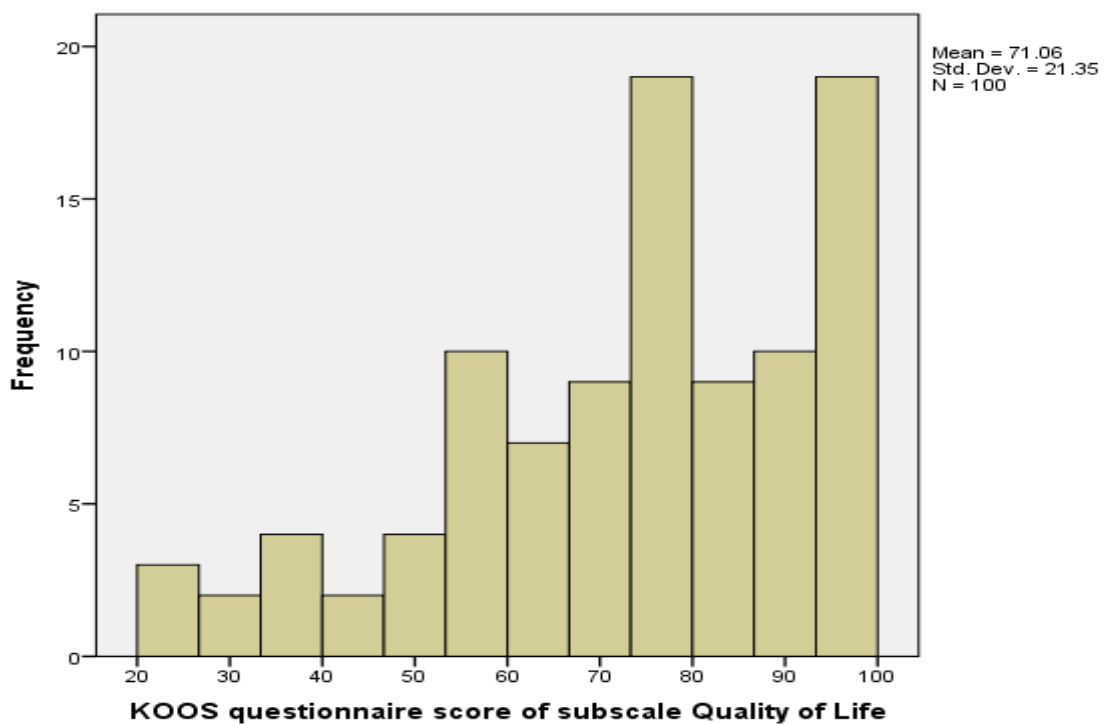


Figure 6.6 Distribution of KOOS score for quality of life subscale among those who reported knee problems (n= 100).

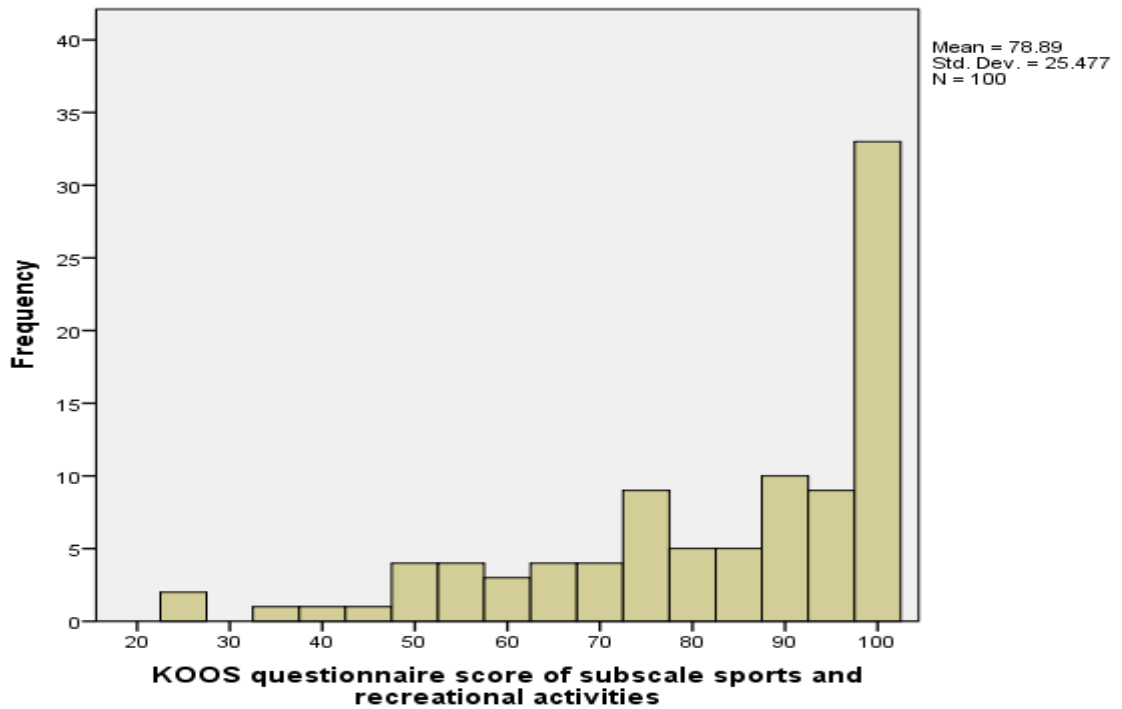


Figure 6.7 Distribution of KOOS score for sports and recreational activities subscale among those who reported knee problems (n= 100).

6.3.3 Prevalence of knee pain among the participants reporting knee problems at the baseline

Knee pain was measured using a specific question: *Thinking about your right/left knee, what do you consider is your main problem with your knee?* Of the 314 participants at baseline, knee pain prevalence was 20.7% (n=65, 95% CI 16.0% to 26.3%) (Figure 6.8). Among the 100 participants who reported knee problems, knee pain was reported as a dominant symptom by 19 (57.6%) participants from those with a left knee problem only, 13 (59.1%) participants from those with a right knee problem only, and 33 (75.0%) participants with knee problems in both knees. Of the 65 participants who reported knee pain as the dominant symptom there was no frequency between those

who reported gradual onset and those who reported traumatic onset of knee problems (Fisher's exact test p-value = 0.081).

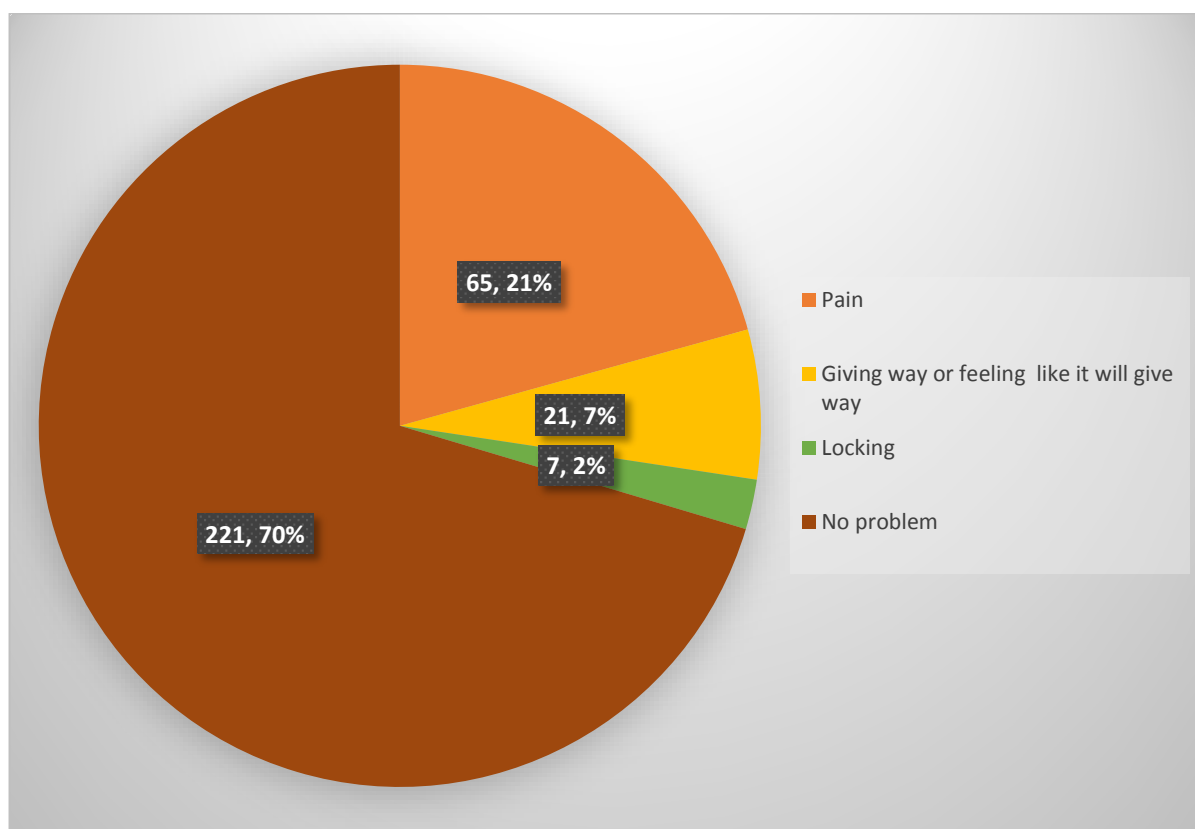


Figure 6.8 Proportions of participants reporting different predominant symptoms of knee problems in the study cohort. There were seven missing values.

6.3.4 How the knee problems developed among the participants reporting knee problems at the baseline

The response of participants to the question: *Did the current knee problem come on because of a sudden injury, e.g. twist, fall or accident that you needed to see a doctor about* was used to estimate the frequency with which participants reported a traumatic knee injury. Trauma was reported as the cause of knee problems in 31 of the 314 participants (9.9%, 95% CI 7.0% to 13.7%). Among the 100 participants who reported

knee problems in the left, right and both knees, trauma was reported to be the main cause of knee problems in 14 (42.4%), 8 (36.4%) and 9 (20.5%) participants respectively.

6.4 Examining the relationship between the prevalence of knee problems and gender

Of the 176 males enrolled on this study, 61 reported knee problems (34.7%, 95% CI 28.0% to 42.0%) and among the 138 females, 39 reported knee problems (28.3%, 95% CI 21.3% to 36.4%). Univariate analysis was performed with gender as the explanatory variable. The analysis showed females were 0.7 times as likely to report knee problems as males (95% CI 0.5 to 1.2) although this difference was non statistically significant (Wald test Chi square=1.45, p-value = 0.23).

6.5 Age of participants at the baseline

The mean (SD) age of participants who reported a knee problem was 22.6 years (5.3). This was similar to the mean (SD) age of those not reporting the knee problem 21.9 years (4.9). To investigate whether there was a linear or quadratic relationship between an increase in age and the frequency of knee problems; age was categorised into four groups: *18 to 22 years*; *23 to 28 years*; *29 to 34 years*; and *35 to 39 years*. Univariate analysis using the age group was performed with *18 to 22 years* as the reference group (see Table 6.5).

Table 6.5 Comparison of prevalence of knee problems between different age groups.

Age	OR 95% CI	P value
Age		0.25
18 - 22	1	
23 - 28	1.5 (0.9 – 2.8)	0.15
29 - 34	1.5 (0.7 – 3.5)	0.33
35 - 39	1.1 (0.3 – 3.6)	0.90
Odds ratio (OR).		

The odds ratio does not suggest linear relationship although the relationship could be quadratic. Alternatively, it could be as a result of the small number of participants within the age range of 30 years and over in the study (section 6.2.1). This affected the number of participants within the last two age groups.

6.6 Prevalence of mental distress at baseline

Of the 309 participants that completed the HSCL-10 at baseline, 47 (15.2%) had a mean score above 1.85, suggesting they may be mentally distressed. The proportion of those whose mean score was above the threshold for mental distress was 24 (17.6%) in women and 23 (13.3%) in men.

6.6.1 Comparison of mental distress in those with and without knee problems

Of the 100 participants who reported knee problems, 21 (21.0%) had a score suggesting they were mentally distressed (Figure 6.9). Of the 209 participants without knee problems, 26 (12.4%) were mentally distressed (Figure 6.10). The analyses show the odds of having a knee problem was increased by a multiple of 1.5 (95% CI 0.8 to 2.4) for every unit increase in HSCL-10 score but the increase was not statistically significant (Wald test = 1.25, p-value = 0.26).

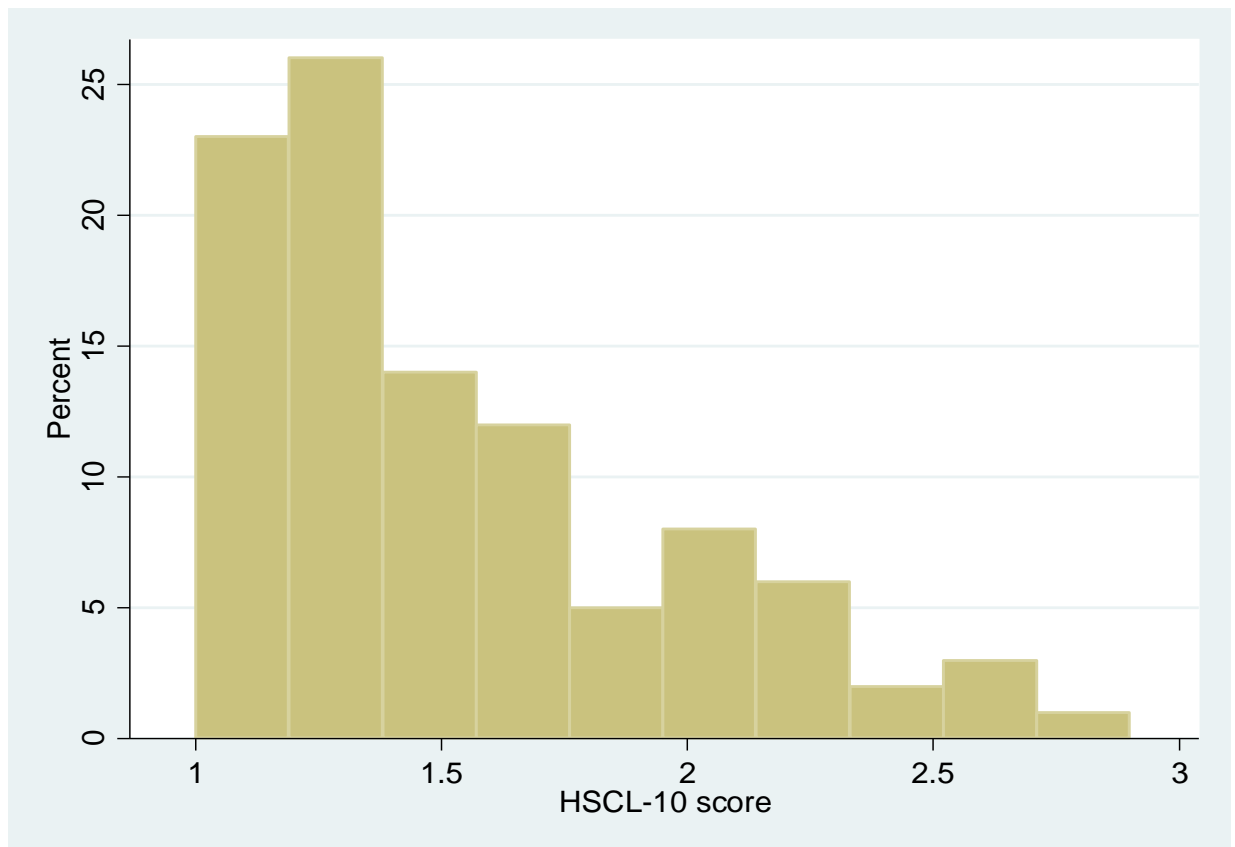


Figure 6.9 Distribution of HSCL-10 score of those who reported a knee problems.

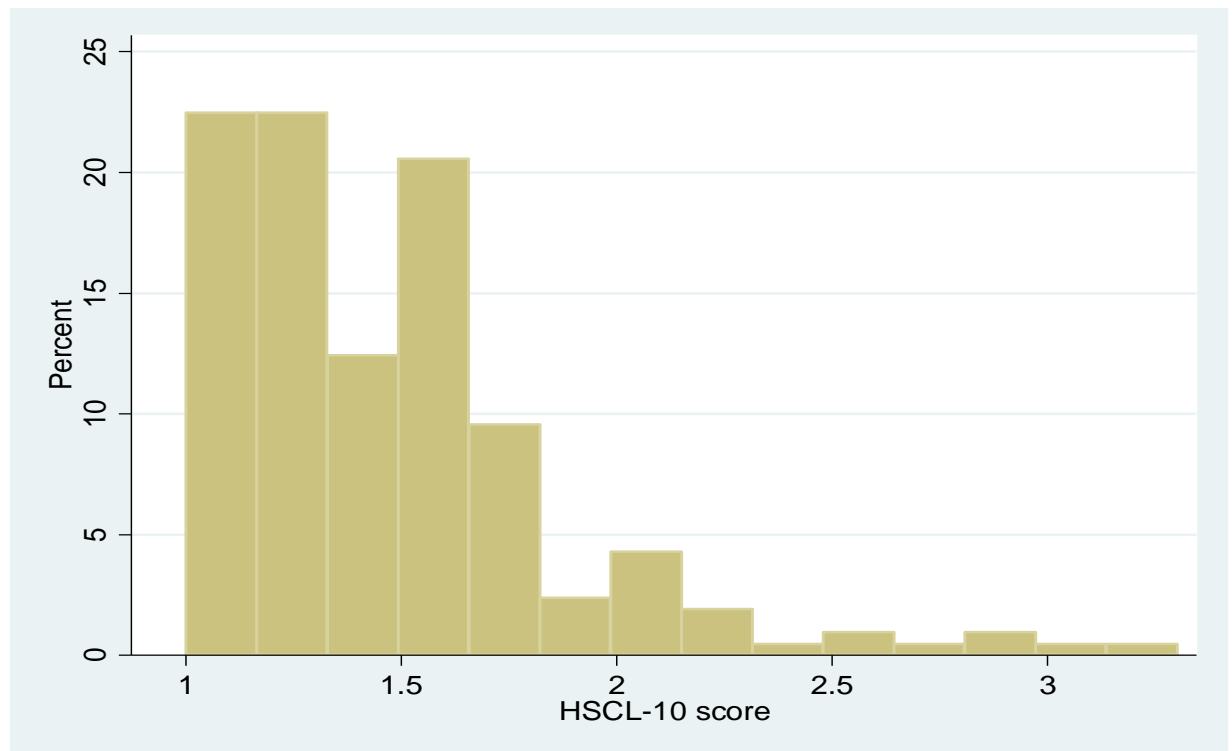


Figure 6.10 Distribution of HSCL-10 score of those without knee problems.

Another univariate analysis was performed using the categorised HSCL-10 variable (based on the threshold), showing that the odds ratio for mental distress compared to no mental distress was 1.9 (95% CI 1.0 to 3.5). However, mental distress was marginally not statistically significantly when associated with the presence of knee problems (Wald test = 3.766, p-value = 0.052). The categorised HSCL-10 variable was used for further analysis to explore the relationship between mental distress and other variables.

6.7 Comparison of the nature of sport participation in those with and without knee problems at the baseline

Among the sports which were recorded as having a high weekly participation, running / jogging / cross country recorded the highest percentage of participants reporting knee problems ($n = 38$, 40%) (Table 6.1). However, some sports with lower weekly participation reported a higher percentage of knee problems but the numbers are small.

6.8 BMI at baseline

Out of the 314 participants recruited 248 (79%) agreed to direct measurement of their height and weight which was used to calculate their BMI (that is directly measured BMI) (Table 6.6). The number of participants who reported their height and weight was 284 (90%). This was used to calculate their BMI (that is self-reported BMI). Three participants neither self-reported their height and weight, nor agreed to direct measurement of their height and weight. The number of cases with unreported BMI for both self-reported and direct measurement was 90 (28.9%) and the number of cases with reported BMI was 221 (71.1%). Overall, the mean of self-reported and directly measured BMI was similar (Table 6.6).

The mean (SD) BMI calculated using self-reported height and weight was 23.7kg/m² (4.3) and using directly measured height and weight it was 24.1kg/m² (4.2) (Table 6.6). For self-reported participants, the BMI ranged between 12.5 to 41.3 kg/m² and for participants directly measured, BMI ranged from 16.7 to 41.4 kg/m² (Table 6.6). When BMI was categorised, using self-reported height and weight, 57 (20.1%) of the

sample were overweight, 25 (8.8%) obese, and 2 (0.7%) super obese. When directly measured height and weight was used: 52 (21.0%) were overweight, 24 (9.7%) obese and 2 (0.8%) super obese.

Table 6.6 Comparing self-reported and directly measured height and weight.

Variable	BMI (kg/m ²) self-reported	BMI (kg/m ²) directly measured
Total no: 314	284	248
Missing	30 (9.6%)	66 (21.0%)
Mean (SD) [Range] BMI (kg/m ²)	23.7 (4.3) [12.5 to 41.3]	24.1 (4.2) [16.7 to 41.4]
<i>Males (N)</i>	162	131
<i>Missing</i>	14 (8.0%)	45 (25.6%)
<i>Mean (SD) BMI for male</i>	24.3 (4.1)	24.5 (4.6)
<i>Females (N)</i>	122	117
<i>Missing</i>	16 (11.6%)	21 (15.2%)
<i>Mean (SD) BMI for female</i>	22.9 (4.5)	23.7 (4.4)
Categorised BMI (kg/m ²)	N (%)	N (%)
<i>Underweight (<18.0)</i>	19 (6.7%)	8 (3.2%)
<i>Normal (18 – 24.9)</i>	181 (63.7%)	162 (65.3%)
<i>Overweight (25 – 29.9)</i>	57 (20.1%)	52 (21.0%)
<i>Obese (30 – 39.9)</i>	25 (8.8%)	24 (9.7%)
<i>Super obese (>40.0)</i>	2 (0.7%)	2 (0.8%)

Body mass index (BMI) and Standard deviation (SD).

6.8.1 Estimating the missing values of directly measured BMI

The total number of directly measured BMI missing values was 66 (21.0%). Using directly measured BMI in the analyses could introduce bias due to the high number of missing values. To reduce the potential bias associated with missing values of directly measured BMI, the missing values were imputed using self-report BMI values. However, there was a need to ascertain if the two methods of measurement of BMI can be used interchangeably. If they did differ, the imputation of the missing value using linear regression could be adopted. The scatterplot (Figure 6.11) shows how closely the data points cluster around an imaginary line of perfect agreement which demonstrates a strong relationship between the two variables. The general pattern of BMI is from the left-hand bottom corner to the right-hand top corner which shows a positive relationship. Self-reported BMI was similar to directly measured BMI, though some difference was observed among those reporting lower and higher BMI in the scatterplot Figure 6.11.

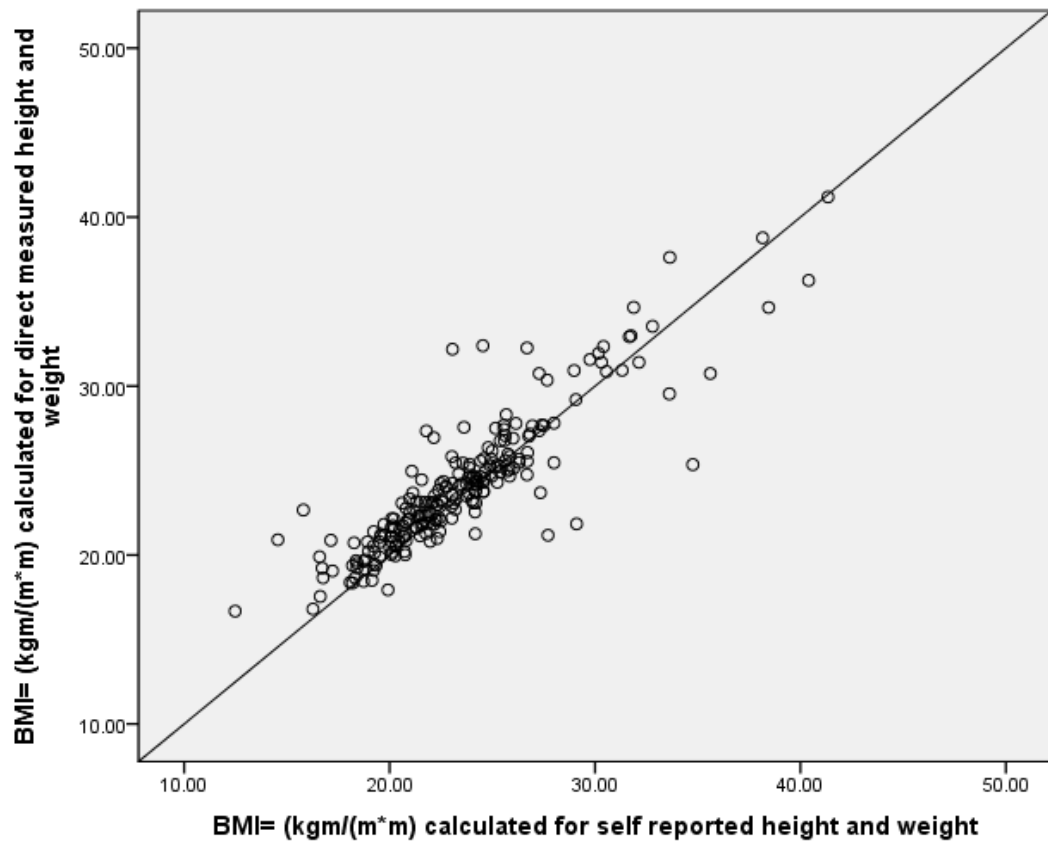


Figure 6.11. Scatterplot showing the imaginary line of agreement between Body mass index (BMI) measured through direct measurement and self-reporting.

To explore the differences a plot of the difference and average of self-reported and directly measured BMI (Bland & Altman 1986) was performed (Figure 6.12) to investigate bias and agreement between the two measurements. The mean (SD) difference of self-reported and directly measured BMI was -0.65 (2.00) (paired t test = -4.83, $p < 0.001$), which indicated that the two methods systematically produced different results on average. The 95% limit of agreement for the mean was from -4.57 to 3.27 (Figure 6.12).

The difference between the methods tends to get larger as the average of self-reported and directly measured BMI increases or decreases (Figure 6.12). There were some

notable differences between participants who reported being underweight and obese. It was noted from the plot Figure 6.12 that underweight participants were underestimating their BMI, while the overweight participants were overestimating. In addition, males were more likely to have missing values for BMI of direct measurement and females were somewhat more likely to have missing values for self-reported BMI (Table 6.6). This means that the mean of directly measured BMI would be influenced by the BMI of females which is on average less than the BMI of males (Table 6.6). Hence, the mean of self-reported BMI cannot be used for directly measured BMI.

The Bland & Altman plot has shown the interchangeability of self-reported and directly measured BMI is not possible. An alternative approach is the use of linear regression to predict the missing values of directly measured BMI (Dancey et al. 2012). The correlation between the self-reported and directly measured BMI was 0.89. This is close to perfect positive correlation but not necessarily perfect agreement, which would be required to allow valid interchangeability. A scatterplot of BMI of direct measurement (y) and BMI of self-reported (x) shows a visual linear relationship between the two variables (Figure 6.11 & Figure 6.13). The general formula for linear regression is: $y = bx + a$.

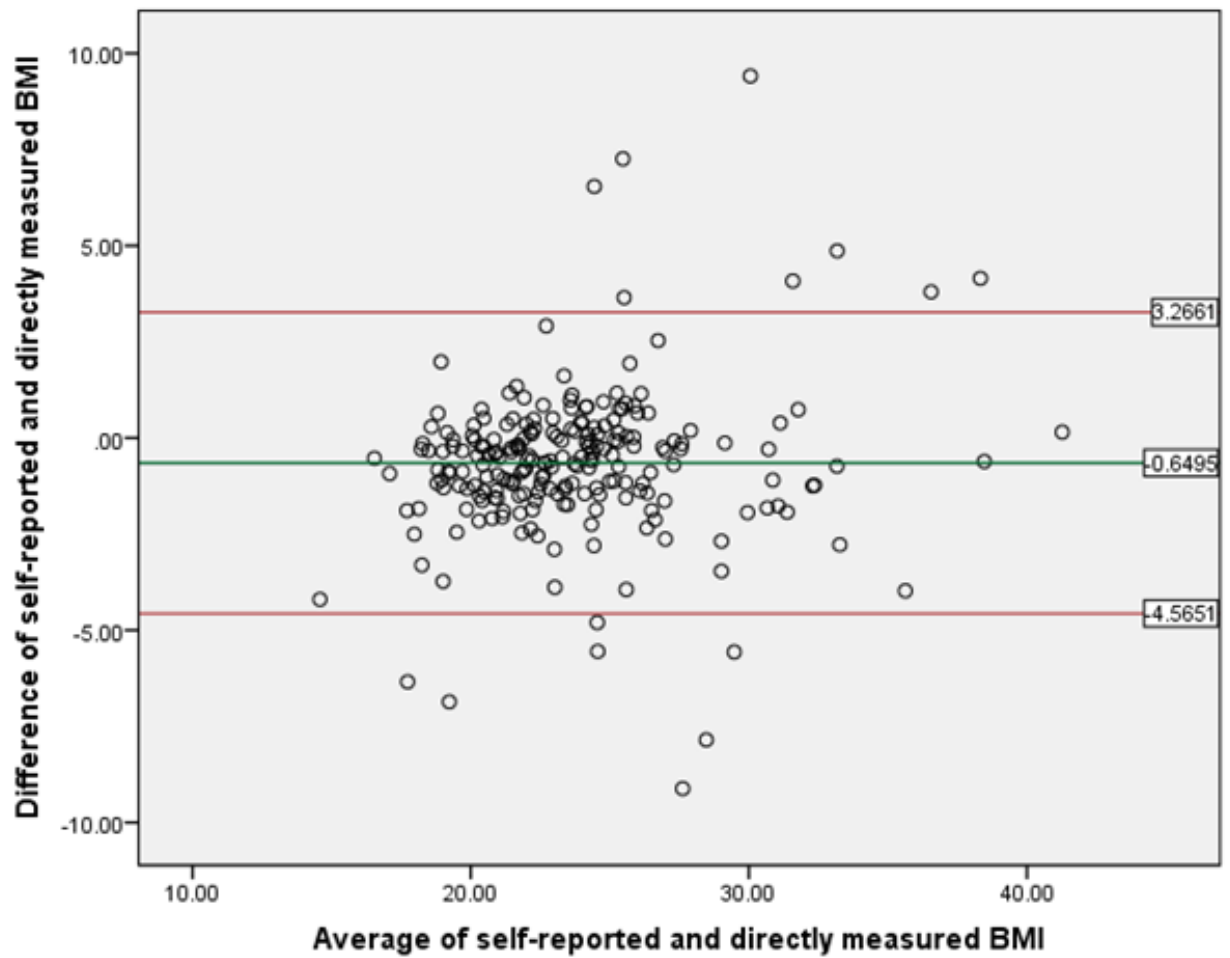


Figure 6.12 Bland & Altman plot demonstrating the agreement between the Body mass index (BMI) measured by self-report and direct measurement.

Based on this linear relationship between self-reported and directly measured BMI, linear regression was used to impute the missing values of the directly measured BMI with the self-reported BMI as the explanatory variable.

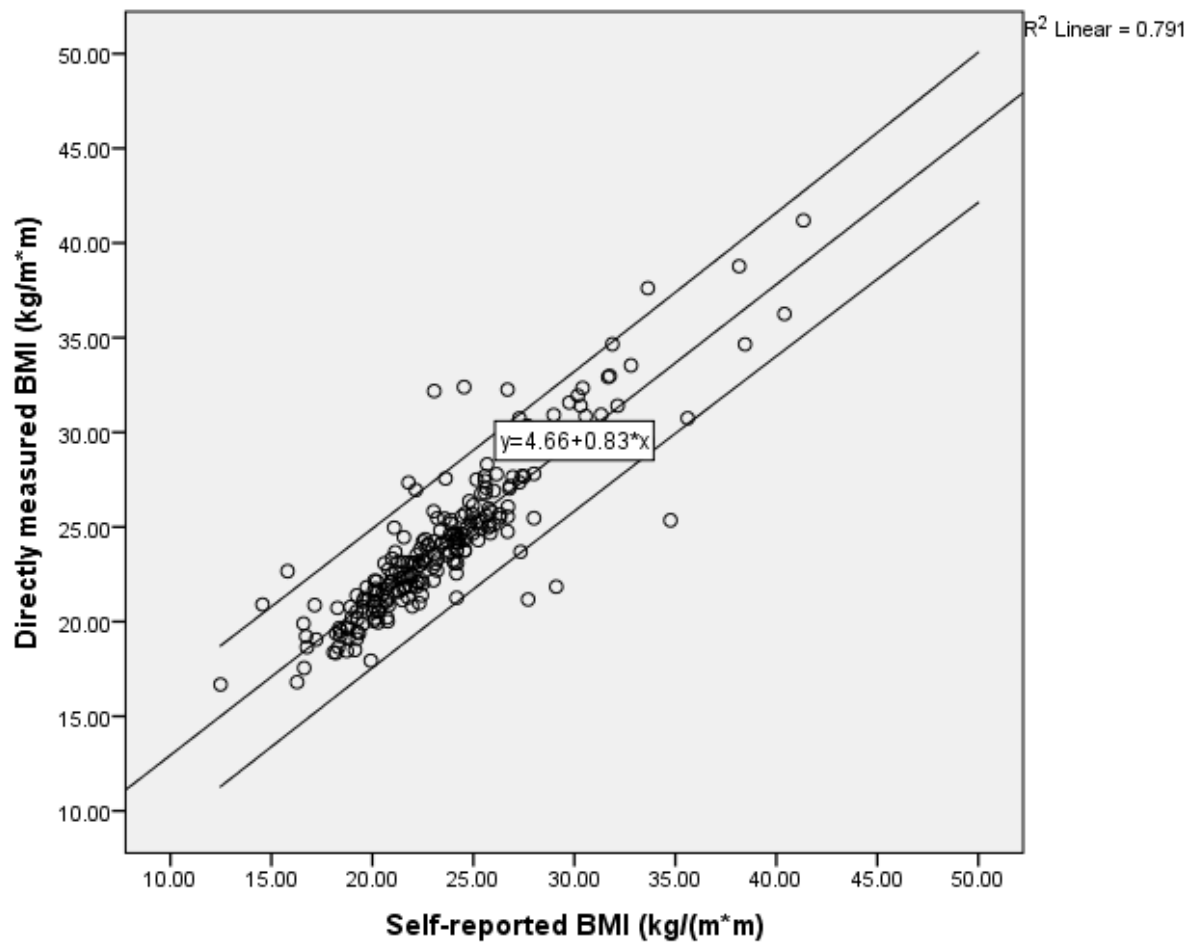


Figure 6.13. A scatterplot of self-reported and directly measured Body mass index (BMI) with best fit line and 95% CI showing how self-reported BMI explains directly measured BMI.

The reference line in the scatterplot (Figure 6.13) is the line of the best fit which best describes the relationship between self-reported BMI and directly measured BMI. The R^2 was 0.791, which suggests that 79% variation in directly measured BMI can be accounted for by self-reported BMI (Figure 6.13). The slope of the line in the graph represented by b in the equation above, shows that for every one unit increase in self-reported BMI, directly measured BMI changes by 0.83 (95% CI 0.77 to 0.89) (Figure 6.13).

For example, participant A's self-reported BMI was 24.6, if the above formula is applied to predict the directly measured BMI it will be:

$$\text{Directly measured BMI} = 4.66 + 0.83 * \text{self-reported BMI}$$

$$= 4.66 + 0.83 * 24.6$$

$$= 4.66 + 20.418$$

$$\text{Directly measured BMI} = 25.1.$$

The estimated regression line using the self-reported BMI was used to estimate the missing values of directly measured BMI. The estimated BMI values were used to replace only the missing values when directly measured BMI was not obtained from the participants.

The BMI characteristics of the participants using imputed values for the missing directly measured values, and how it compared to both self-reported and directly measured BMI is illustrated in Table 6.6. Figure 6.14 shows the distribution of participants' BMI using the imputed values for the missing directly measured values. It should be noted that the mean of the imputed BMI is likely to be influenced by the mean of self-reported BMI of the males which is higher than the females' BMI, as the latter is more likely to self-report missing values (Table 6.6). The imputed BMI values replaced only missing directly measured values and takes into account the individual's reported BMI rather than being based on an overall average. The mean imputed BMI (SD) was 24.3 (4.1). The imputed BMI was used in further analysis when BMI as a continuous variable was used. The proportion of each BMI category for the imputed BMI was slightly less than that of directly measured BMI. However, it was noted that

the proportion of the overweight category of the imputed BMI was higher than the directly measured overweight category (Table 6.7).

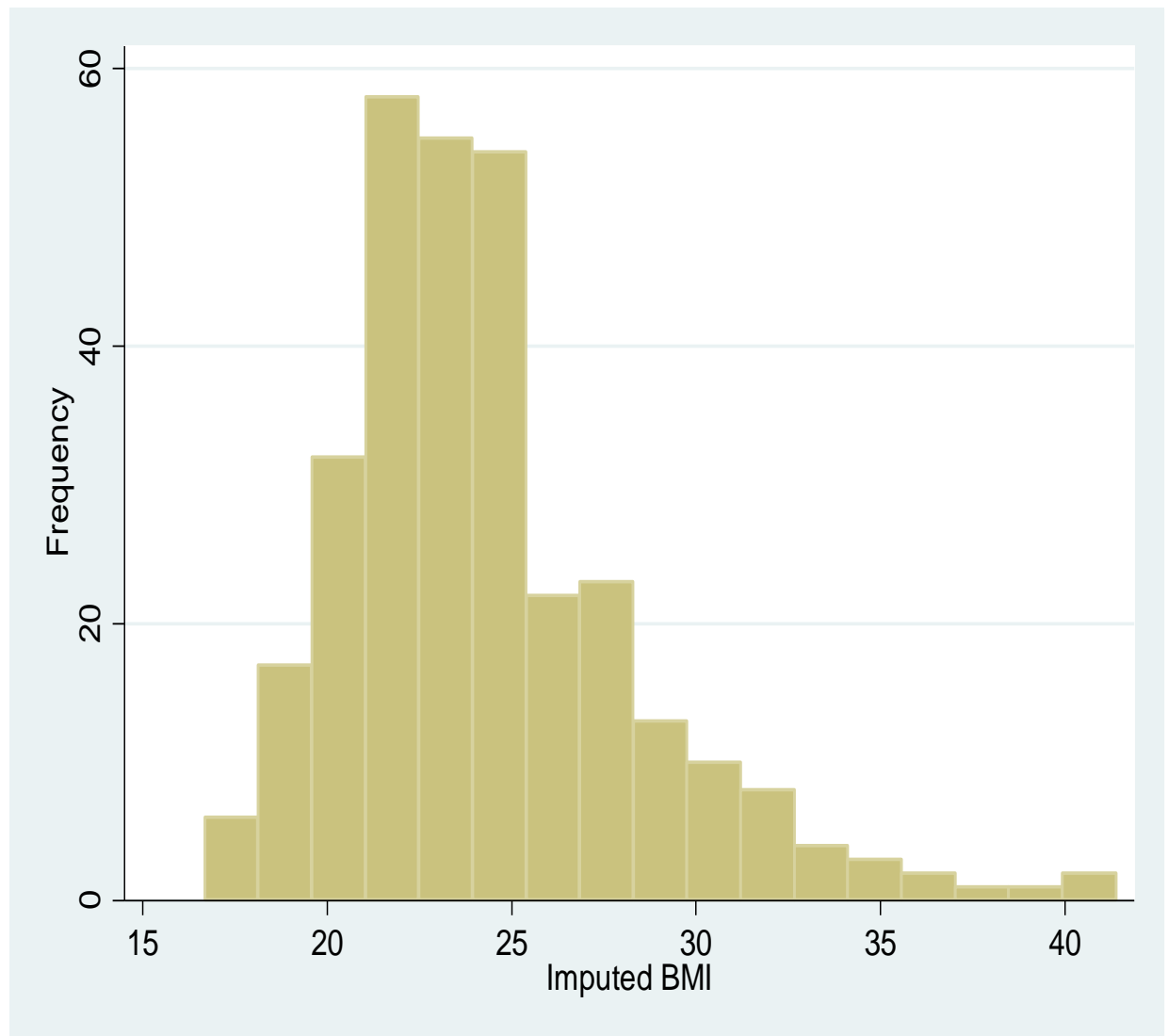


Figure 6.14 Distribution of participants' BMI which includes the imputed Body mass index (BMI) for every missing directly measured BMI.

As a result of the low number of participants in the underweight or super obese categories, these were collapsed to form categories of sufficient size for further analysis. Figure 6.15 shows the distribution of the participants' BMI across the remaining three categories. Overall, for imputed BMI, 72 (23.2%) of the whole sample

was overweight. For all males, 47 (27.2%) were overweight and 18 (10.4%) obese compared to all 138 females, 25 (18.1%) overweight and 13 (9.4%) obese.

Table 6.7 Description of the participants' BMI after replacing missing values with imputed values compared to self-reported and directly measured BMI.

Variable	Self-reported BMI n = 284	Directly Measured BMI n = 248	Imputed BMI n = 311
Mean (SD) BMI (kg/m ²)	23.7 (4.3)	24.1 (4.2)	24.3 (4.1)
Missing	30 (9.6%)	66 (21.0%)	3 (1%)
Categorised BMI			
<i>Underweight</i> (<18.0)	19 (6.7%)	8 (3.2%)	9 (2.9%)
<i>Normal</i> (18.0 – 24.9)	181 (63.7%)	162 (65.3%)	199 (64.0%)
<i>Overweight</i> (24.9 – 29.9)	57 (20.1%)	52 (21.0%)	72 (23.2%)
<i>Obese</i> (29.9 – 39.9)	25 (8.8%)	24 (9.7%)	29 (9.3%)
<i>Super obese</i> (> 40.0)	2 (0.7%)	2 (0.8%)	2 (0.6%)
Body mass index (BMI), Standard deviation (SD).			

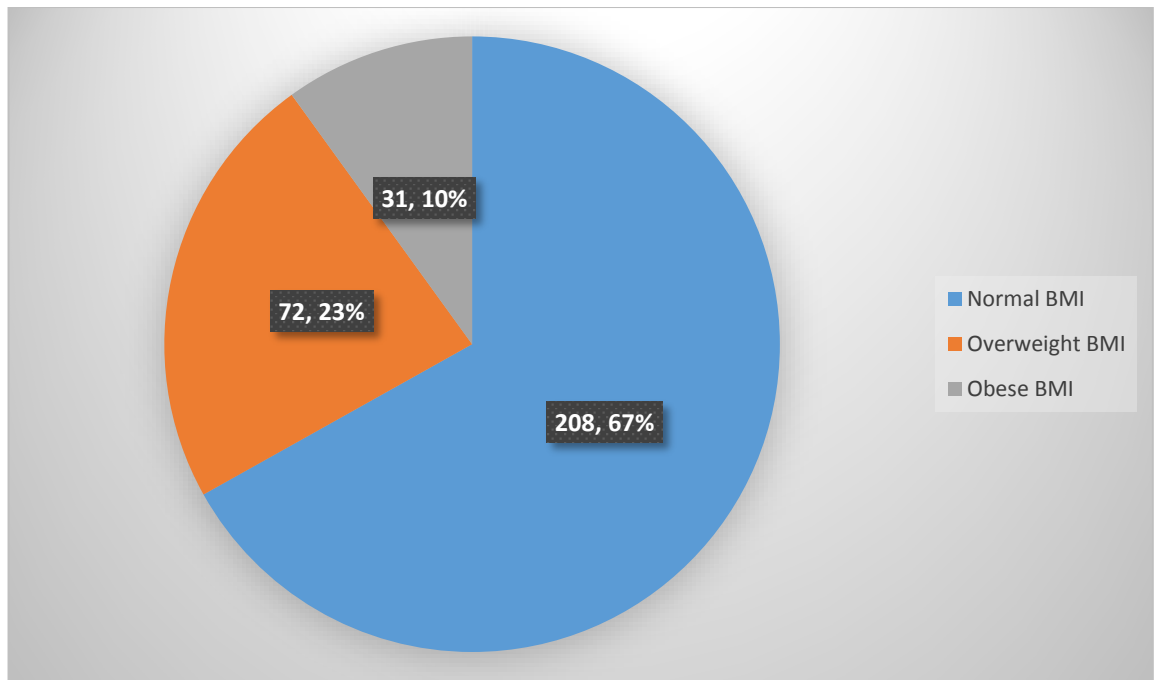


Figure 6.15 The distribution of participants' mean imputed Body mass index (BMI) across the three categories.

6.8.2 Comparison of BMI in those with and without knee problems at the baseline

The mean (SD) BMI of the participants reporting knee problems (24.8kg/m² [4.1]) was similar to those without knee problems (24.1kg/m² [4.1]) ($t = 1.452$, degree of freedom = 309, $p\text{-value} = 0.074$). Using the imputed BMI, the proportion of participants with knee problems who reported normal BMI was 29.8%, in those who reported being overweight 37.5%, and 35.5% in those who reported being obese (Figure 6.16). Reported knee problems were higher in participants who reported being overweight compared to those who reported BMI within the normal range. However, the reporting of knee problems was slightly lower in those who were obese compared to those who were overweight.

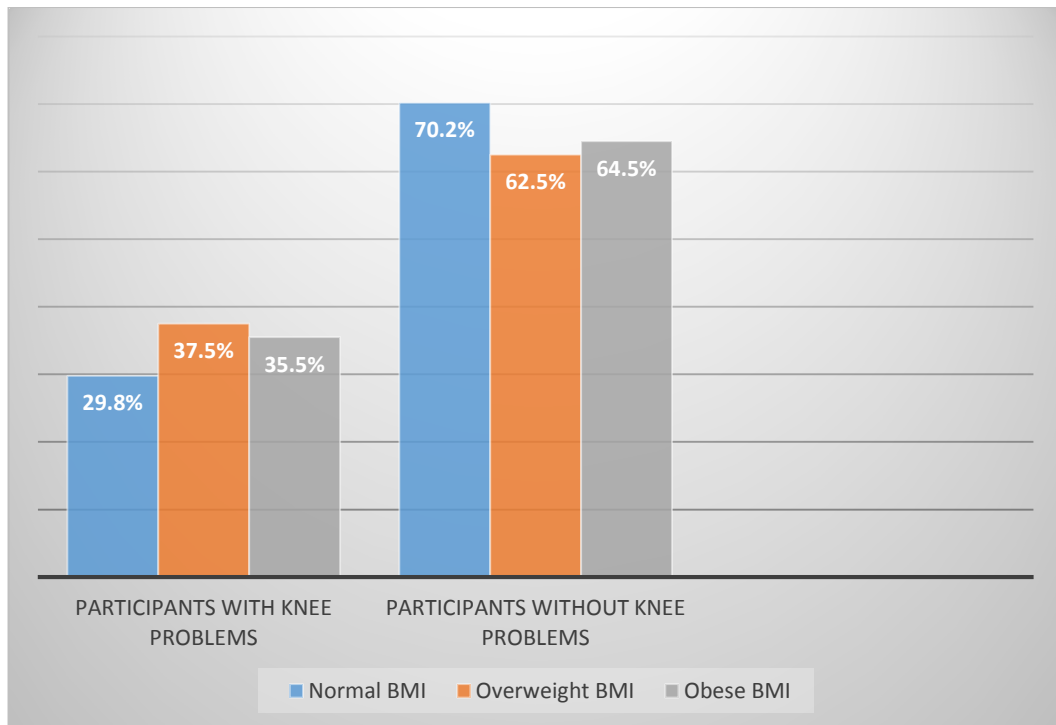


Figure 6.16 The proportion of the participants with knee problems across the BMI categories.

6.8.3 Examining the relationship between the prevalence of knee problems and BMI at the baseline

An investigation was performed to evaluate whether the relationship between the presence of knee problems and BMI was linear or quadratic. Participants were categorised into nine groups using their BMI. The probability and odds of a knee problem in each group was estimated (Table 6.8). The logit of the odds of a knee problem was plotted against the BMI groups to explore the nature of the relationship between the two variables that is whether it was linear or quadratic (Figure 6.17).

Table 6.8 Demonstrating risk and odds of knee problems across different categories of BMI.

No.	BMI Category kg/m ²	Total participants	Knee problems	Risk(P)	Odds (P/1-P)	Logit_odds (P/1-P)
1	16.00 - 18.99	13	5	0.38	0.6129	-0.4896
2	19.00 – 21.99	79	15	0.19	0.2346	-1.4499
3	22.00 -24.99	116	42	0.36	0.5625	-0.5754
4	25.00 – 27.99	58	23	0.40	0.6667	-0.4054
5	28.00 – 30.99	22	6	0.27	0.3699	-0.9945
6	31.00 – 33.99	13	5	0.38	0.6129	-0.4896
7	34.00 – 36.99	6	2	0.33	0.4925	-0.7083
8	37.00 – 39.99	2	2	1	1	0
9	40.00 – 42.99	2	0	0	0	-

Body mass index (BMI).

The scatterplot shows that for every unit increase in the BMI category, the logit odds of knee problems increase by a multiple of 0.08 (Figure 6.17). This suggests that 21.2 % (R^2) of the variation in logit odds of knee problems can be explained by a linear term of BMI. This shows that the linear relationship is not strong. The scatterplot shows that logit of odds of knee problems increase as BMI increases. However, the ‘line of best fit’ in the plot which was drawn in the best place possible to describe the relationship showed that only one data point was close to the straight line (Figure 6.17). From the scatterplot, there was no possible quadratic relationship between BMI and the logit odds of knee problems. BMI was put in the regression model as BMI, not BMI squared.

Using univariate analyses with the presence of knee problems as the dependant variable, a logistic regression model was constructed to test whether BMI explains the presence of knee problems. The odds of knee problems was multiplied by 1.53 per 10kg/m² increase in BMI (95% confidence interval 0.85 to 2.71) Wald test = 2.14, p-value = 0.15 and was non-significant.

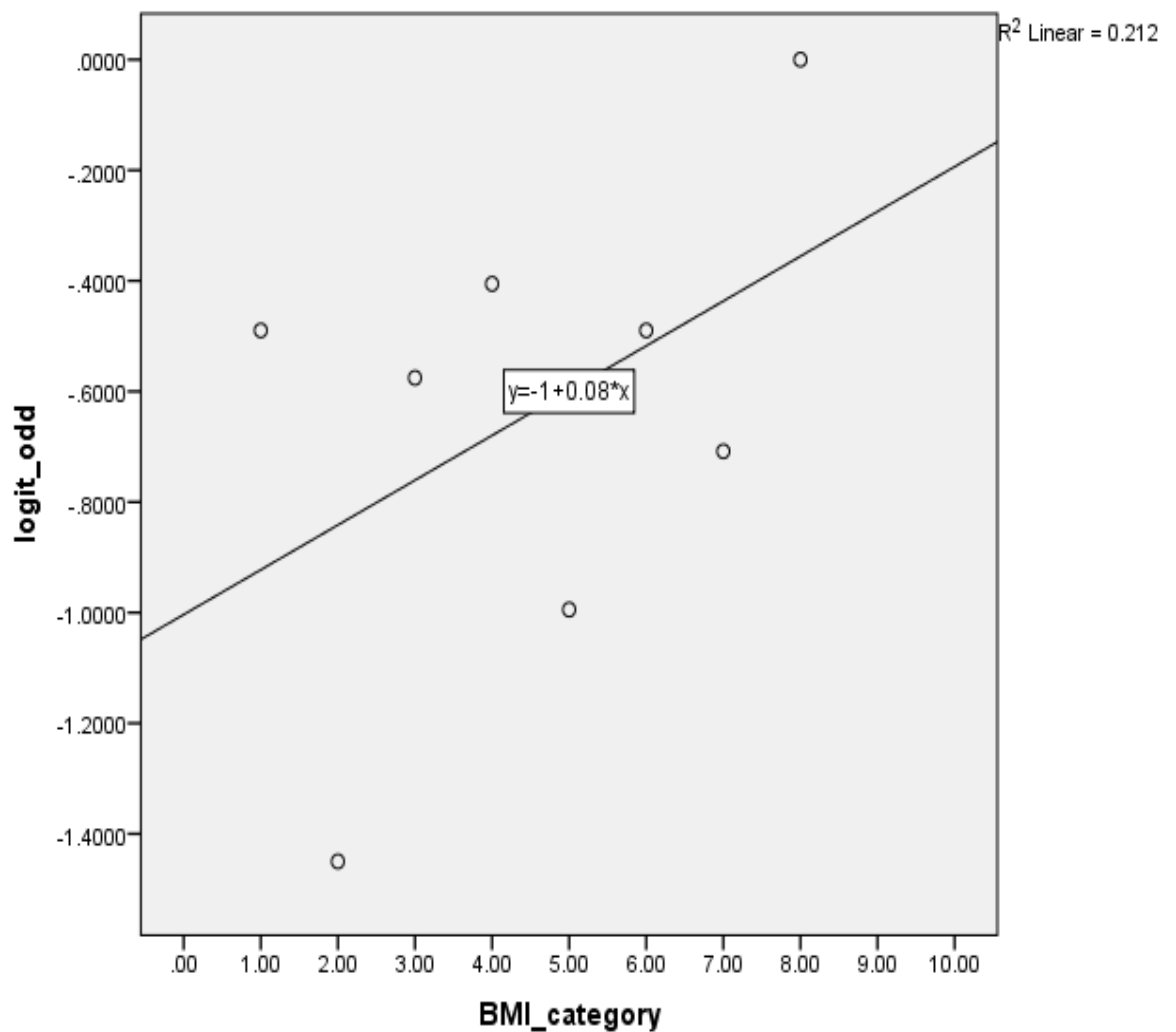


Figure 6.17 A scatterplot of the Body mass index (BMI) category against the logit of the odds of knee problems.

6.9 Physical inactivity (sedentary behaviour) in the cohort at the baseline

Measuring physical inactivity as sitting time per day in hours; the mean (SD) total hours spent sitting per day at baseline was 5.6 (2.6). The number of missing values was 11 (3.5%). Across gender, the mean sitting time per day in hours was similar in females (5.4 hours) and males (5.1 hours) (Figure 6.18).

6.9.1 Comparison of physical inactivity in those with and without knee problems at the baseline

The mean (SD) hours sitting was 5.9 (2.9) for those with knee problems and 5.5 (2.5) for those without knee problems. Sitting time was fitted in a regression model to test its crude effect on explaining knee problems. The risk of knee problems increased by 1.06 (95% confidence interval 0.97 to 1.17, Wald test = 1.66, p-value = 0.20 and was non-significant.

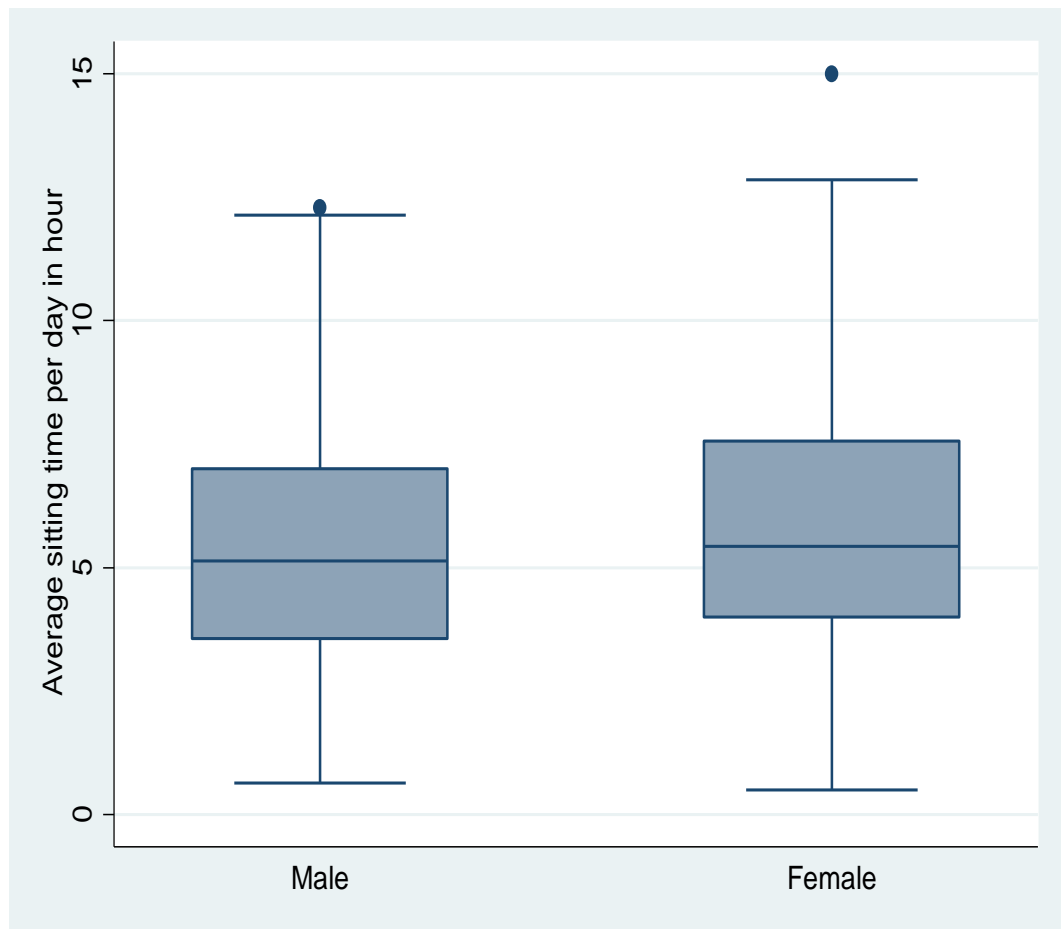


Figure 6.18 Boxplot demonstrating average sitting time per day in hours across genders.

An investigation was performed to evaluate whether the relationship between the presence of knee problems and sitting time was linear or quadratic. Participants were categorised into six groups using their average sitting time per day in hours. The probability and odds of a knee problem in each group was estimated (Table 6.9). The logit of the odds of a knee problem was plotted against the average sitting time per day in hours to explore the nature of the relationship between the two variables and whether it was linear or quadratic (Figure 6.19).

Table 6.9 Demonstrating risk and odds of knee problems across different categories of physical inactivity.

No	Physical inactivity category in hour	Total participants	Knee problems	Risk (P)	Odds (P/1-P)	Logit_odds (P/1-P)
1	0.01 – 2.99	37	14	0.38	0.6129	-0.4896
2	3.00 – 5.99	141	35	0.25	0.3333	-1.0987
3	6.00 – 8.99	93	28	0.30	0.4286	-0.8472
4	9.00 – 11.99	26	13	0.50	1	0
5	12.00 – 14.99	5	3	0.6	1.5	0.4055
6	15.00 – 17.99	1	0	0	-	-

The scatterplot graph shows that the relationship between knee problems and physical inactivity may be non-linear and might be sufficiently well approximated by a quadratic relationship. From the graph (Figure 6.19) it could be suggested that sitting for three to six hours per day was protective against knee problems whereas sitting for less than three or more than six hours per day increased the risk of knee problems. The R^2 of 88.2% suggests a good quadratic relationship between logit odds of knee problems and physical inactivity. Sitting time centred (as linear and quadratic terms) was fitted in a regression model to investigate if it is important in the explanation of knee problems.

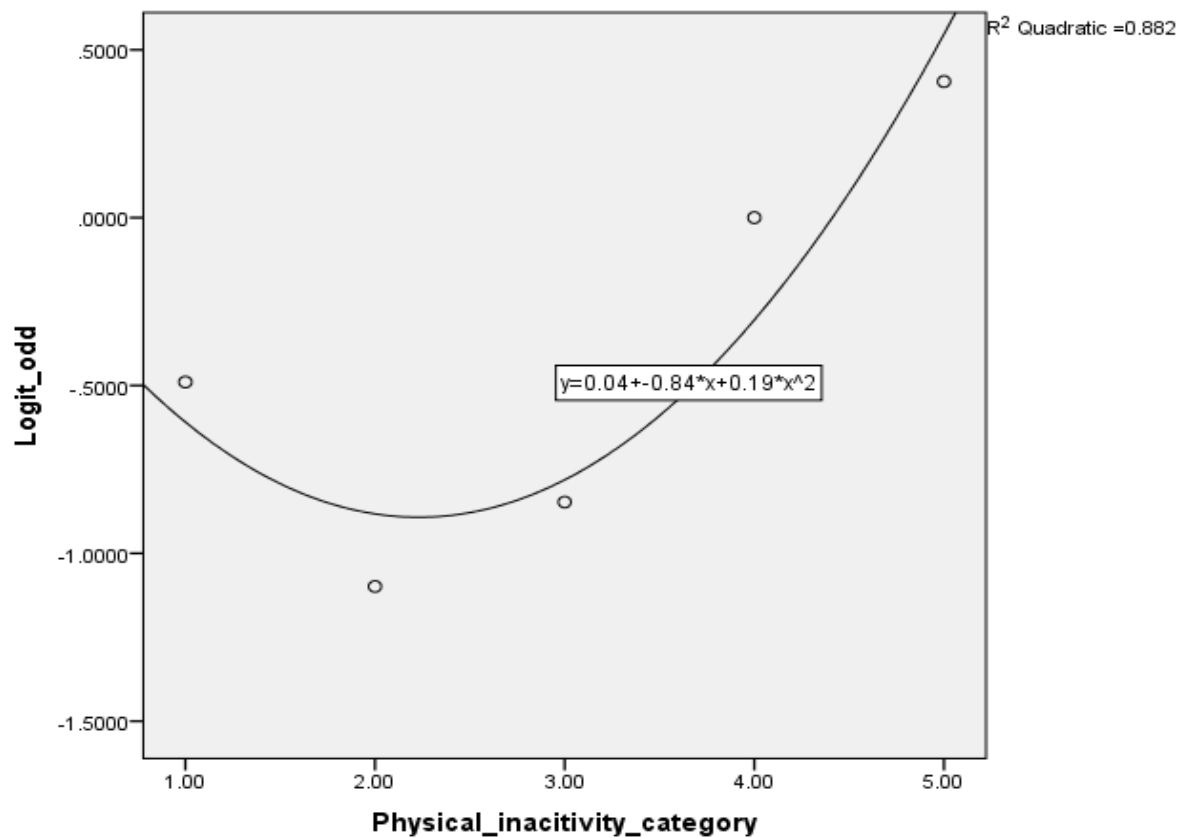


Figure 6.19 A scatterplot of the physical inactivity category against the logit of the odds of knee problems showing a quadratic relationship.

A regression analysis was performed on sitting time as a pair of linear and quadratic terms to investigate if there was any change in the explanation of knee problems. The quadratic term improved the significance of the model beyond that which includes only the linear term. The overall impact of linear and quadratic terms was $p\text{-value} = 0.17$ compared to only the linear term $p\text{-value} = .20$.

6.9.2 Examining the relationship between the physical inactivity level and BMI at the baseline

A scatterplot between BMI and physical inactivity squared was performed to investigate if there was a linear relationship between the two variables (Figure 6.20).

The figure shows there was no evidence of a linear relationship between BMI and physical inactivity.

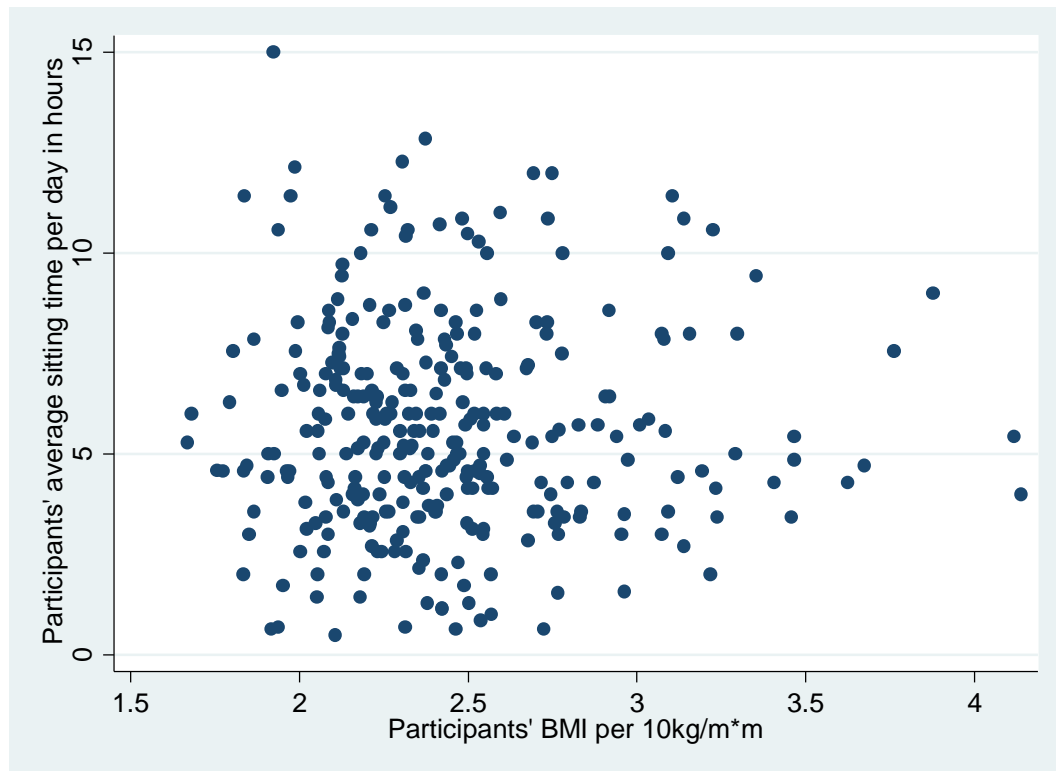


Figure 6.20 A scatterplot showing the relationship between the BMI and Physical inactivity.

Sitting time centred (as a pair of linear and quadratic terms) and BMI centred was fitted in the regression analysis to investigate if there is an interaction between the two variables in explaining knee problems. There was no change to the result of the individual univariate analysis of the variables as they independently explain knee problems.

The interaction between sitting time centred (as a pair of linear and quadratic terms) and BMI centred was non-significant for the explanation of the presence of knee

problems in the cohort (p-value = 0.57). These variables were not included in the final regression model as an interaction term.

6.10 Physical activity levels in the cohort at baseline

There are three level of physical activity measured by IPAQ-Long – high, medium, and low. Physical activity levels measured with IPAQ-Long showed that over half of the participants (n=165, 52.9%) reported low physical activity with similar proportions reporting moderate (n= 75, 24.0%), and high (n=72, 23.1%) physical activity levels (Figure 6.21). The number of missing values was just 2 (0.6%). A significantly higher proportion of the female participants reported low physical activity levels (n= 86, 62.3%) compared to males (n=79, 45.4%), and fewer female participants reported high physical activity compared to males (n=22, 15.9%) and (n=50, 29.3%) respectively; Pearson Chi-Square = 10.90, degree of freedom = 2, p-value = 0.006).

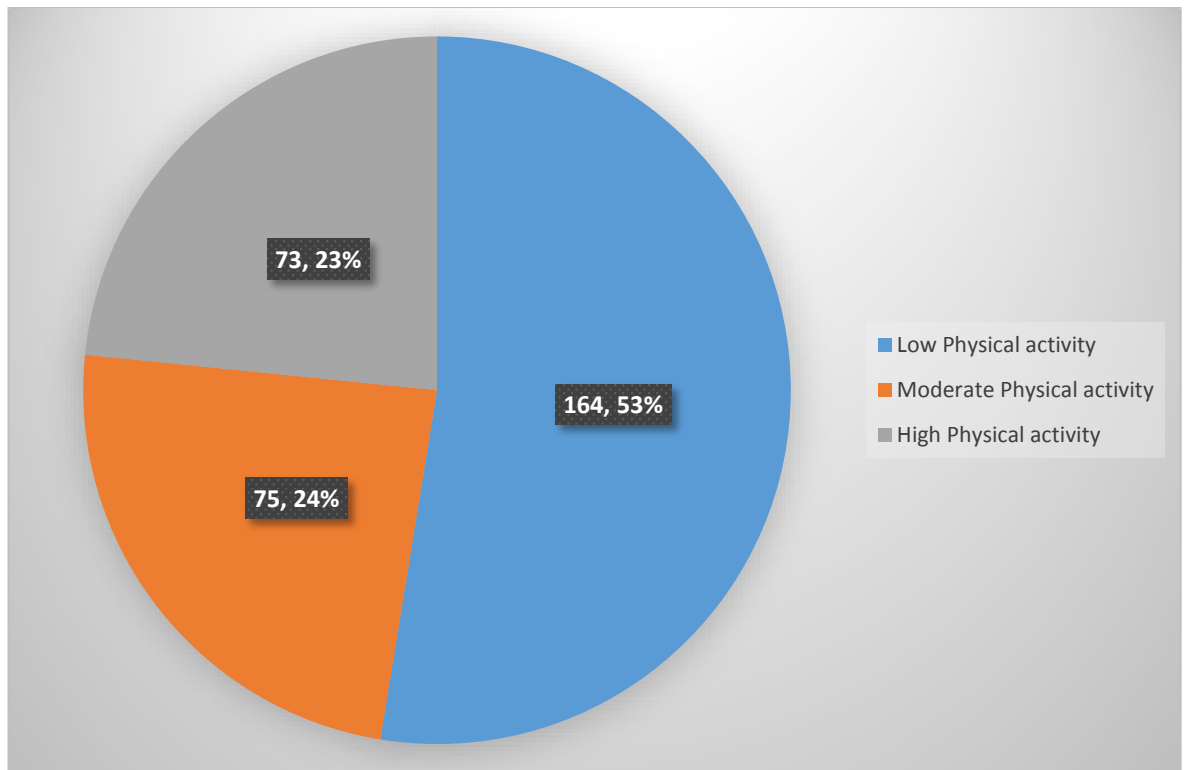


Figure 6.21 Distribution of reported physical activity levels across genders.

6.10.1 Comparison of physical activity levels in those with and without knee problems at the baseline

Of the 214 who reported an absence of knee problems, 120 (56.8%) reported low physical activity, 50 (23.5%) reported moderate physical activity, and 43 (19.7%) reported high physical activity. Of the 100 participants reporting knee problems, 44 (44.4%) reported low physical activity, 25 (25.3%) reported moderate activity and 30 (30.3%) reported high activity (Figure 6.22). Figure 6.22 shows that among those who reported knee problems, the percentage of those reporting participation in high physical activity was higher compared to that of those who reported no knee problems. Univariate analysis was used to explore the overall effect of physical activity levels and differences in explaining knee problems in this study.

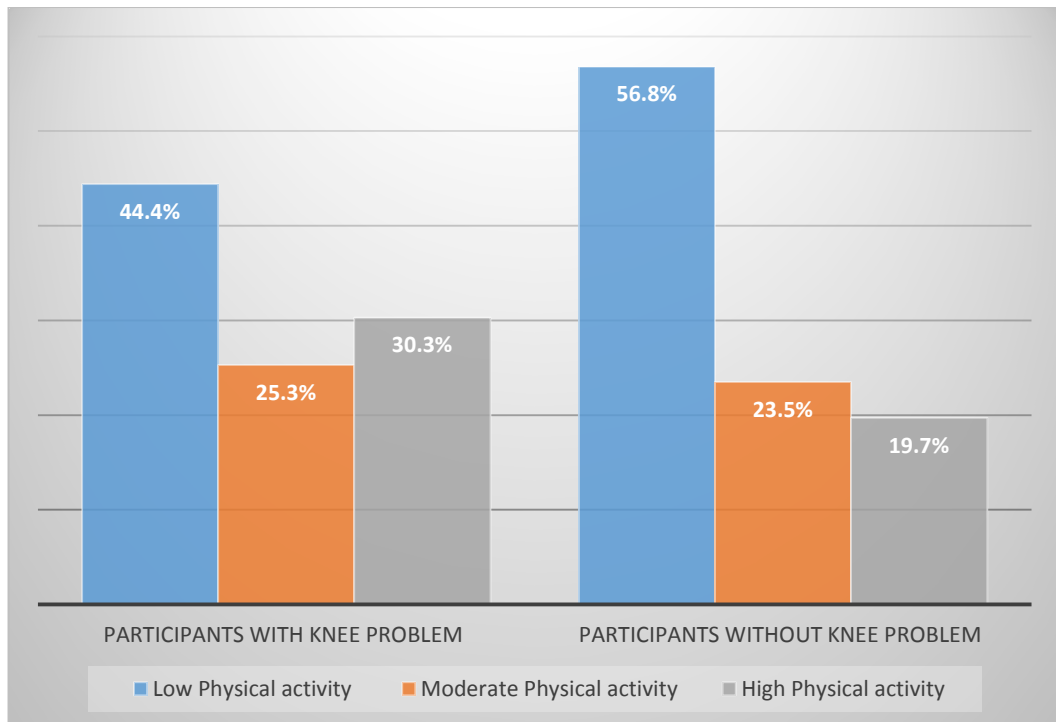


Figure 6.22 Physical activity levels among the participants without knee problems compared to the participants with knee problems at the baseline.

The overall effect of physical activity levels in explaining knee problems was marginally non-significant in explaining knee problems (Wald test chi square=5.25, degree of freedom = 2, p-value =0.072). When comparing knee problems in the different activity level groups, using low level of activity as a reference point, those with a moderate level of physical activity had higher odds of knee problems, but this was not statistically significant (OR 1.4 (95% CI 0.8 to 2.5 Wald test chi square =1.06, p-value = 0.291). The odds of knee problems in those reporting a high level of physical activity was even higher and confidence intervals were consistent with statistical significance (OR 1.9, 95% CI 1.1 to 3.4 Wald test= 4.72, p-value = 0.023).

6.10.2 Examining the relationship between the physical activity level and physical inactivity at the baseline

The distribution of times spent sitting (per day in hours) differed significantly across categories of physical activity level (Kruskal-Wallis test = 6.6, degree of freedom = 2, p-value = 0.038). The median sitting time was highest in those who reported moderate physical activity levels, but the Inter-quartile range (IQR) was wider in those who reported low physical activity levels (Figure 6.23).

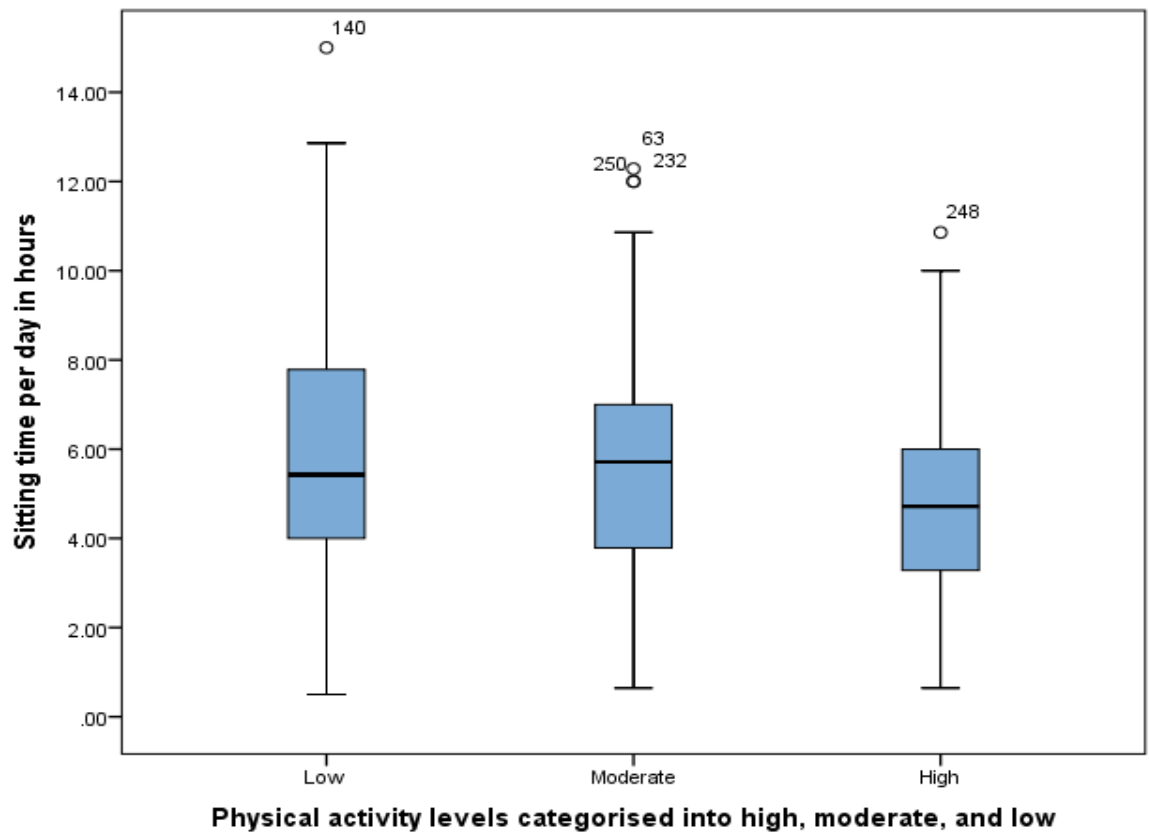


Figure 6.23 Boxplot showing the distribution of average sitting time per day in hours across different categories of physical activity levels. Participants that reported low, moderate, and high activity were 165, 75, and 72 respectively.

The two variables (physical activity levels and physical inactivity) centred as a pair of linear and quadratic terms were put into the regression model together to investigate how their main effect explains knee problems while adjusting for each other. The overall effect of physical activity levels was significant in explaining knee problems (Wald test Chi square=8.86, degree of freedom=2, p-value =0.012). Average sitting time per day in hours was non-significant (Wald test Chi square = 4.89, degree of freedom = 2, p-value = 0.087), however, P-value decreases relative to the univariate analysis. The odds ratios of the moderate and high categories of physical activity levels relative to low activity in explaining knee problems increased relative to the univariate analysis (Table 6.10). Reporting high levels of physical activity was statistically significant in explaining the report of a knee problem (Wald test chi square= 7.93, p-value = 0.004) (see Table 6.10).

Table 6.10 Effects of physical activity level and physical inactivity on the prevalence of knee problems at the baseline.

Variable	OR Univariate (95% CI)	P value	OR Multivariate* (95% CI)	P Value
Physical activity level		0.072		0.012
<i>Low</i>	1		1	
<i>Moderate</i>	1.4 (0.8 – 2.5)	0.29	1.7 (0.9 – 3.1)	0.094
<i>High</i>	2.0 (1.1 – 3.5)	0.023	2.5 (1.3 – 4.5)	0.004
Average sitting time (in hours)		0.17		0.087
<i>Linear term</i>	1.03 (0.93 – 1.14)		1.05 (0.95 – 1.17)	
<i>Quadratic term</i>	1.02 (0.99 – 1.04)		1.02 (0.99 – 1.04)	

*Odds ratio (OR) for knee problems adjusted for the other factors in the table.

The logistic regression analyses of the interaction between the two variables performed shows that there was no interaction between the main effect of average sitting time as a pair of linear and quadratic term and physical activity levels in explaining the report of knee problems at their different values (p-value = 0.83). The two variables were not included in the final regression as an interaction term.

6.10.3 Examining the relationship between the physical activity level, physical inactivity and BMI at the baseline

Table 6.11 shows the result from a multivariate regression analysis performed to explore the relationship between three risk factors: BMI, physical activity and physical inactivity. The odds ratios of physical activity level, BMI and sitting time in explaining knee problems slightly increased and their P-value improved (see Table 6.11). Participating in a high physical activity level remained statistically significant.

All the regression models used so far in analysis were checked for their ability to explain knee problems. Comparing the performance of all modelling used (Table 6.12), model number 5 and 6 appeared to be the best for the percent correct predictions of the presence of knee problems in this study cohort. However, model 6 included the three risk factors. From Table 6.12, the accuracy of the model in explaining knee problems increases as more explanatory variables (risk factors) were fitted in to the model which shows that the main effect of one risk factor may not be enough to accurately explain knee problems.

Table 6.11 Effects of the risk factors on the prevalence of knee problems at baseline.

Variable	OR Univariate (95% CI)	P value	OR Multivariate* (95% CI)	P value
BMI / 10kg/m ²	1.5 (0.9 – 2.7)	0.14	1.8(1.0 – 3.2)	0.066
Physical activity level		0.072		0.009
<i>Low</i>	1		1	
<i>Moderate</i>	1.4 (0.8 – 2.5)	0.29	1.8 (1.0 – 3.4)	0.059
<i>High</i>	2.0 (1.1 – 3.5)	0.023	2.5 (1.4 – 4.7)	0.003
Average sitting time (in hours)		0.17		0.086
<i>Linear term</i>	1.03 (0.93 – 1.14)	0.54	1.05 (0.95 – 1.17)	
<i>Quadratic term</i>	1.02 (0.99 – 1.04)	0.17	1.02 (0.99 – 1.05)	

*Odds ratio (OR) for knee problems adjusted for the other factors in the table. Body mass index (BMI).

Table 6.12 Using Percent Correct Predictions to compare regression model performance across different logistic regression results for the risk factors.

Model Nos.	Variable	% Correct Predictions
1	BMI/10kg/m ²	67.8
2	Physical activity levels	68.3
3	Average sitting time (as linear & quadratic terms)	68.6
4	BMI/10kg/m ² and Average sitting time (as linear & quadratic terms)	69.0
5	Average sitting time (as linear & quadratic terms) and Physical activity levels	70.2
6	BMI/10kg/m ² , Average sitting time (as linear & quadratic terms), and Physical activity levels	70.2

Body mass index (BMI).

6.11 Examining the relationship between risk factors for knee problems and confounding factors

Age, gender and mental distress variables were included individually into the regression model to explore their influence on the odds ratio and P-values of the three risk factors (BMI, physical activity and physical inactivity) (Table 6.12) in explaining knee problems. Age remained non-significant when added to model A with the three risk factors (model B Table 6.13). There were slight changes in the odds ratio and P-confidence intervals of two of the three risk factors along with that of age; there was no change in odds ratio and confidence intervals for physical activity level. The odds ratios, confidence intervals and P-values of the three risk factors remained similar to that in model A, when gender was included in the regression model (Table 6.13 model C). Slight changes were observed in the odds ratio, confidence interval and P-value of gender (Table 6.13 model C).

The significance level of scoring ≥ 1.85 in the HSCL-10 was of borderline significance (p-value = 0.052) for independent explanation of knee problems as the univariate analyses with odds ratio of 1.9. When put into model A (see Model D in Table 6.13) it was statistically significant (p-value = 0.021). The odds of mental distress in explaining knee problems increased from 1.9 to 2.2 with the lower limit of the confidence interval not including 1. Changes were noted in the effect of the three risk factors on the risk of knee problems (see model D). Mental distress appeared to be a confounding variable as it influences the estimates of the three risk factors. It increased the odds ratios of BMI and physical activity levels by 0.1.

Table 6.13 Effects of different confounding factors on the effect of the three risk factors on the prevalence of knee problems at baseline while adjusting for other variables.

Variable	Model A OR (95% CI)	P value	Model B OR (95% CI)	P Value	Model C OR (95% CI)	P Value	Model D OR (95% CI)	P Value
BMI / 10kg/m ²	1.8 (1.0 – 3.2)	0.066	1.7 (0.9 – 3.2)	0.077	1.8 (1.0 – 3.2)	0.070	1.9 (1.0 – 3.5)	0.048
Physical activity level		0.009		0.009		0.009		0.006
<i>Low</i>	1		1		1		1	
<i>Moderate</i>	1.8 (1.0 – 3.4)	0.059	1.8 (0.9 – 3.3)	0.074	1.8 (1.0 – 3.4)	0.063	1.9 (1.0 – 3.7)	0.040
<i>High</i>	2.5 (1.4 – 4.7)	0.003	2.5 (1.4 – 4.7)	0.003	2.5 (1.3 – 4.7)	0.004	2.6 (1.4 – 5.0)	0.002
Average sitting time (in hours)		0.086		0.089		0.086		0.065
<i>Linear term</i>	1.05 (0.95 – 1.17)		1.05 (0.94 – 1.16)		1.05 (0.95 – 1.17)		1.05 (0.94 – 1.16)	
<i>Quadratic term</i>	1.02 (0.99 – 1.05)		1.02 (0.99 – 1.05)		1.02 (0.99 – 1.05)		1.02 (1.00 – 1.05)	
Age / 5 years			1.1 (0.9 – 1.4)	0.32				
Gender								
<i>Male</i>					1			
<i>Female</i>					1.0 (0.6 – 1.6)	0.91		
Mentally distressed								
< 1.85							1	
≥1.85							2.2(1.1 – 4.4)	0.021

Another analysis was performed in a model that contained the three risk factors and which accounts for all confounding factors (Table 6.14). The accuracy of the model in explaining knee problems was evaluated using % correct prediction. Model E contains all confounding factors (including age, gender, psychological factors as mentally distressed) and risk factors (including obesity, physical activity and physical inactivity). From Table 6.14, the best model identified was model E as it has 73.8% correct prediction of the knee problems in this cohort compared to the rest of the models.

Table 6.14 Using Percent Correct Predictions to compare regression model performance across different logistic regression results of the risk and confounding factors.

Model	Variable	% Correct Predictions
B	BMI/10kg/m ² , Average sitting time (as linear & quadratic terms), physical activity, and age	70.2
C	BMI/10kg/m ² , Average sitting time (as linear & quadratic terms), physical activity, and gender.	69.9
D	BMI/10kg/m ² , Average sitting time (as linear & quadratic terms), physical activity, and mental distressed.	72.4
E	BMI/10kg/m ² , Average sitting time (as linear & quadratic terms), physical activity, age, gender, and mentally distressed.	73.8
Body mass index (BMI).		

6.11.1 Explanatory factors of knee problems in the cohort at the baseline

The result from using model E shows that the odds ratio of mental distress in explaining the reported knee problems was 2.3 (95% CI 1.2 to 4.6), which was statistically significant (p-value = 0.017) see Table 6.15.

Table 6.15 Effects of demographic variables on the prevalence of knee problems at baseline while adjusting for other variables.

Variable	OR (95% CI)	P value
Age / 5 years	1.2 (0.9 -1.5)	0.25
Gender		
<i>Male</i>	1	
<i>Female</i>	0.9 (0.5 – 1.6)	0.74
Mental distress		
<1.85	1	
≥1.85	2.3 (1.2 – 4.6)	0.017
BMI / 10kg/m ²	1.8 (1.0 – 3.4)	0.063
Physical activity levels		0.010
<i>Low</i>	1	
<i>Moderate</i>	1.9 (1.0 – 3.5)	0.057
<i>High</i>	2.6 (1.4 – 4.9)	0.003
Average sitting time (in hours)		0.069
<i>Linear term</i>	1.04 (0.93 – 1.16)	
<i>Quadratic term</i>	1.02 (1.00 – 1.05)	

*Odds ratio (OR) for knee problems adjusted for the other factors in the table. Body mass index (BMI).

The imputed BMI included in the final regression model as a continuous variable shows an odds ratio of 1.80 (95% CI 0.97 to 3.38) for reporting a knee problem, although the relationship between knee problem and BMI was marginally non-statistically significant $p\text{-value} = 0.063$. Average sitting time was not an independent risk factor for knee problems.

Overall physical activity level was significant in the explanation of knee problems in the study (Wald test Chi square= 9.21, degree of freedom = 2, $p\text{-value} = 0.010$). Reporting a high physical activity level, increased the odds of knee problem by a factor of 2.6 (95% CI 1.4 to 4.9 $p\text{-value} = 0.003$) (Table 6.15).

Of all the explanatory variables investigated, being mentally distressed and physical activity level were the only variables that significantly explain knee problems in this cohort.

6.11.2 Evaluating the performance of Model E

To investigate the classification accuracy of model E a Receiver Operating Characteristic (ROC) curve was plotted for the presence and absence of knee problems (Figure 6.24). The Area under the Curve (AUC) was 0.7, which is a fair and acceptable level of discrimination. The Hosmer-Lemeshow goodness-of-fit test showed there was no evidence against the null hypothesis that this model was appropriate ($p\text{-value} = 0.16$).

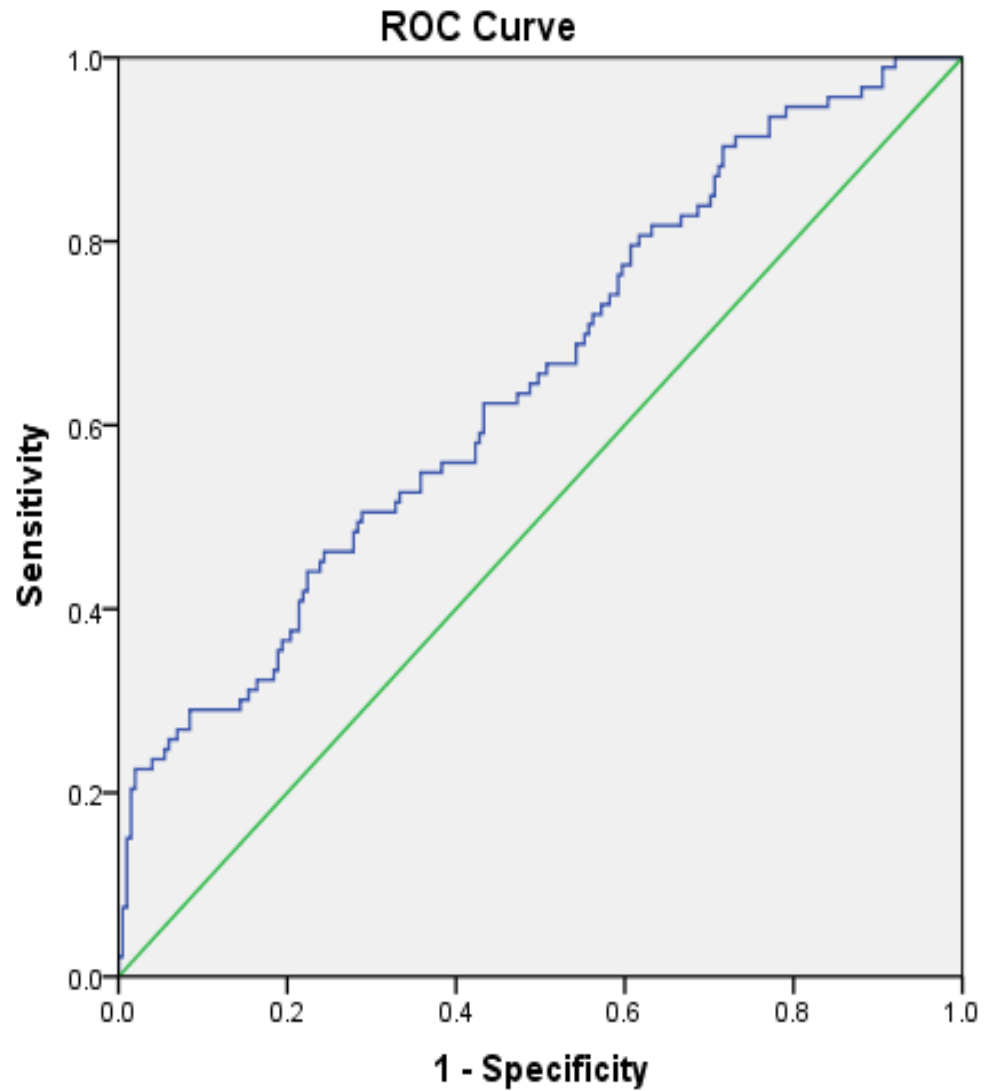


Figure 6.24 The Receiver Operating Characteristic (ROC) Curve of modified screening question for knee problems.

6.12 Summary of key findings from the prevalence study

Of the 314 participants 100 (31.8% [95%CI 26.9% to 37.7%]) reported knee problems. Gradual onset of knee problems was reported as the most common way knee problems developed as only 31 of the 314 participants reported trauma that is 9.9% (95%CI

7.0% to 13.7%). Of those who reported knee problems only 52 (52%) reported seeking medical care because of the knee problem.

Physical inactivity was measured as average sitting time per day in hours. Sitting between three to six hours presents a lower risk of knee problems, while participating in a high level of activity and being mentally distressed were the only variables that independently explain knee problems.

Chapter 7 Result of the epidemiological study of knee problems in young adults- Follow up data

7.1 Introduction

This chapter presents the details on the cohort follow up, and how it compares to the baseline cohort. This is followed by estimation of the incidence of knee problems, and the association between new knee problems and risk factors (BMI, physical activity and physical inactivity).

7.2 Follow up of participants at one year

Of the 314 participants at the baseline assessment, only 126 (40.1%) participants responded to the follow up assessment (see Figure 7.1). Regardless of the high attrition rate, the characteristics of the follow up cohort were similar to those recorded at baseline for the whole study population (Table 7.1).

Of the 126 participants 70 (55.6%) were males and 56 (44.4%) were females. The gender distribution in the follow up cohort was similar to that of the baseline cohort (Table 7.1). The mean (SD) age of the population was 23 (5.6) years compared to 22 (5.1) years at the baseline (Table 6.16). The psychological status of participants at follow up was similar to that at baseline (Table 7.1).

Table 7.1 Characteristics of participants at the baseline and follow up.

Variable	Baseline (n=314)	Follow-up (n= 126)
Mean (SD) age	22 (5.2)	23 (5.6)
Mean (SD) BMI	24.3 (4.1)	24.1 (3.8)
Mean (SD) average sitting time per day in hours	5.6 (2.6)	6.0 (2.7)
Mean (SD) HSCL-10	1.5 (0.4)	1.5 (0.4)
Gender		
<i>Male</i>	176 (56.1%)	70 (55.6%)
<i>Female</i>	138 (43.9%)	56 (44.4%)
Physical activity level		
<i>Low</i>	165 (52.9%)	69 (55.2%)
<i>Moderate</i>	75 (24.0%)	29 (23.2%)
<i>High</i>	72 (23.1%)	27 (21.6%)
Knee problem in the study cohort		
<i>Yes</i>	100 (31.9%)	40 (31.8%)
<i>No</i>	214 (68.1%)	86 (68.2%)
Dominant symptom reported in the study cohort		
<i>Pain</i>	65 (20.7%)	34 (27.0%)
<i>No pain</i>	249 (79.3%)	92 (73.0%)
Main source of knee problems in the study cohort		
Trauma	31 (9.9%)	15 (11.9%)
No trauma	283 (90.1%)	111 (88.1%)

Standard deviation (SD), Body mass index (BMI), Hopkins symptoms Checklist-10 (HSCL-

10).

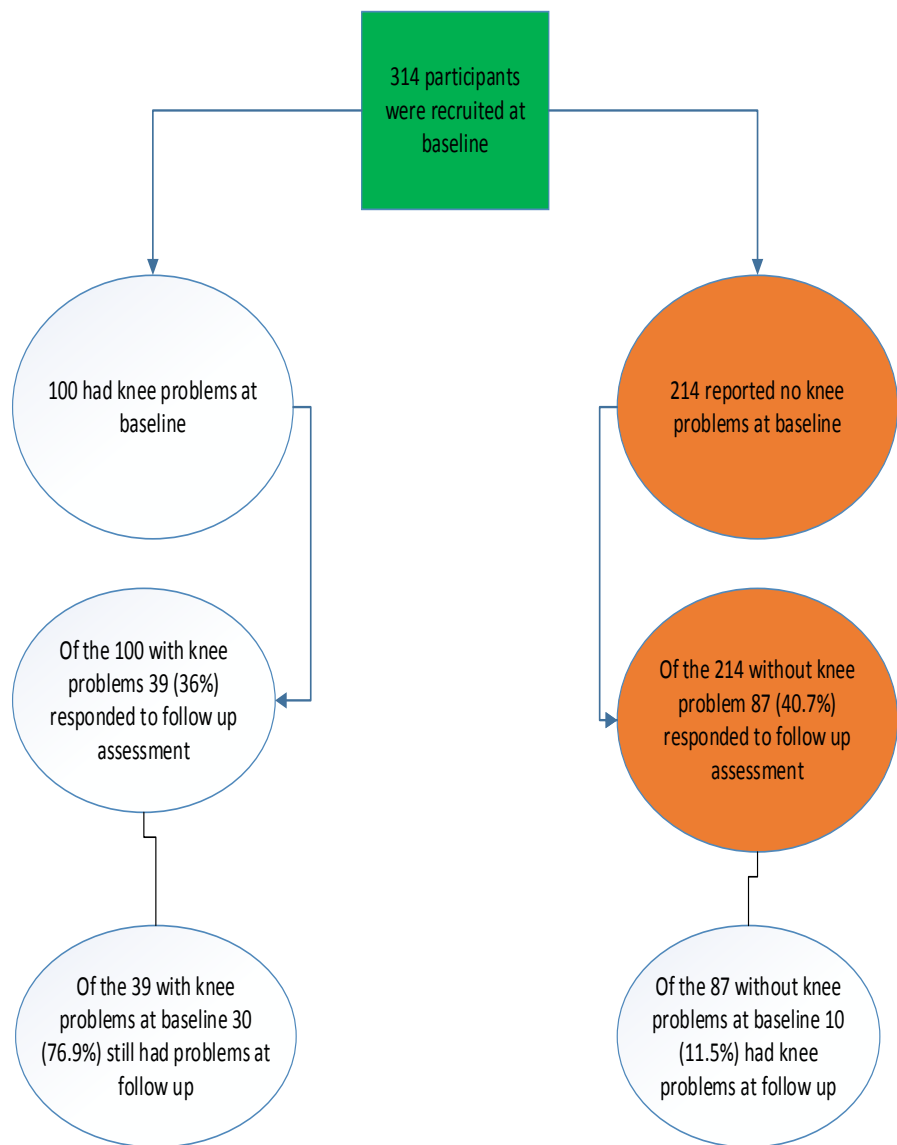


Figure 7.1 Flow chart showing on-going cases and new cases of knee problems at follow up.

7.2.1 Investigating the potential effect of a cluster sampling on confidence interval estimates for knee problems, knee pain and trauma at follow up

The inflation factor suggested that there was no effect of clustering on the standard error. Therefore, confidence interval (CI) and P-value estimates of the prevalence of knee problems and of knee pain as the predominant symptom (Table 7.2) were not adjusted to take account of any effect of clustering. The analysis of trauma as the main cause of knee problem was adjusted for clustering as the inflation factor exceeded one, as was any logistic analysis.

Table 7.2 Estimation of the inflation factor for the standard error estimate of prevalence of knee problems, knee pain as dominant symptom, and knee problems due to trauma at follow up due to clustering.

Variable	Standard error unadjusted for clustering	Robust standard error adjusted for clustering	Inflation factor
Prevalence of knee problems	0.0416	0.0385	0.93
Prevalence of knee pain as dominant symptom	0.0397	0.0358	0.90
Prevalence of knee problems due to trauma	0.0290	0.0339	1.17

7.2.2 Prevalence of knee problems at follow up

At baseline 100 out of 314 participants reported knee problems, and 214 reported no knee problems (Figure 7.1). Of the 100 participants who reported knee problems at baseline, 39 (39%) responded to the follow up assessment (Figure 7.1).

Of the 126 participants who responded to follow-up, the prevalence of knee problems was 31.7% ($n = 40$, 95% CI 23.9% to 40.9%) (Table 7.1) compared to 31.8% ($n=100$, 95% CI 26.9% to 37.2%) at the baseline. There were 30 (23.8%) participants out of 126 at follow up who reported seeking medical care as a result of a knee problem. Of the 40 participants who reported a knee problem, 23 (57.5%) participants reported seeking medical care because of the knee problem.

At follow up, of the 56 females, 20 reported a knee problem (35.7%, 95% CI 24.1% to 49.2%) compared to 19 out of 69 males (28.6%, 95% CI 19.1% to 40.4%). The analysis showed females were 1.4 times (95%CI 0.7 to 3.0) more likely to report knee problems than males (Wald test: Chi-square = 0.73, p -value = 0.39); given the CI, the result is consistent with the baseline prevalence.

Among those who reported knee problems, 60 knees were reported to be affected. Of those, 9 (22%) participants reported a left knee problem only, 13 (31.7%) reported a right knee problem only, and 19 (46.3%) reported a problem in both knees (Figure 7.2). A similar percentage of participants reported a problem with both knees at both the baseline (44 (44.4%) and follow-up 19 (46.3).

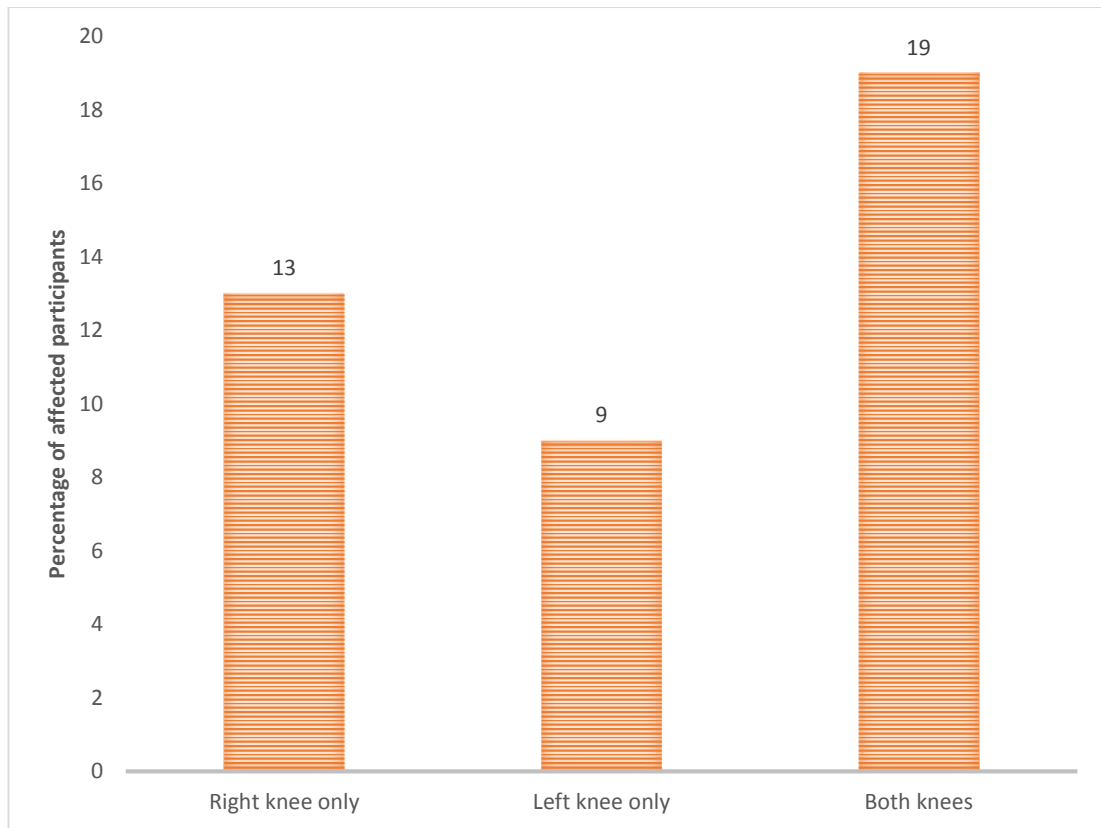


Figure 7.2 Percentage of the participant reporting affected knee at follow up.

7.2.3 Prevalence of knee pain as predominant symptoms among the participants at follow up

Of 126 participants who responded to follow up, 34 participants reported knee pain (27.0%, 95% CI 19.9% to 35.5%). Knee pain as the dominant symptom was reported by 10 participants for right knees only (29.4%) and 7 participants for left knees only (20.6%). The report of knee pain was highest when both knees were affected, for 17 (50%) participants.

The additional question “*Have you had pain, aching, or stiffness lasting at least a month in or around the knee during the past 12 months?*” (Ling J et al. 2010) was

added to enable comparison to literature. Of the 126 participants at follow up, 27 participants answered yes to this question (21.4%, 95% CI 15.8% to 28.3%). A gender difference was not noted: the proportion of the males answering yes was 21.7% (95% confidence interval 13.4% to 33.2%) and of the females was 21.4% (95% confidence interval 12.4% to 34.3%).

7.2.4 Source of knee problems among the participants reporting knee problems at follow up

The prevalence of trauma as the main cause of knee problems at follow up was 11.2% (n=14, 95% CI 5.8% to 20.5%) (Table 7.3).

Table 7.3 Knee Pain and Trauma at baseline and follow up.

Variable	Baseline (n=314)	Follow up (n= 126)
	No. (% , 95% CI)	No. (% , 95% CI)
<hr/> Predominant symptom		
Knee pain	65 (20.7, 16.6 – 25.6)	34 (27.0, 19.9 – 35.5)
Source of knee problems		
Traumatic	31 (9.9, 7.0 – 13.7)	14 (11.1, 5.8 – 20.5)
<hr/>		

7.2.5 Changes noted at follow up among the participants with knee problem at the baseline

The number of participants who had knee problems at both the baseline and follow up was 30 (Figure 7.1). Their mean (SD) age was 24.3 (6.4) years at baseline. There were 15 males and 15 females. Their mean (SD) BMI was 24.7kg/m² (4.4), 19 (63.3%) had normal BMI, 8 (26.7%) were overweight, and 3 (10.0%) were obese at the baseline. Among the 30 participants with knee problems at both assessments points, a high percentage of participants reported a high activity level at follow up compared to the baseline (Table 7. 4) but this was not statistically significant (Marginal homogeneity Stuart-Maxwell test = 4.46, degree of freedom = 2, p-value = 0.10). The mean average sitting time per day for those with knee problems at both baseline and follow-up decreased significantly by follow up (paired t-test $t = 1.81$, degree of freedom = 27, p-value = 0.040, see Table 7.4).

The impact of knee problems on the individuals measured by the KOOS questionnaire showed mean differences which were not statistically significant for level of pain (paired t-test $t = 1.15$, degree of freedom = 29, p-value = 0.87), and quality of life (paired t-test $t = 0.80$, degrees of freedom = 29, p-value = 0.22, [see Table 7.4]) for the 30 participants who reported knee problems at the baseline and follow up. One participant's data on KOOS score from the baseline was missing, resulting in a comparison of 29 participants instead of 30.

Table 7.4 Physical activity levels, physical inactivity, KOOS score, and knee pain as predominant symptom at the baseline compared to follow-up for those with knee problems at both the baseline and follow-up (n= 30).

Variable	Baseline	Follow-up
Physical activity levels		
<i>Low</i>	12 (42.8%)	10 (34.5%)
<i>Moderate</i>	8 (28.6%)	6 (20.7%)
<i>High</i>	8 (28.6%)	13 (44.8%)
Physical inactivity		
Mean (SD) average sitting per day in hours	6.5 (2.6)	5.7 (2.1)
KOOS scores		
Mean (SD) KOOS score on pain	77.0 (22.0)	81.7 (14.7)
Mean (SD) KOOS score on symptom	79.6 (13.9)	80.6 (14.9)
Mean (SD) KOOS score on quality of life	67.0 (22.0)	64.3 (21.6)
Mean (SD) KOOS score on activity of daily living	89.0 (14.9)	91.6 (10.3)
Mean (SD) KOOS score on sport & recreational activities	78.7 (24.6)	78.1 (22.6)
Standard deviation (SD), Knee Injury and Osteoarthritis Outcome Score (KOOS).		

7.3 Incidence of knee problems after 12-month follow up

Incidence of knee problems in the follow up group was measured in two ways: the presence of knee problems; and knee pain, aching or stiffness. The effect of clustering on the incidence of knee problems was estimated. From Table 7.5, the inflation factor suggested there was a clustering effect on the standard error. Therefore, the confidence interval and p-values estimates of the incidence of knee problems and of knee pain, aching or stiffness were adjusted for clustering.

Table 7.5 Estimation of the inflation factor for the standard error estimate of the incidence of knee problems and of knee pain, aching or stiffness due to clustering.

Variable			Standard error unadjusted for clustering	Robust standard error adjusted for clustering	Inflation factor
Incidence of knee problems			0.0344	0.0371	1.08
Knee pain, aching or Stiffness			0.0293	0.0305	1.04

Of the 87 participants without knee problems at the baseline who were followed up, 11.5% (n=10, 95% CI 5.6% to 22.1%) developed a new knee problem. This was measured by answering “*Have you had pain or problems in the last year in or around the knee? Yes / No*”. The prevalence of knee pain as the dominant symptom among the 87 participants followed up was 10.3% (n=9, 95%CI 4.8% to 21.0%). Of the 87

participants, 8.0% (n=7, 95% CI 3.5% to 17.5%) reported experiencing pain, *aching, or stiffness lasting at least a month in or around the knee during the past 12 months.*

Of those participants reporting a new case of knee problem, nine (90%) had pain as the dominant symptom in 13 knees (3 left knees, 2 right knees, and 4 both knees). Trauma was responsible for the development of a new knee problem in only one knee (a left knee) (10%).

A slightly similar mean (SD) BMI was observed for the 77 participants (24.2 (3.7) without knee problems at follow up and 10 participants (23.3 (3.7) that later developed knee problems (Table 7.6).

The mean average sitting time at follow up compared to baseline among the 77 participants without knee problems was slightly but non-significantly lower (paired t test $t = 1.02$, degree of freedom = 75, p-value = 0.84) (Table 7.6). Conversely, the mean sitting time per day in hours at follow up and baseline for those with new knee problems was increased but not significantly greater than zero (paired t test $t = 1.12$, degree of freedom = 8, p-value = 0.15). Participants reporting new knee problems reported an increase in their physical activity level compared to their physical activity level at baseline but this was not statistically significant (Marginal homogeneity (Stuart-Maxwell) = 5, degree of freedom = 2, p-value = 0.082).

Table 7.6 Characteristics of those without knee problems at the baseline.

Variable	Without knee problems (n= 77)	New knee problems (n= 10)
Age (SD)	22.6 (5.7)	23.2 (3.7)
Gender		
<i>Male</i>	44 (57.1%)	5 (50%)
<i>Female</i>	33 (42.9%)	5 (50%)
Mean (SD) BMI kg/m ²	24.2 (3.7)	23.3 (3.7)
Baseline Physical activity		
<i>Low</i>	45 (58.4%)	6 (60%)
<i>Moderate</i>	15 (19.5%)	3 (30%)
<i>High</i>	17 (22.1%)	1 (10%)
Baseline Mean (SD) of Average sitting per day in hours	6.0 (2.8)	5.9 (2.8)
Follow up Physical activity		
<i>Low</i>	42 (54.5%)	3 (30%)
<i>Moderate</i>	10 (13.0%)	1 (10%)
<i>High</i>	25 (32.5%)	6 (60%)
Follow up Mean (SD) of Average sitting per day in hours	5.6 (2.6)	6.7 (2.8)

Standard deviation (SD), Body mass index (BMI).

7.3.1 Investigation of the relationship between the incidence of knee problems and other variables

A univariate regression analysis was performed to test whether age, gender, BMI / 10kgm², physical activity levels, and average sitting time per day in hours (as pair of linear & quadratic terms) at baseline independently predict incidents of knee problems. It should be noted that the univariate analysis unadjusted for clustering effect would yield large p-values. Although a clustering effect was observed it could be argued to be pointless to adjust for clustering effect in this case as it would only inflate the standard error, hence widening the CI and increasing the already large p-values. None of the effects were close to being statistically significant without this inflation.

None of the variables were significant in predicting the incidence of knee problems in the study cohort. For the confounding factors, the estimated OR of age was 1.09 and gender was 1.33 (Table 7.7). For the risk factors; the OR of BMI / 10kg/m² was 0.47; high physical activity level was 0.48 with moderate physical activity level at 1.53.

HSCL-10 score was removed from the analysis as none of the participants that reported new cases of knee problem reported a score ≥ 1.85 .

Table 7.7 Univariate analysis of the effects of baseline factors on incidents of knee problems at follow up.

Variable	OR (95% CI)	P value
Age / 5 years	1.09 (0.61 – 1.95)	0.76
Gender		
<i>Male</i>	1	
<i>Female</i>	1.33 (0.36 – 4.99)	0.67
BMI / 10kg/m ²	0.47 (0.06 – 3.53)	0.46
Physical activity levels		0.59
<i>Low</i>	1	
<i>Moderate</i>	1.53 (0.34 – 6.90)	0.58
<i>High</i>	0.48 (0.05 – 4.29)	0.51
Average sitting time (in hours)		0.91
<i>Linear term</i>	1.20 (0.44 – 3.30)	
<i>Quadratic term</i>	0.99 (0.91 – 1.06)	

Odds ratio (OR), Body mass index (BMI).

Pairwise interactions between three risk factors were investigated by adding them to the logistic regression model but none was statistically significant. This analysis would have had extremely low power due to the number of participants which makes any conclusion difficult to make.

Model E used in the multivariate regression performed for the prevalence data was adopted for the analysis of the incidence data. All the variables were put into the regression model except HSCL-10 score (Table 7.8). Performing multivariate

analysis, none of the variables included in the model were significant in predicting incidents of knee problems in the cohort.

Table 7.8 Effects of baseline factors on incidents of knee problems at follow-up adjusting for other variables.

Variable	OR (95% CI)	P value
Age / 5 years	1.10 (0.50 – 2.41)	0. 82
Gender		
<i>Male</i>	1	
<i>Female</i>	1.64 (0.36 – 7.52)	0.52
BMI / 10kg/m ²	0.41 (0.04 – 4.64)	0.47
Physical activity levels		
<i>Low</i>	1	0.54
<i>Moderate</i>	1.94 (0.38 – 9.96)	0.43
<i>High</i>	0.53 (0.05 – 5.14)	0.59
Average sitting time (in hours)		0.91
<i>Linear term</i>	1.08 (0.40 – 2.94)	
<i>Quadratic term</i>	0.99 (0.92 – 1.07)	

Odds ratio (OR), Body mass index (BMI).

The AUC was poor (0.6), which indicated that the model’s ability to predict incidents of knee problems was little better than chance (Figure 7.3).

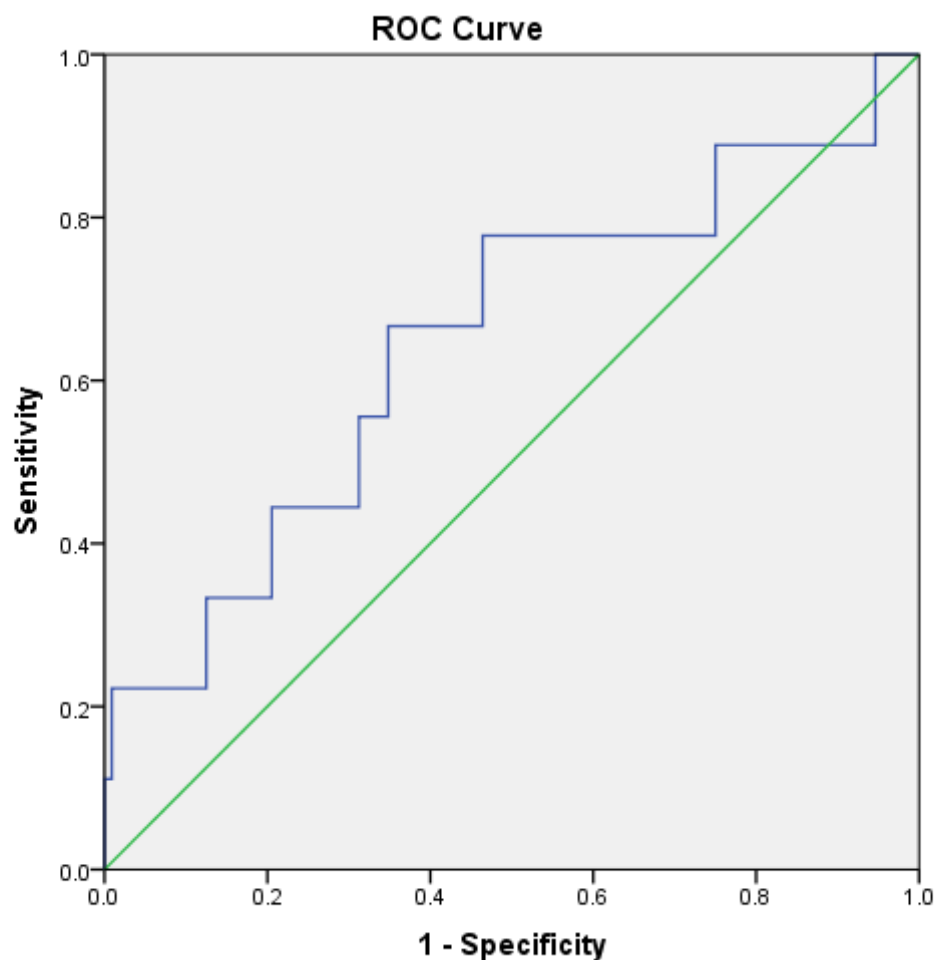


Figure 7.3 Receiver Operating Characteristic (ROC) curve plot showing the trade-off between sensitivity and specificity.

7.4 Summary of key findings from follow-up

Of the 314 participants recruited at baseline, only 126 (40.1%) responded to follow-up. At follow-up the prevalence of knee problems was 31.7% (95%CI 23.9% to 40.9%) compared to 31.8% (95%CI 26.9% to 37.2%) at the baseline. Of the 39 participants who reported knee problems at the baseline 30 (76.9%) still had knee problems at follow-up. Of the 30 participants still with knee problems at follow-up

their sitting time had decreased significantly (p-value = 0.040). The impact of knee problems on those participants who reported knee problems at the baseline and follow up measured by the KOOS questionnaire showed no mean differences.

Of the 87 participants without knee problems at the baseline who were followed up, 10 (11.5% [95%CI 5.6% to 22.1%]) developed new cases of knee problems. There was no mean difference between sitting time at the baseline and follow-up for those who reported new cases of knee problems.

Chapter 8. Discussion

8.1 Introduction

This thesis aimed to explore the epidemiology of knee problems among young adults aged 18 to 39 years old inclusive, with an emphasis on measuring the prevalence and incidence of this problem and on whether obesity, physical activity and physical inactivity are risk factors. A systematic review of studies of knee problems in young adults identified that there is a lack of comprehensive evidence on obesity, physical activity and physical inactivity as risk factors for the incidence of knee problems among young adults in the general population. The systematic review highlighted that the majority of the studies that investigated knee problems in young adults have been in athletic populations (military and sports cohorts). How knee problems were defined in these studies makes it difficult to compare studies because they mainly focused on specific conditions. It also made it difficult to determine incidence.

Therefore, there was a gap in the understanding of the public health burden of knee problems among young adults in the general population. Such a study of the epidemiology of knee problems among young adults is relevant given the short and long term outcomes of knee problems, for example, osteoarthritis of the knee, and temporal changes in the risk factors (Felson et al. 1987; WHO 2003; Jinks et al. 2004; van der Waal et al. 2006, Grotle et al. 2008).

To contribute to the understanding of knee problems among young adults, 314 participants were recruited to a one year follow-up study, this sample was made up of those with or without knee problems. This study was undertaken to estimate

prevalence and incidence rates of knee problems in young adults and to explore whether physical activity, obesity and physical inactivity are risk factors for knee problems. However, due to a low number of participants at follow-up, the exploratory analysis on the risk factors had to be performed on the prevalence data. The implications of this is discussed further in this chapter.

In this chapter, a summary of the findings from the systematic review will be discussed in relation to the literature and the implications for the rationale for the methods of the planned epidemiological study. Thereafter, the prevalence of knee problems among the participants recruited for the baseline assessment will be discussed. This will be followed by a discussion on the inter-relationship and relationship between knee problems, physical inactivity, obesity and physical activity in young adults and then the incidence of knee problems. This chapter further discusses the impact of knee problems on lifestyle, for example, the quality of life among those reporting knee problems. The strengths and limitations of the epidemiological study are discussed, followed by the implications of this study on the understanding of the epidemiology of knee problems among young adults. Finally, areas requiring further investigation with the aim of improving the understanding of knee problems among young adults will be proposed.

8.2 Findings from the systematic review

Prior to commencing the study of knee problems in university students, a review of the risk factors for knee problems in young adults, using systematic methods, was completed. The findings of the review confirmed that there is a lack of comprehensive

evidence on obesity, physical inactivity and physical activity as risk factors for the incidence of knee problems among young adults (Chapter 2). There was conflicting evidence across the studies reviewed in relation to incidence of knee problems and relationship between knee problems, physical activity and BMI, which may be due to a lack of a clear definition of knee problem and variation in the measurement methods used in measuring knee problems (Chapter 2). This prompted the epidemiological study of knee problems among young adults with a clear definition of knee problems that encapsulates any type of knee problem.

According to the findings of Lankhorst et al. (2012), who undertook a systematic review of risk factors for patellofemoral pain syndrome, most of the studies reviewed have few events relative to the number of independent variables being evaluated in their logistic model (type I error) (Peduzzi et al. 1996). The sample sizes of studies have been too small to investigate several risk factors (Lankhorst et al. 2012). The review conducted for this thesis highlighted important potential confounders (age, gender and psychological factors) and potential risk factors (obesity and physical activity). The review also highlighted the fact that no study has previously examined the relationship between obesity, physical inactivity and knee problems among young adults. These confounders and risk factors were investigated in the epidemiological study of knee problems among young adults.

8.3 Knee problems in the cohort

Developing the case definition for the epidemiological study of knee problems among young adults for this thesis, a holistic approach was taken as there were other knee

problems which might not be covered should either a specific (e.g., patellofemoral pain) or more generic term (e.g., knee injury or knee pain) be used (Chapter 3). This section will discuss estimates of the prevalence of knee problems, in relation to the literature identified in more recent research. It will highlight and discuss the prevalence of different types of knee problems reported in the cross-sectional study.

8.3.1 Measurement of knee problems in the cohort

In this study a knee problem was defined as any form of knee problem other than a doctor diagnosed lower limb osteoarthritis, inflammatory arthritis, or other systemic disorder which severely affects walking. No study in the systematic review had taken such a holistic approach to investigating the epidemiology of knee problems among young adults.

The case definition developed for this thesis was carefully formulated to be comprehensive of all types of problems which might cause knee problems in healthy young adults and to encompass all symptoms of these disorders. This was different from other studies in the systematic review which were found to focus on either pain, a specific knee related condition, or injury. To ensure an appropriate measurement tool was used, a systematic review of measurement tools used in the incidence studies was undertaken (Chapter 4), as no instrument is universally applicable across the spectrum of knee problems and groups of individuals used for measurement of knee problems (Garratt et al. 2004; Howe et al. 2012; Rodriguez-Merchan 2012). **Knee problems were defined as a deviation from the normal function of the knee joint with or without any unpleasant sensational feeling such as pain around the joint area.**

This definition was used as the measure to identify instruments used in the identification of knee problems in this study. The questionnaire that most closely fitted the criteria was the Knee Pain Screening Tool (KNEST) (Jinks et al. 2004). However, the KNEST questionnaire needed to be modified to ensure that it met the case definition for this thesis as it encapsulates all knee ‘problems’ (Chapter 4). Two questions were modified “*Have you ever been to a doctor because of knee problems?*” and “*Have you had pain or problems in the last year in or around the knee?*” These modified questions have also been used by Selfe et al. (2015) in an exploratory cross-sectional study. So findings of the present study were compared to findings of Selfe et al. (2015) and other literature.

8.3.2 Prevalence of knee problems in the cohort

The data gathered in the cross-sectional study of 314 participants used this modified question that matched the case definition construct to identify participants with or without a knee problem. Using this definition, the prevalence of knee problems was estimated to be 31.8% in the cohort at the baseline and more than 40% of the participants who reported knee problems have never seen a doctor concerning knee problems. The prevalence of knee problems in this study seems high, but recent research appears to verify the finding (Selfe et al. 2015). Selfe et al. (2015) sampled 101 participants aged 18 to 55 years from amongst staff, students and general public members attending a three-day annual Lancashire Science Festival, and found an overall 33.7% prevalence of knee problems.

On the other hand, some authors have reported a lower prevalence of 8% to 20.5% knee problems among young adults (Urwin et al. 1998; Webb et al. 2004; Jones et al. 2007; Boling et al. 2010; S  et al. 2011) and others a slightly higher prevalence of 35% to 40% (Majewski et al. 2006; Zhai et al. 2007). The variation in the prevalence of knee problems in literature could be as a result of the instrument used in measuring knee problems, conditions being measured, the sampling method and the setting from where participants were recruited.

Boling et al. (2010) investigating patellofemoral pain among freshmen at the United States Naval Academy reported a 13.5% prevalence of patellofemoral pain. Their study was only recording patellofemoral pain, not all knee pain and therefore was likely to underestimate as they considered only a subset of the problem covered by the case definition used in this study.

S  et al. (2011) explored knee problems as knee pain in a population-based study of 2,297 individuals aged ≥ 20 years old in South America. Homes were randomly selected to recruit participants. Data on knee pain was collected by a trained interviewer who interviewed participants from selected homes, using a body map in which knee pain was defined as pain between the distal one-third of the thigh and the proximal one third of the leg. The prevalence of knee pain in the subgroup aged 20 to 34 years old was estimated to be 8.1%. Their study was not without its critics. Firstly, the robustness of the training given to the trained interviewers was not highlighted in their study. The tool used to identify knee pain in their cohort was not consistent across their participants and the period of time that they were investigating was not clear. Finally, only 0.7% of their cohort participated in intense physical activity, 11.7%

moderate, 15.9% light and 71.7% were non-practitioners of physical activity. This could explain the lower prevalence of knee pain in their cohort as the physical activity level was not found to be associated with knee pain, whereas it was in the present study (see section 8.5 below).

Majewski et al. (2006) reported that 40% of all sport-related injuries were knee injuries. Their study comprised samples of selected athletes rather than the general population and only sport-related knee injuries were included. They also included older participants than those in this study, therefore their result are not directly comparable with this study.

8.3.3 Knee related predominant symptoms

The modified question used in this study demonstrated that participants who reported knee problems had different types of knee predominant symptoms such as knee pain, locking and ‘giving way’ or knee buckling (Felson et al. 2007). This is a novel finding, as no study has investigated knee problem dominant symptoms among young adults. At baseline assessment, 21% of the 314 participants reported knee pain as a predominant symptom, 7% reported experiencing giving way or feeling like it will give way, and 2% reported locking as the predominant symptom. This finding might explain some of the differences between the prevalence reported in this study and that of other studies. Exploring knee problems among young adults with a focus on knee pain is likely to lead to an underestimation of knee problems as other predominant symptoms might be present. Although small in number at just 2% it is interesting that there is no other study reporting the prevalence of locking of the knee as the dominant

symptom in young adults in literature. There is a need for a further investigation of the prevalence of types of knee problems among young adults due to their impact on the affected individuals. Recall bias may affect the types of knee symptoms more likely to be reported in a prevalence study; for example, participants may be more likely to report symptoms that have more or longer impact.

8.3.4 The instruments used to measure the prevalence of knee problems

It was perceived after the baseline assessment that the prevalence of knee problems was high compared to the literature. This is because other studies of the prevalence look at osteoarthritis and therefore their definitions focus on knee pain and have much more stringent criteria such as stiffness, aching, swelling and pain (Zhai et al. 2006; Ling et al. 2010; Soni et al. 2012; Jhun et al. 2013). However, the question used in this study is less stringent and only asks about knee pain or problems. To investigate whether the instrument itself was the cause of this higher than expected prevalence, a validated specific question used in the identification of knee pain (Ling et al. 2010) was introduced at follow up assessment. This was to enable direct comparison of the prevalence of knee pain in this study with other literature which has used the question. The specific question: *“Have you had pain, aching, or stiffness lasting at least a month in or around the knee during the past 12 months?”* used in the identification of knee pain introduced at follow up, estimated a prevalence of knee pain of 21.4% (95%CI 15.0% to 29.6%) in those responding to the follow-up questionnaire compared to 31.7% as the prevalence of knee problems estimated by the modified question at the same point. At follow-up, the prevalence of knee pain as a predominant symptom was 27% (95%CI 19.9% to 35.5%). The CI encompasses 21.4%, making it consistent. The

modified question appears to estimate a universal set of knee problems (holistic approach) in which knee pain is a subset which implies there are other types of knee problems other than knee pain among the participants. Estimating the prevalence of knee problems among young adults based on this study, focusing on knee pain only could lead to a potential approximate 10% underestimate of knee problems. This suggests that a more holistic approach to defining outcomes should be adopted in the exploration of knee problems among young adult populations.

The prevalence of knee pain of 21.4% identified using the validated specific question in this study is similar to Jones et al.'s (2007) study of newly employed workers, whose mean age was 23 years, from 12 diverse occupational settings in England. In their study, the newly-employed workers consisted of final year students, new trainees in service organisations and newly opened workplaces (e.g. supermarkets, postal distribution centres). Jones et al. (2007) reported the prevalence of knee pain of 20.5% in 1081 individuals. Knee pain was measured by asking participants whether they had experienced any knee pain in the past month that lasted for \geq one day (Jones et al. 2007).

Despite the differences in geographic locations, sampling methods and recruitment strategies between Jones et al.(2007), Sá et al.'s (2011) and the present study, the findings of the present study indicates that Jones et al.(2007) and Sá et al.'s (2011) were underestimating knee problems as they focus solely on knee pain. If they had taken the holistic approach used in the present study, the prevalence reported in their study would have been the true picture of knee problems and given a better comparison, as it would have included other types of knee problems in which pain is

not the predominant symptom. However, there was no indication they were trying to estimate the prevalence of knee problems and their findings depend on the purpose of their study. The holistic approach taken in collection of data on knee problems is good and should be adopted in further investigations of knee problems among young adults.

8.3.5 Measurement of how knee problem developed

The literature suggests that vigorous exercise is a risk factor for traumatic musculoskeletal pain and the most common site affected is the lower limb (El-Metwally et al. 2007). The traumatic onset of knee problems resulting from traffic accidents and athletic injuries have been stated to be the most common way knee problems develop resulting in conditions such as rupture of an anterior cruciate ligament (ACL) or posterior cruciate ligament (PCL) (Schulz et al. 2003; Yang et al 2005; Parkkari et al. 2008).

In this study, the majority of those who reported knee problems reported a gradual onset of knee problems (69%), not a traumatic onset (31%) as suggested in the literature. Therefore most are not from accidents or sudden injury. This is an important finding as the gradual onset of knee problems has been regarded as self-limiting but in this study, most still had a knee problem a year later (Utting et al. 2005; van Dijk and van der Tempel 2008). The gradual onset of knee problems, such as that seen in conditions like patellofemoral pain, may be explained by chronic overloading of the knee joint (Dye 1996). Loads transmitted across an individual knee vary and are influenced by complex factors, including the weight of the individual. In a conditioned individual a single load event could occur without resulting in either overt or covert

damage. However, if the knee is not conditioned or the frequency of the loading is increased, this could initiate a complex biologic cascade of trauma (Dye 1996). Such biologic trauma could be manifested as the gradual onset of knee problems.

In this study 69% of those who reported knee problems reported gradual onset which is similar to that of Rathleff et al.'s (2013) study of 2846 adolescent participants which suggests 68.3% reported gradual onset. These investigators went further to show there was no difference in pain frequency between those who reported gradual onset and traumatic onset of knee problems, both have similar consequences relating to quality of life (Rathleff et al. 2013). This was not same for this study as no difference in reported knee pain as the predominant symptom was found between those who reported gradual onset and traumatic onset.

8.3.6 Gender and Age in knee problems

In the literature, there is no consensus regarding gender-related differences in the prevalence of knee problems, with some authors having reported a difference (Urwin et al. 1998; Boling et al. 2010; Sá et al. 2011; Selfe et al. 2015) and others (Jones et al. 2007; Rathleff et al. 2013) not finding a difference. Such variations could be as a result of a specific condition investigated as no difference is noted under a broad outcome measure, as seen in this study and the systematic review (Chapter 2). Some authors have argued that gender differences in reports of knee problems could be multifactorial, for example, as a result of anatomical, biomechanical (Sigward & Powers 2006; Pollard et al. 2006), and hormonal factors (Hewett et al. 1999; Hewett et al. 2004; Hewett et al. 2006). The role of anatomical, hormonal and biomechanical

factors in explaining gender differences is discussed in Chapter 1 section 1.3. The prevalence of knee problems was higher in females in Boling et al.'s (2010) study of patellofemoral pain; whereas, in Jones et al.'s (2007) study of knee pain there was no gender difference.

In this study, difference in the prevalence of knee problems across gender was not significant ($p\text{-value} = 0.74$). The confidence interval of the multivariate analysis shows the direction of the effect could be either way (OR of 0.9 (95% CI 0.5 to 1.6). This observation might be as a result of the holistic approach taken to investigate knee problems. Such a holistic approach could have cancelled out the gender differences noted across the different conditions making up knee problems.

The increased prevalence of knee problems with increasing age reported in Peat et al. (2001); Zahi et al. (2007); Sá et al. (2011) and Selfe et al. (2015) was not supported by this study. Increase in age in this study does not increase the odds of knee problems, although the estimate suggest a possible upward effect (OR 1.2 (0.9 -1.5); $p\text{-value} = 0.25$). It could be that the age range in this study compared to the literature was not sufficient to demonstrate any effect as the effect might start to appear once the age range is beyond 40 years (Sá et al. 2011; Selfe et al. 2015). Moreover, it could be that among those aged 18 to 40 years old, the effect is insufficiently prominent to be statistically significant so the overall effect may not be linear.

8.4 Inter-relationship between knee problems and obesity, physical inactivity and physical activity

In this section, the relationship between knee problems and its risk factors (physical activity, obesity and physical inactivity) is discussed. Obesity has been identified as a risk factor for knee osteoarthritis in the elderly population, but there is conflicting evidence regarding physical activity as a risk factor for knee pain in younger people (Urquhart et al. 2008; 2011; Richmond et al. 2013). The review undertaken for this thesis suggested that there had been a lack of study of the relationship between physical inactivity and knee problems, although its relationship with obesity has been described (Petersen et al. 2004; Tammelin et al. 2004). The risk factors for knee problems are discussed. The impact of other variables considered in this study on the inter-relationship between knee problems and the three risk factors is also discussed.

8.4.1 BMI as a risk factor for knee problems

BMI was used to measure obesity in this study. In this study, BMI was not found to be an independent risk factor for knee problems; although the OR suggested that there were more knee problems as BMI increased and the upper 95% confidence limit was consistent with a large effect, whilst the lower 95% CI confidence limit of the OR was consistent with no association (OR 1.8 95% CI 1.0 to 3.4). This could as a result of low sample size of participants who are obese, characteristics of the sample, for example activity levels, or it might be the use of BMI to measure obesity. However, some literature suggested that BMI is related to knee problems (Gelber et al. 2000; Miranda et al. 2002; Parkkari et al. 2008; Kuikka et al. 2011; Sá et al. 2011; Richmond

et al. 2013), and to functional limitation among younger people (Stovitz et al. 2008), and increases vulnerability of the knee to early degenerative changes (Dequeker et al. 1983). Such pain and functional limitation are commonly viewed as barriers to being physically active among young adults reporting knee problems (McAllister et al. 2003; Carey et al. 2006). The profound effect obesity has on the knee joint contributes to knee problems through mechanical stress of the excess weight on the joint (Dye 1996; Wearing et al. 2006), which suggest obesity may contribute to the relationship between knee problems and physical inactivity.

8.4.2 Physical inactivity as a risk factor for knee problems

Physical inactivity was measured with the IPAQ-long questionnaire (van Poppel et al. 2010, The IPAQ group 2014). The data from the baseline assessment demonstrated the presence of a potential quadratic relationship between physical inactivity and knee problems. The quadratic relationship means that at a given optimal point – average sitting time of 4.7 hours per day that is a point in the middle of the curve on the graph of Figure 6.18, the risk of knee problems is less. The further you move away from this point the risk increases. This could explain the high prevalence of knee problems recorded in this study as men and women in the general population spend on average six or more hours of total sedentary time on both weekdays (31% and 29% respectively) and weekend days (40% and 35% respectively) (Health Social Information Centre 2012). The independent effect of physical inactivity using the quadratic term in explaining knee problem was marginally non-significant (p-value = 0.069). This is because it was difficult to demonstrate it clearly in this cohort.

No study has investigated the relationship between physical inactivity and knee problems among young adults. Such studies have been conducted in the adult population of over 40 years old (Yoshimura et al. 2004; Muraki et al. 2009). Dahaghin et al. (2009) in their study included young adults (participants aged 17 to 88 years). They found sitting as a form of physical inactivity for one to two hours is protective against knee osteoarthritis unlike for those who spent less time sitting, and that sitting for a longer period was not protective (Dahaghin et al. 2009). This study found that sitting for between three to six hours is protective against knee problems. There is no evidence of an interaction between physical inactivity and BMI. There is a need for a study to investigate potential causality and its direction between the two variables and knee problems.

8.4.3 Physical activity as a risk factor for knee problems

Physical activity measured as the nature of the sport participated in, hours of sport per week, etc., has been shown to increase the risk of knee problems (Chapter 2). In this study, physical activity levels were measured in categories (low, moderate and high). This is because the research student anticipated the cohort to be likely to be less active than the types of populations that have been chosen previously (see Chapter 2). The distribution of physical inactivity within different categories of physical activity levels in the cohort differs. Participating in a high level of physical activity was an independent risk factor in explaining knee problems OR 2.6 (95% CI 1.4 to 4.9) relative to a low level of physical activity. The lower limit of the 95% confidence interval of OR suggests an association with the upper limit of the CI, suggesting a large effect.

Physical activity is known to offer great health benefits and has been recommended as one of the ways to reduce the high prevalence of obesity in the general population (Butland et al. 2007; WHO 2010; DOH 2011). In one study, lack of physical activity was found to increase the odds of functional decline, whereas regular exercise protects one against such decline of physical function of the knee among participants of a mean (SD) age of 68.6 (10.8) years (Sharma et al. 2003). However, the greater the intensity of activity, such as in marathon running, the higher the risk of knee problems (Caselli and Longobardi 1997) whereas walking for leisure lowers this risk by 33% (Hootman et al. 2002). Despite the substantial health benefits attributable to physical activity (WHO 2010; DOH 2011), knee problems resulting from physical activity can result in immobility (Thibault et al. 2010) which can lead to physical inactivity that is associated with obesity (Petersen et al. 2004). In this study, the KOOS subscale on quality of life showed that participants who reported knee problems reported low quality of life and marginally not significant associated with physical inactivity.

However, caution should be taken when applying this finding as it is analysis of cross-sectional data which cannot explain the nature of the relationship or the direction of the association (Glasziou et al. 2001) between these variables and knee problems. This relationship was further explored with the incidence study. The confidence interval of estimates from the incidence data support the association highlighted by the cross-sectional data. However, the incidence data was relatively small, which suggest results from the analysis of the incidence data could be as a result of chance.

In this study, participants who reported a new knee problem also reported higher sitting times. It could be that these participants are moving from a state of rest into

physical activity without conditioning the knee. There is an assumption that knee problems that occur during leisure sports activities might be as a result of improper training and inadequate assessment of one's own capability (Aaltonen et al. 2007). A systematic review of randomized controlled trials by Aaltonen et al. (2007) found prophylactic training routines involving multidirectional training could prevent the incidence of knee problems. This should be taken into account when planning interventions to improve physical activity patterns, and consideration should be given to weight management and psychological status as they may affect the success of such an intervention.

8.4.4 Psychological factors as a confounding factor of knee problems

From the review, other factors were potential risk factors for knee problems. These included psychological factors measured as mental distress, age, and gender. Information about these was collected in the epidemiological study and entered into the multivariate analysis. Individually, they had little effect on the relationship between BMI, physical activity and physical inactivity and knee problems. Mental distress was an independent risk factor for knee problems.

Psychological status was measured with HSCL-10. A HSCL-10 score above the threshold of ≥ 1.85 was classed as being mentally distressed (Strand et al. 2003). Reporting being mentally distressed was an independent risk factor for knee problems OR 2.3 (95% CI 1.2 to 4.6) which is statistically significant. The lower limit of the 95% confidence interval of the OR demonstrates an association between being mentally distressed and knee problems. The upper limit of the 95% confidence interval

of the OR suggested a large effect. There is evidence of a relationship between depression and knee pain among adults aged 40 and over in the literature (Phyomaung et al. 2014). Among younger people, in the literature it has been shown a new onset of knee pain increased with increasing levels of psychological distress (Jones et al. 2007). The incidence data was unable to confirm this association between knee problems and being mentally distressed. This is because the number of new cases of knee problems was too small and the difference in the psychological status of those reporting new cases was not enough to perform any analysis.

8.5 Incidence of knee problems

Of 214 participants without knee problems at the baseline, only 87 were followed up for 12 months. Using the modified screening question, the incidence rate of knee problems was 11.5%. The use of the validated knee pain specific question (Ling J et al. 2010) shows an incidence rate of 8% for knee pain. This finding suggests the finding from the baseline data that focusing on knee pain in a study that investigates knee problems among young adults could lead to a potential underestimation of the true picture of the problem (see section 8.3.4).

The review identified that the incidence of knee disorders ranged from 0.07% to 42% (Chapter 2). It is suggested that such a difference could have resulted from the wide range of specific knee disorders investigated across the reviewed studies. Jones et al. (2007) was the only study that focussed on knee pain. Jones et al. (2007) reported 8.2% new cases of knee pain after follow-up of one year. In the same study they went

further to report 10.2% new cases of knee pain among those free of knee pain after the first year (Jones et al. 2007).

Gradual onset was the most common way knee problems developed among those who reported new cases of knee problems. This supports the finding from the baseline data that gradual onset of knee problems is the most common way knee problems arise in young adults.

The low precision of the estimate is evident from the wide confidence interval which is consistent with an incident rate as low as 5.6% and as high as 22.1%. The small number of new cases of knee problems makes interpretation of other analyses problematic. However, those who reported new knee problem reported no statistically significant change in both their physical activity levels and their sitting time.

8.6. The impact of knee problems among those reporting knee problems

The KOOS questionnaire was used to measure the impact of knee problems on the participants reporting knee problems at baseline. The KOOS measures five subscales: pain; symptoms; activity of daily living; sport and recreational activities; and quality of life. A score of 100 in any subscale means no problems, a score of 0 meaning severe problems in those with knee problems (Roos et al. 2011). The mean subscale score of activity of daily living (90.8) was closer to 100 than the other subscale scores. This is an important finding. It means that those who reported knee problems were engaging in normal activities of daily life. The lowest KOOS subscale score was for quality of life (71.1). Although participants with knee problems were able to engage in activities

of daily life (score 90.8) they were somewhat dissatisfied, which may be related to the relatively low score on sports and recreation (78.9). The KOOS subscales scores remained similar over 12 months among participants who reported knee problems at both points of assessment.

Physical inactivity among the 30 participants who reported knee problems at the baseline and follow up, significantly decreased over the 12 months period of study (p -value = 0.040). It could be that they were recovering and participating in their usual activities of daily life, and sport and recreation measured by KOOS subscales on these variables, which showed no mean differences over 12 months. In addition, there was no statistically significant change in their physical activity level (p -value = 0.10) over 12 months. It could be that the function of the knee joint of these 30 participants may have decreased and that they are functioning within the limit of their present knee joint given the upper limit to be the threshold between homeostatic loading and loading good enough to initiate re-injury of the knee joint (Dye 1996). The reinjured knee joint can manifest these clinical symptoms; discomfort, tenderness, swelling, pain and warmth (Dye 1996). All these symptoms can explain their low mean subscale score of quality of life reported at baseline (67.0) and follow up (64.3) assessment points. The frequency of loading is proportional to the rate of re-injury (for example, in marathon running) or nature of the load (body weight) (Dye 1996). These 30 participants might have to resort to a new level of physical activity which might not be satisfying hence their low mean score on quality of life. In the literature, McAllister et al. (2003) and Carey et al. (2006) found that participants with ACL injury are likely to be forced to drop their performance and among sport professionals in some cases change their profession.

The nine participants who reported knee problems at baseline but not at follow up reported no change in their average physical inactivity. It could be that they restricted their activities to post-knee problem for fear of re-injury (Kvist et al. 2005), as those that returned to their pre-injury activity levels have a high risk of re-injury (Von Porat et al. 2004; Walden et al. 2006).

8.7 Strengths of the findings of this study

Despite the shortcomings of this thesis, this thesis was still able to demonstrate that the prevalence of knee problems is high in this population, and that knee problems, and their risk factors, in young adults should be further investigated in a large scale population based cohort study. The estimate of incidence provided by this study will enable accurate estimation of sample size needed in further study. Although this study was unable to retain a higher number of participants during follow-up (40.1% retention), it demonstrated that the inclusion of a prize draw as an incentive at follow-up, and maintaining contact with participants through emails, telephone and face-to-face contact could improve retention of participants (Chapter 5, section 5.7.3). The introduction of two prize draws one at the baseline and another at follow-up (Harkness and Mohler 1998) and the use of short message service (SMS) (Kew 2010) could have improved retention. However, due to resources and constraints around being a research student, it was not possible to implement these strategies.

The poster used for recruitment to the study placed the emphasis on individuals with or without knee problems. It was anticipated that an emphasis on individuals with knee

problems would affect the number of individuals without knee problems volunteering for this study.

This research programme used a self-administered questionnaire to collect data (White et al. 2008) and validated questionnaires were used where possible. The questionnaire was written in easy-to-understand English language and administered under the assumption that the participants understood the questions asked. This ensured the right data was collected. The research student was present to answer any query concerning the questions on the questionnaire. It might be possible that some participants misunderstood the questions, and this can lead to misclassification bias (Bowling 2005) although there is no evidence to support this assumption. The self-administered questionnaire made the study feasible and low cost (Bowling 2005).

BMI as a measurement of obesity was directly measured by only the research student to ensure values were true values and measurement errors were minimised (White et al. 2008). This directly measured height and weight (used to calculate BMI) was used in the analysis instead of self-reported BMI to avoid bias associated with self-reported BMI (Kuczmarski et al. 2001; Wada et al. 2005; Peixoto et al. 2006; Boucher & Maslach 2009; Granberg et al. 2009; Thruston et al. 2010). Such bias could affect the estimation of the relationship between obesity and knee problems. There were 221 (71.1%) participants whose BMI was both self-reported and directly measured (Chapter 6). The missing values of directly measured BMI were imputed to reduce potential bias associated with the missing values, as directly measured BMI was to be used in the analysis. The accuracy of this imputation had been suggested to likely be influenced by different factors, for example, the number of missing values (Razia

Azen and David Budescu 2009). There are 66 (21%) missing values of directly measured BMI (Chapter 6). Imputed values will underestimate the standard error and their respective parameter values (Razia Azen and David Budescu 2009). This is because an error term was not included in the estimate of the imputed data which makes the estimate fit perfectly along the regression line, causing the relationship to be over identified. The degree of underestimation is proportional to the number of cases that have both measurements. In this study, only 71.1% of the cohort have both measurements, hence it is likely the imputed variable might be slightly underestimated. However, such potential bias was minimised, as imputed values replaced only the missing directly measured values and it takes into account the individual's reported BMI rather than being based on an overall average.

On the other hand, the National Institute for Health and Care Excellence (NICE) (2006) advocates caution should be taken when interpreting BMI as it is not a direct measure of obesity. According to NICE, recommendations on the assessment of health risks associated with overweight and obesity should be based on BMI and waist circumference of those with a BMI less than 35kg/m². The waist circumference is one of the proxy measures that measure body fat, which is difficult to measure accurately and consistently across a large sample (National Obesity Observatory 2009). The true measures of body fat are impractical or expensive (due to resource constraint) to use at population level (e.g., bioelectrical impedance analysis or hydro densitometry) (National Obesity Observatory 2009). In the UK, BMI is widely used for research proposes (Dinsdale et al. 2011) as it is an easy, cheap and non-invasive means of assessing excess body fat. It is widely used around the world making comparison possible.

In this study, from the baseline data, participating in high physical activity levels was found to be statistically significant in explaining knee problems. The intensity of exposure to physical activity is a variable that may have affected this relationship. This was measured in this study using the self-report questionnaire IPAQ-long, and self-reporting is related to over reporting of physical activity amount/intensity (Villanueva 2001). Accelerometers, instruments that measure vertical accelerations and intensity of physical activity (Matthews et al. 2002; Kumahara et al. 2004), have been advocated in the literature for direct measurement of physical activity. However, accelerometers do not provide information on the type of physical activity and underestimate activities such as cycling (Lee et al. 2013). Dahaghin et al. (2009) has identified cycling as a risk factor for knee problems and it might be important in planning an intervention. The use of the IPAQ-long questionnaire eliminates such disadvantages. These limitations of measurement of physical activity must be balanced against the considerable strength of this study, which include the large sample size at the baseline, and the descriptive characteristics of the participants (age and gender), and direct measurement of their BMI. In this study, females were more likely to report low physical activity, which is consistent with the report on the general population (Health and Social Care Information Centre 2014). Further research involving the measurement of physical activity and physical inactivity can employ both direct measurement of physical activity and self-reporting, and inclusion of a seven days diary to ensure nothing is missed.

Attrition introduces bias in studies (Marcellus 2004, Ahern & Brocque 2005, Karlson & Rapoff 2009, and Vogt & Johnson 2011) and it is thought to be a significant concern if it exceeds 20% (Marcellus 2004). It has been shown in the literature that long a

follow-up period increases the number of participants that drop out of a study (Karlson & Rapoff 2009). This could explain the 59.9% attrition in this study, despite the inclusion of an incentive at both baseline and follow-up, one strategy recommended to combat the attrition rate (Brueton et al. 2014, and Spring et al. 2014). Notwithstanding this, at follow-up, the cohort remained broadly representative of the baseline cohort.

The prevalence of knee problems at baseline was 31.8%, and 31.7% after 12 months. The similarity of the prevalence at both points of data collection is reassuring given the 59.9% loss to follow up. The holistic approach used in the collection of data on knee problems is good, as it encompass other specific knee disorders. It could suggest the number of new cases of knee problems was balancing out the number of those recovering (Chapter 6). There were nine participants with knee problems at the baseline who did not report knee problems at follow up, whereas 10 participants without knee problems at the baseline reported knee problems at follow up.

8.8 Limitations of the findings of this study

The design of the study increases the risk of recall bias, which could affect the validity of the data on the prevalence of knee problems and the proportion of knee problems attributable to trauma at the baseline. Recall bias may have occurred, as physical activity exposure was recalled retrospectively and may have been overestimated in individuals with knee problems, leading to an overestimation in the relationship between knee problems and physical activity. The results from baseline data (cross-sectional data) made up the bulk part of the findings discussed and could introduce

bias associated with cross-sectional study design. The cross-sectional study measured risk factors and outcome at the same time. Hence, caution should be applied when interpreting and applying the findings from the baseline data as it is difficult to infer the direction of the association between the risk factors (obesity, physical inactivity and physical activity levels) and the outcome (s) (knee problems). As this is cross-sectional, data which is a snapshot of the issue, it is not possible to state if having knee problems lead to more physical activity or if participating in more physical activity leads to knee problems. The relationship might be different if chronicity is measured. Although the lower limit of 95% confidence interval of OR estimates from the incidence data support no association highlighted by the cross-sectional data, the upper limit of 95% confidence interval suggested an effect. The width of the 95% confidence intervals resulting from the relatively small sample size at follow up, suggest such results could be better than chance.

A convenience sample of staff and students of the university was used in the selection of participants. This made the study feasible, which is evident by the large sample size recruited at the baseline. This sampling method could have introduced a selection bias considering the composition of the cohort (for example, a low representation of obese participants in the study and a skewed gender distribution). Chapter 5, section 5.6.2 highlights implication of using convenience sampling. The university enrolls more female (54%) than male (46%) students, but this study recruited more males (56.1%) than females (43.9%). It should also be highlighted that the sample recruited in this study included members of staff, which could explain the imbalance in gender distribution. Weighting of the cohort showed that the proportion of participants that reported knee problems in this study (31.8%) was similar to what it could have been

(31.2%) should the sample be a true representative of the university population with respect to gender distribution. Although the prevalence of knee problems weighted by gender is similar to the expected number in the university population, findings could not be generalised. This is due to other unknown variables not taken into account, for example, gender distribution in the general population, occupation of participants, etc. In the literature, occupation (manual and hard labour) is suggested to be a risk factor for knee problems (Jones et al. 2007). The university population is not a true representative of the general population with respect to occupation which has been demonstrated to be an important risk factor for knee problems (Jones et al. 2007). Some of the participants engage in part-time work. However, the nature of the part-time work and its attribution to the prevalence of knee problems in this study cannot be estimated as such data was not collected. In addition, the most common student part-time work is as sales assistants (34%) and only 0.6% engage in plant machine operations (DfEE 2000). This might not be applicable to student and staff of the university, and, if it was, the extent was not explored in this thesis.

At baseline assessment, there were 30 and 60 missing values for the question on height & weight for self-reported and directly measured respectively. This resulted in the imputation of missing values of direct measure using self-reported values. Although the imputed values were used to replace only those missing, this might have impacted on the estimations performed using the values. Five missing values were noted on the psychological factors variable, 11 on physical inactivity, and two on physical activity. The amount of missing data in this study could have been reduced if adequate time for the checking of completed questionnaires was allocated, although this was improved in the follow-up phase.

In the literature, obesity measured by BMI has been demonstrated to be associated with knee disorders (Gelber et al. 2000; Miranda et al. 2002; Parkkari et al. 2008; Sá et al. 2011; Kuikka et al. 2011; Richmond et al. 2013). This study was not able to replicate such a relationship (Chapter 6, section 6.11.1) which could be as a result of the number of overweight and obese people recruited to this study being lower than reported in the general population (Health and Social Care Information Centre 2014). It could be that the period of study was insufficient for repetitive overloading of knee joint due to high BMI (Dye 1996) to cause significant joint damage (knee problems). In addition, BMI has been criticised as an indicator of body fat which may also have led to it not being observed as an independent risk factor of knee problems (section 8.7, fifth paragraph) (NICE 2006). Another reason could be the direct measurement of BMI used in this study which might have scared off many obese individuals hence, introducing selection bias, as they may not want to identify with things that remind them of their weight due to the perceived social stigma of being obese (Ogden and Clementi 2010). In addition, some of the studies that have demonstrated an association between BMI and knee problems have a higher proportion of their participants being classed as overweight or obese and are less active (Miranda et al. 2002; Sá et al. 2011) compared to this study and this could have influenced their estimates and the precision of their estimates.

From a biomechanical perspective, there are indications that obesity has profound effects on the knee joint which can subsequently cause musculoskeletal lesions (Dye 1996; Wearing et al. 2006), and increases the vulnerability of the knee to early degenerative changes (Dequeker et al. 1983). The relationship between obesity and

knee problems warrants further investigation with a larger sample of a representative of obese individuals, to ascertain the relationship between obesity and knee problems among young adults.

8.9 Implications of the findings for Public Health Specialists

Knee problems among young adults may be higher than anticipated from the literature, as this study found that three in ten young adults have knee problems. Knee problems contribute to functional limitations, demonstrated by mean subscale scores of activities of daily life of KOOS. There are public health implications as a result of the negative health consequences associated with medium and long term outcomes of the early onset of knee problems among young adults (von Porat et al. 2004; Lohmander et al. 2004; Roos 2005). Previous knee problems have been demonstrated to be associated with osteoarthritis in young adults (Roos 2005). Hence a particular focus on knee problems among young adults is warranted given the potentially negative medium and long term outcomes associated with the condition.

Participating in physical activity has health benefits. There is a global recommendation on physical activity for health (WHO 2010) and at the national level by the Department of Health through a white paper: 'Healthy lives, healthy people: A call to action on obesity in England' (DOH 2011) which has promoted participation in physical activity in the population. This is meant to get people to do more and reduce the high prevalence of obesity reported in the general population (Health and Social Care Information Centre 2014). According to the *Active People survey* (APS) that measures sport participation amongst adults aged 16 years and over, younger people are

participating more in physical activity (HSE 2012). From APS7 2012/2013, 15.3 million adults (35.2%) played sport at least once a week which is an increase of 1.4 million adults compared to APS 2005/2006 (HSE 2012). Although, men (67%) and women (55%) aged 16 and over meet the recommendation of aerobic activity there are still men (19%) and women (26%) who are inactive, and the percentage of those meeting the recommendation of aerobic activity decreases with age (Health and Social Care Information Centre 2014). The present study found that participating in a high physical activity level is associated with a higher risk of knee problems, and a quadratic relationship exists between knee problems and physical inactivity. A high prevalence of knee problems may subsequently lead to a high incidence of the early onset of knee osteoarthritis going into mid adulthood.

Although evidence from this study did not consider the longer term outcomes of knee problems, knee disorders could lead to longer term physical impairment resulting in decreased mobility (Thibault et al. 2010). Hence, there is a need for an incidence study which will inform preventative action. The impact of knee problems on functional status and quality of life has been documented in the literature (Agaliotis et al. 2013). This study shows that for those who reported a knee problem their quality of life was affected. Such an effect can lead to lost productivity (Agaliotis et al. 2013). This lost productivity impacts upon the individual and national economy as it affects the state through lost revenue from taxation, and increased need for benefits due to disability and low-income. The economic costs need to be considered in the context of the prevalence of knee problems to appreciate the overall societal economic impact.

Public health specialists and public health commissioners should be aware of the actual level of the burden of knee problems among young adults and inform future

policies. In the literature, training and warm-up before engaging in activity has been found to reduce the incidence of knee problems (Aaltonen et al. 2007). A guideline is needed to highlight the implications of engaging in physical activity and ways to prevent knee problems associated with it. Public health commissioners should work in partnership with organisations that work with sport populations, schools, colleges and younger people in the draft of such guidelines and their promotion. Such strategic action will help in planning and allocation of funds targeting prevention of knee problems among young adults.

8.10 Implications of the findings for Clinicians

Clinicians should be aware that the prevalence of knee problems is high in the age group 18 to 40 years old. Gradual onset of knee problem was more common than traumatic onset. Knee pain was the most prevalent symptom but how it developed was not related to trauma. Chronicity of knee problems was not directly measured in this study but was suggested as most participants with knee problems at baseline also had knee problems at follow up. This challenges the long-held belief that knee problems which have gradual onset are usually self-limiting (Lankhorst et al. 2015).

Clinicians should be aware that BMI used to measure obesity in this study was not found to be an independent risk factor for knee problems; although the OR suggested that there were more knee problems as BMI increased and the upper 95% confidence limit was consistent with a large effect. Clinicians should be aware that participating in a high level of physical activity may be an independent risk factor for knee problems; this might suggest a greater emphasis by clinicians on prevention. From this

thesis it could be suggested that knee problems affect quality of life, although function of daily activities might not be greatly affected. In this study being mentally distressed was also associated with knee problems although the direction of the association is unclear because the data was cross-sectional data. Clinicians should be aware that it is likely that a patient presenting with knee problems might be mentally distressed (Mercer et al. 2012) and this might impact on their compliance with advice. Hence, clinicians should embrace patient-centred care with patients presenting with knee problems. This could include a holistic assessment and management of possible psychological factors. Using the expectations of the patient to inform treatment might improve their quality of life.

8.11 Implications of the findings for Researchers

This study was able to show some interesting findings, but the implications of these are limited because of the number of participants followed up. From this thesis, it could be suggested that a more generic definition of knee problems is needed. A qualitative study might give more in-depth understanding about how knee problems impact young adults (Creswell and Clark 2007; Colin 2011). This study suggests that knee problems may be chronic in this population. There is need for further investigation to confirm and find out the factors that are associated with knee problems becoming chronic and acute. Physical activity and being mentally distressed may be independent risk factors for knee problems but BMI and physical inactivity were less conclusive. The association of psychological factors with the onset of musculoskeletal pain has also been shown in literature (Pincus et al. 2002; Christensen & Knardahl 2010; Phyomaung et al. 2014). These could not be confirmed in the incidence study

due to the low response rate at follow-up, hence, a larger study of incidence in young adults in general populations with better follow up strategies are needed to confirm findings. There is need to undertake a study that explores the economic burden of knee problems among young adults as this would influence policy on prevention and management of knee problems among young adults.

Chapter 9.0 Summary

One of the most common sites for musculoskeletal disorder is the knee (Urwin et al. 1998; Jinks et al. 2004; Peach et al. 2005). Knee disorders can lead to a reduction in functional ability, increased dependency, reduced participation in major daily activities and substantial health service and personal costs (WHO 2003; Ackerman et al. 2015). Obesity and physical inactivity which are associated with chronic knee disorders in older people have become more prevalent in younger adults.

A systematic review of 19 studies reporting on the incidence of and/or risk factors for knee disorders in young adults (chapter 2) confirmed that most studies have been undertaken in military and sports populations and focussed on specific knee conditions. There was conflicting evidence on obesity and physical activity as risk factors for the incidence of knee problems among young adults and no investigation of physical inactivity. This prompted an epidemiological feasibility study of knee problems among young adults attending one university using a definition of knee problems that encapsulated any type of knee problem. For the feasibility study, this thesis defined the outcome measure “knee problem” as a deviation from the normal function of the knee joint with or without any unpleasant sensation around the joint area.

The feasibility study consisted of a cross-sectional study to investigate prevalence of knee problems and a cohort study to investigate incidence and the relationship between knee problems and obesity, physical inactivity and physical activity. It was designed as a feasibility study to inform a large-scale cohort study in the general population.

Three hundred and fourteen staff and students of the University of Central Lancashire were recruited and followed up for 12 months. Data was collected through self-report questionnaires (HSCL- 10 [to measure mental distress], KOOS [to measure knee severity], SNAPPS [to measure traumatic and gradual onset]) and IPAQ-Long form. When possible direct measurement of height and weight in order to calculate BMI. The IPAQ-Long questionnaire was used to measure physical activity and physical inactivity (sitting time). Logistic regression was used to investigate any plausible relationship between knee problems and BMI, physical inactivity, and physical activity levels.

The mean (SD) age of participants was 22 (5.2) years. There were more men (n=176, 56.1%) than woman (n=138, 43.9%). The mean (SD) score of HSCL-10 (mental distress) was 1.5 (0.4), mean (SD) BMI was 24.3 (4.1), and mean (SD) total hours spent sitting per day at baseline was 5.6 hours (2.6). Over half of the participants (n=165, 52.9%) reported low physical activity with similar proportions reporting moderate (n= 75, 24.0%), and high (n= 72, 23.1%) physical activity levels.

The prevalence of knee problems was high 31.8% [95% CI 26.9% to 37.2%] in the cross-sectional study and more than 40% of the participants who reported knee problems had never seen a doctor concerning knee problems. The difference in the prevalence of knee problems across gender was not significant (p-value = 0.74); the holistic definition of knee problems cancelled out the gender differences noted across the different knee conditions.

Knee pain was the most prevalent symptom but 7% reported experiencing giving way or feeling like the knee will give way, and 2% reported locking as a predominant symptom. In those who reported knee problem, the knee problem had come on gradually rather than following a sudden injury. Exploring knee problems among young adults just focusing on knee pain or injury may lead to an underestimation of the impact of knee problems in this population. This is important because those with knee problems had low quality of life scores.

Only 126 (40.1%) participants responded to the follow up at 12 months. Three quarters of those with knee problems at baseline still had problems at 12 months and the incidence of new knee problems was 11.5%.

Because of the low response rate, the relationship between knee problems and obesity, physical activity and physical inactivity was explored using cross-sectional data. Multivariate logistic regression analysis on cross-sectional data showed that high physical activity levels (OR 2.6 [95% CI 1.4-4.9]) and mental distress (OR 2.3 [95% CI 1.2-4.6]) were the only independent risk factors.

9.1 Conclusion

This study showed that the prevalence of knee problems is high and sustained in young adults. The incidence study provides an estimate that can be used for sample size estimation in the design of a future large scale population based-study that explores the incidence of knee problems in young adults. This study suggests that physical activity may be a risk factor for knee problems in this age group. However, the follow up rate was low, and this finding could not be confirmed using incident data. A large

scale cohort population based study with lower attrition is needed. This is important because there is increasing emphasis on promoting physical activity in the population, and more attention may need to be paid towards prevention of knee problems. Quality of life among those with knee pain was low and mental distress was associated with knee problems, therefore future studies are needed to evaluate the economic burden of knee problems among young adults as this could influence policy in relation to management of knee problem.

10.0 References

- Aaltonen S, Karjalainen H, Heinonen A, et al. (2007) Prevention of sports injuries: systematic review of randomized controlled trials. *Arch Intern Med.*, 167:1585–92.
- Ackerman IN, Bucknill A, Page RS, Broughton NS, Roberts C, Cavka B, Schoch P, Brand CA. (2015) The substantial personal burden experienced by younger people with hip or knee osteoarthritis. *Osteoarthritis and Cartilage.* 23 (8) 1276-1284.
- Agaliotis M, Fransen M, Bridgett L, Nairn L, Votrubec M, Jan S, Heard R, Mackey M. (2013) Risk factors associated with reduced work productivity among people with chronic knee pain. *Osteoarthritis Cartilage*, 21, 1160–1169.
- Agaliotis M, Mackey MG, Jan S, Fransen M. (2014) Burden of reduced work productivity among people with chronic knee pain: A systematic review. *Occupational and Environmental Medicine.* 71 (9) 651-659.
- Ahern K, Le Brocque R. (2005) Methodological issues in the effects of attrition: Simple solutions for social scientists. *Field Methods*, 17:53-69.
- Alan Agresti (2007) *An introduction to categorical data analysis.* 2nd Ed. Hoboken, NJ, John Wiley & Sons, Inc.
- American Statistical Association (1999) *Ethical guidelines for statistical practice.* Alexandria (Virginia): American Statistical Association.
- Andreyeva T, Puhl RM, Brownell KD. (2008) Changes in perceived weight discrimination among Americans, 1995-1996 through 2004-2006. *Obesity (Silver Spring)*, 16:1129–1134.

Arai L, Britten N, Popay J, Roberts H, Petticrew M, Rodgers M, Sowden A (2007) 'Testing Methodological Developments in the Conduct of Narrative Synthesis: A Demonstration Review of Research on the Implementation of Smoke Alarm Interventions', *Evidence and Policy*, 3: 361–83.

Armitage P, Berry G. (1987) *Statistical methods in medical research*, 2nd Ed. Oxford: Blackwell Scientific Publications.

Azen R, Budescu D. (2009). Application of multiple regression in Psychological Research in Millsap ER, Maydeu-Olivares A. Eds. (2009) *The SAGE Handbook of Quantitative Methods in Psychology*.

Barchard KA, Pace LA. (2008) Meeting the challenge of high quality data entry: A free double-entry system. *International Journal of Services and Standards*, 4 (4): 359–376.

Barchard KA, Pace LA. (2011) Preventing human error: The impact of data entry methods on data accuracy and statistical results. *Computers in Human Behavior*, 27 (5):1834–1839.

Barchard KA, Verenikina Y. (2013) Improving data accuracy: Selecting the best data checking technique. *Computers in Human Behavior* 29: 1917–1922.

Bellamy N, Campbell J, Stevens J, Pilch L, Stewart C, Mahmood Z. (1997) Validation study of a computerized version of the western Ontario and McMaster universities VA30 osteoarthritis index. *Journal of Rheumatology*, 24 (12):2413–2415.

Bhopal R. (2002) *Concepts of Epidemiology: An Integrated introduction to ideas, theories, principles and methods of epidemiology*. Oxford. Oxford University Press.

Bland JM, Altman DG (1986) Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet*, 1(8476):307-310.

Boling M, Padua D, Marshall S, Guskiewicz K, Pyne S, Beutler A. (2010) Gender differences in the incidence and prevalence of patellofemoral pain syndrome. *Scand J Med Sci Sports*, 20:725-730.

Boling M, Padua D, Marshall S, Guskiewicz K, Pyne S, Beutler A. (2009) Gender differences in the incidence and prevalence of patellofemoral pain syndrome. *Scandinavian Journal of Medicine & Science in Sports*, 9999(9999):1–6.

Booth FW, Laye M J, Roberts M D. (2011) Lifetime sedentary living accelerates some aspects of secondary aging. *Journal of Applied Physiology*, 111(5):1497–1504.

Boucher HC, Maslach C. (2009) Culture and individuation: The role of norms and self-construals. *J Soc Psychol.*, 149:677–693.

Bowling A. (2005) Mode of questionnaire administration can have serious effects on data quality. *Journal of Public Health*, 27 (3): 281-291.

Bowling, A. (2014). Quality of life: measures and meanings in social care research. London, GB, NIHR School for social care research.
<http://eprints.soton.ac.uk/373668/1/MR16.pdf>

Briggs KK, Lysholm J, Tegner Y, Rodkey WG, Kocher MS, Steadman JR. (2009) The reliability, validity, and responsiveness of the Lysholm score and Tegner activity scale for anterior cruciate ligament injuries of the knee: 25 years later. *American Journal of Sports Medicine*, 37 (5): 890–897.

Brueton VC, Tierney JF, Stenning S, Meredith S, Harding S, Nazareth I, Rait G. (2014) Strategies to improve retention in randomised trials: a Cochrane systematic review and meta-analysis. *BMJ Open*, 4:e003821. doi:10.1136/bmjopen-2013-003821.

Butland B, Jebb S, Kopelman P, McPherson K, Thomas S, Mardell J, Parry V. (2007) Foresight tackling obesity: future choices project report. 2nd Edition. UK: Government Office for Science.

Callaghan M, Selfe J, Dey P. (2009) Activity-associated pain in patellofemoral pain syndrome: how does it inform research and practice? *Physiotherapy*, 95(4):321-2.

Callaghan M, Selfe J. (2007) Has the incidence or prevalence of patellofemoral pain in general population in the United Kingdom been properly evaluated? *Physical Therapy in Sport*, 8:37-43

Campbell MK, Grimshaw JM. (1998) Cluster randomized trials: time for improvement. The implications of adopting a cluster design are still largely being ignored. *BMJ*, 317:1171–1172.

Carey JL, Huffman GR, Parekh SG, Sennett BJ. (2006) Outcomes of anterior cruciate ligament injuries to running backs and wide receivers in the National Football League. *American Journal of Sports Medicine*, 34(12):1911-7.

Carr S, Unwin N, Pless-Mulloli T. (2007) An introduction to Public Health and Epidemiology. 2nd Ed. Berkshire. Open University Press.

Caselli MA, Longobardi SJ. (1997) Lower extremity injuries at the New York City Marathon. *J Am Podiatr Med Assoc.*, 87:34–7.

Chapple CM, Nicholson H, Baxter GD, Abbott JH. (2011) Patient characteristics that predict progression of knee osteoarthritis: a systematic review of prognostic studies. *Arthritis Care Res.*, 63(8):1115–1125.

Chen A, Gupte C, Akhtar K, Smith P, Cobb J. (2012) The Global Economic Cost of Osteoarthritis: How the UK Compares. *Arthritis*, ID 98709, 6. doi:10.1155/2012/698709.

Chiolero A, Peytremann-Bridevaux I, Paccaud F. (2007) Associations between obesity and health conditions may be overestimated if self-reported body mass index is used. *Obes Rev.*, 8:373–374.

Christensen J, Knardahl S. (2010) Work and neck pain: a prospective study of psychological, social, and mechanical risk factors. *Pain*, 151(1):162–173.

Clinical Epidemiology. 56 (8):730e5.

Colin R. (2011) Real world research: a resource for users of social research methods in applied settings. 3rd Edition. West Sussex: John Wiley & Sons.

Collins NJ, Bierma-Zeinstra SM, Crossley KM, van Linschoten RL, Vincenzino B, van Middelkoop M. (2013) Prognostic factors for patellofemoral pain: a multicentre observational analysis. *Br J Sports Med.*, 47(4):227-233.

Collins NJ, Misra D, Felson DT, Crossley KM, Roos EM. (2011) Measures of knee function: International Knee Documentation Committee (IKDC) Subjective Knee Evaluation Form, Knee Injury and Osteoarthritis Outcome Score (KOOS), Knee Injury and Osteoarthritis Outcome Score Physical Function Short Form (KOOS-PS), Knee Outcome Survey Activities of Daily Living Scale (KOS-ADL), Lysholm Knee Scoring Scale, Oxford Knee Score (OKS), Western Ontario and McMaster

Universities Osteoarthritis Index (WOMAC), Activity Rating Scale (ARS), and Tegner Activity Score (TAS) Arthritis Care Research, 63(S11):S208–S228.

Concato J, Peduzzi P, Holford TR, Feinstein AR. (1995) Importance of events per independent variable in proportional hazards analysis. I. Background, goals, and general strategy. *J Clin Epidemiology.*, 48:1495-1501.

Craig CL, Marshall AL, Sjostrom M, et al. (2003) International physical activity questionnaire: 12 country reliability and validity. *Med Sci Sports Exercise*, 35:1381–95.

Creswell JW and Plan Clark VI. (2007) *Designing and conducting mixed methods research*. London: Sage Publication Inc.

Crossley KM, Bennell KL, Cowan SM, Green S. (2004) Analysis of outcome measures for persons with patellofemoral pain: which are reliable and valid? *Archives of Physical Medicine and Rehabilitation*. 85(5):815e22.

Curtis L. (2009) *Unit Costs of Health and Social Care*, Personal Social Services Research Unit, The University of Kent, Kent, UK.

Dahaghin, S, Tehrani-Banihashemi, S A, Faezi S T, Jamshidi A R, Davatchi F. (2009) Squatting, sitting on the floor, or cycling: Are life-long daily activities risk factors for clinical knee osteoarthritis? Stage III results of a community-based study. *Arthritis & Rheumatism*, 61:1337–1342. doi: 10.1002/art.24737.

Dancey CP, Reidy JG, Rowe R. (2012) *Statistics for the Health Sciences: a non-mathematical introduction*. London, Sage Publications.

Davies AP. (2002) Rating systems for total knee replacement. *Knee*, 9:261–6.

Dawson J, Fitzpatrick R, Murray D, Carr A. (1998) Questionnaire on the perceptions of patients about total knee replacement. *Journal of Bone & Joint Surgery Br*, 80:63–9.

De Groot IB, Favejee MM, Reijman M, Verhaar JAN, Terwee CB. (2008) The Dutch version of the Knee Injury and Osteoarthritis Outcome Score: a validation study. *Health Qual Life Outcomes*, 6:16–22.

de Loes M, Dahlstedt LJ, Thomee R. (2000) A 7-year study on risks and costs of knee injuries in male and female youth participants in 12 sports. *Scan J Med Sci Sports*, 10:90–7.

Department for Education and Employment (DfEE). (2000) *Students in The Labour Market Nature, Extent and Implications of Term-Time Employment Among University of Northumbria Undergraduates*. Her Majesty's Stationery Office. Norwich.

Dequeker J, Goris P, Uytterhoeven R. (1983) Osteoporosis and osteoarthritis (osteoarthrosis). Anthropometric distinctions. *JAMA*, 249:1448–51.

Derogatis LR, Lipman RS, Rickels K, et al. (1974) The Hopkins Symptom Checklist (HSCL): a self-report symptom inventory. *Behav Science*, 1:1-15.

Dey P, Callaghan M, Cook N, Sephton R, Sutton C, Hough E, James J, Saqib R, Selfe J. (2016) A questionnaire to identify patellofemoral pain in the community: an exploration of measurement properties. *BMC Musculoskeletal Disorders*. 17:237. doi:10.1186/s12891-016-1097-5.

Dey P, Callaghan M, Erande R, Paterson L, Cook N, Selfe J. (2012) Cohort Studies in Patellofemoral Pain Syndrome: The search for Modifiable Risk Factors: A Systematic

Review and Critique presented in 2nd International Research Retreat, August 31-September 2, 2011, Ghent, Belgium,” J Orthop Sports Phys Therapy, 42(6):A1-A18. doi:10.2519/jospt.2012.0301.

Dinsdale H, Ridler C, Ells L J (2011) A simple guide to classifying body mass index in children. Oxford: National Obesity Observatory. http://www.noo.org.uk/uploads/doc/vid_11762_classifyingBMIinchildren.pdf

Downs SH, Black N. (1998) The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions J Epidemiology Community Health, 52: 377–384.

Duvigneaud N, Bernard E, Stevens V, Witvrouw E, Van Tiggelen D. (2008) Isokinetic assessment of patellofemoral pain syndrome: a prospective study in female recruits. Isokinetics Exerc Sci., 16: 213– 219.

Dye SF. (1996) The knee as a biologic transmission with an envelope of function: a theory. Clin Orthop Relat Res., (325):10- 18.

Ekelund U, Sepp H, Brage S, Becker W, Jakes R, Hennings M, Wareham NJ. (2006) Criterion-related validity of the last 7-day, short form of the International Physical Activity Questionnaire in Swedish adults. Public Health Nutr, 9(2):258-65.

Elgar FJ, Roberts C, Tudor-Smith C, Moore L. (2005) Validity of self-reported height and weight and predictors of bias in adolescents. J Adolescent Health, 37:371–375.

Ells LJ, Lang R, Shield JPH, Wilkinson JR, Lidstone JSM, Coulton S, et al. (2006) Obesity and disability—a short review. Obesity Reviews, 7(4):341–5.

El-Metwally A, Salminen JJ, Auvinen A, Macfarlane G, Mikkelsen M. (2007) Risk factors for development of non-specific musculoskeletal pain in preteens and early adolescents: a prospective 1-year follow-up study. *BMC Musculoskel Dis.*, 8:46.

Engelbrechtsen A H, Myklebust G, Holme I, Engelbrechtsen L, Bahr R. (2011) Intrinsic risk factors for acute knee injuries among male football players: a prospective cohort study. *Scandinavian Journal of Medicine & Science in Sports*, 21: 645–652.

Englund M, Roos EM, Lohmander LS. (2003) Impact of type of meniscal tear on radiographic and symptomatic knee osteoarthritis: a sixteen-year follow up of meniscectomy with matched controls. *Arthritis Rheum.*, 2003; 48:2178-2187.

Engstrom B, Johansson C, Tornkvist H. (1991) Soccer injuries among elite female players. *Am J Sports Med.*, 19:372–5.

Engstrom JL, Paterson SA, Doherty A, Trabulsi M, Speer KL. (2003) Accuracy of self-reported height and weight in women: an integrative review of the literature. *J Midwifery Womens Health*, 48:338–345.

Ezzati M, Martin H, Skjold S, Vander Hoorn S, Murray CJ. (2006) Trends in national and state-level obesity in the USA after correction for self-report bias: Analysis of health surveys. *JR Soc Medicine*, 99:250–257.

Fairbank JC, Pynsent PB, van Poortvliet JA, Phillips H. (1984) Mechanical factors in the incidence of knee pain in adolescents and young adults. *J Bone Joint Surg Br.*, 66:685–693.

Feller JA, Webster KE. (2003) A randomized comparison of patellar tendon and hamstring tendon anterior cruciate ligament reconstruction. *American Journal of Sports Medicine*, 31:564-573.

Felson DT, Naimark A, Anderson J, Kazis L, Castelli W, Meenan RF. (1987) The prevalence of knee osteoarthritis in the elderly. The Framingham Osteoarthritis Study. *Arthritis Rheum.*, 30(8):914-918.

Felson DT, Niu J, McClennan C, Sack B, Aliabadi P, Hunter DJ, Guermazi A, Englund M. (2007) Knee Buckling: Prevalence, Risk Factors, and Associated Limitations in Function. *Ann Intern Med.*, 147:534-540. doi:10.7326/0003-4819-147-8-200710160-00005.

Felson DT, Zhang Y, Hannan MT, Naimark A, Weissman B, Aliabadi P, et al. (1997a). Risk factors for incident radiographic knee osteoarthritis in the elderly: the Framingham Study. *Arthritis Rheum.*, 40:728-33

Fitzpatrick R, Davey C, Buxton MJ, Jones DR. (1998) Evaluating patient-based outcome measures for use in clinical trials. *Health Technology Assessment*, 2: 1 -74.

Fransen J, van Riel PLCM (2009) Outcome measures in inflammatory rheumatic diseases. *Arthritis Research & Therapy*, 11: 244.

Galbraith S, Daniel JA, Vissel B. (2010) A study of clustered data and approaches to Its analysis. *Journal of Neuroscience* 30: 10601–10608.

Gambling Commission (2009)
<http://www.gamblingcommission.gov.uk/pdf/prize%20competitions%20and%20free%20draws%20-%20the%20requirements%20of%20the%20gambling%20act%202005%20-%20december%202009.pdf>

Garratt AM, Brealey S, Gillespie WJ. (2004) Patient-assessed health instruments for the knee: a structured review. *Rheumatology (Oxford)*, 43:1414–23.

Gelber A C, Hochberg MC, Mead LA, Wang NY, Wigley FM, Klag MJ. (2000) Joint Injury in Young Adult and Risk for Subsequent Knee and Hip Osteoarthritis. *Annals of Internal Medicine*, 133(5):321 – 328.

Giugliano DN, Solomon JL. (2007) ACL tears in female athletes. *Phys Med Rehabil Clin N Am.*, 18:417–38i.

Glasziou P, Irwig L, Bain C, Colditz G. (2001) *Systematic Reviews in Health Care: A Practical Guide*. Cambridge. Cambridge University Press.

Gobbi, A., Tuy, B., Mahajan, S., Panuncialman, I. (2003) Quadrupled bone-semitendinosus anterior cruciate ligament reconstruction: a clinical investigation in a group of athletes. *Arthroscopy: Journal of Arthroscopic & Related Surgery*, 19:691-699.

Gorber SC, Tremblay M, Moher D, Gorber B. (2007) A comparison of direct vs. self-report measures for assessing height, weight and body mass index: a systematic review. *Obes Rev.*, 8:307–326.

Gorber SC, Tremblay MS. (2010) The bias in self-reported obesity from 1976 to 2005: A Canada-US comparison. *Obesity*, 2 (18) 354 – 361.

Göritz AS (2006) Incentives in web studies: Methodological issues and a review. *International Journal of Internet Science*, 1 (1): 58–70.

Granberg EM, Simons LG, Simons RL. (2009) Body size and social self-image among adolescent African American girls: The moderating influence of family racial socialization. *Youth Soc.*, 41:256–277

Griebeler ML, Levis S, Gómez-Marín O. (2011) Self-Reported Versus Measured Height and Weight in Hispanic and Non-Hispanic Menopausal Women. *Journal of Women's Health*, 20(4): 599 – 604.

Grotle M, Hagen KB, Natvig B, Dahl FA, Kvien TK. (2008) Prevalence and burden of osteoarthritis: results from a population survey in Norway. *J Rheumatol.*, 35:677-84.

Haavet OR, Sirpal MK, Haugen W, Christensen KS. (2011) Diagnosis of depressed young people in primary health care—a validation of HSCL-10. *Family Practice*, 28: 233–237.

Hair J F Jr., Anderson R E, Tatham R L, Black WC. (1995) *Multivariate Data Analysis*. 3rd Ed. New York: Macmillan.

Halvorsen JA, Dalgard F, Thoresen M, Bjertness E, Lien L. (2009) Itch and mental distress: results from a cross-sectional study among adolescents. *Acta Derm Venereol*, 89:39–44.

Hamilton P, Lemon M, Field RE, Issue R. (2009) Cost of total hip and knee arthroplasty in the UK. A comparison with the current reimbursement system in the NHS. *Journal of Bone and Joint Surgery B*, 91 (1) 112.

Harkness, J. and Mohler, P. (1998) Two Experiments with Incentives on Mail Surveys in Germany. *Survey Methods Newsletter*, 18(2): 15-20.

Health and Social Care Information Centre (2014) *Statistics on Obesity, Physical Activity and Diet: England*. <http://www.hscic.gov.uk/catalogue/PUB13648/Obes-phys-acti-diet-eng-2014-rep.pdf>

Health Survey for England - 2012, Trend tables [NS]

<http://www.hscic.gov.uk/catalogue/PUB13219>

Healthy lives, healthy people: A call to action on obesity in England. Department of Health (DOH) (2011)

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/213720/dh_130487.pdf

Hemmingsson H, Jonsson H. (2005) An occupational perspective on the concept of participation in the international classification of functioning, disability and health—Some critical remarks. *American Journal of Occupational Therapy*, 59: 569–576.

Hetsroni I, Finestone A, Milgrom C, Sira DB, Nyska M, Radeva-Petrova D, Ayalon M. (2006) A prospective biomechanical study of the association between foot pronation and the incidence of anterior knee pain among military recruits. *J Bone Joint Surg Br.*, 88 (7):905–908.

Hewett TE, Lindenfeld TN, Riccobene JV, et al. (1999) The effect of neuromuscular training on the incidence of knee injury in female athletes: A prospective study. *American Journal of Sports Medicine*, 27:699–706.

Hewett TE, Myer GD, Ford KR. (2004) Puberty decreases dynamic knee stability in female athletes: a potential mechanism for increased ACL injury risk. *J Bone Joint Surg Am.*, 86A:1601–8.

Hewett TE, Myer GD, Ford KR. (2006) Anterior cruciate ligament injuries in female athletes: Part 1, mechanisms and risk factors. *Am J Sports Med.*, 34:299–311.

- Higgins LD, Taylor MK, Park D, Ghodadra N, Marchant M, Pietrobon R, et al. (2007) Reliability and validity of the international knee documentation committee (IKDC) subjective knee form joint, bone, spine. *Revue du Rheumatism*, 74 (6): 594–599
- Higgins PT, Green S Eds. (2009) *Cochrane Handbook for Systematic Reviews of Interventions*, The Cochrane Collaboration, London, UK.
- Hootman JM, Macera CA, Ainsworth BE, et al. (2002) Predictors of lower extremity injury among recreationally active adults. *Clin J Sport Med.*, 12:99–106.
- Horn PS, Feng L, Li Y, Pesce AJ. (2001) Effect of outliers and non-healthy individuals on reference interval estimation. *Clin Chem.*, 47:2137–2145.
- Hosmer D W, Lemeshow S, Sturdivant RX. (2013) *The Multiple Logistic Regression Model*, in *Applied Logistic Regression*. 3rd Ed. Hoboken, NJ, John Wiley & Sons, Inc.
- Howe TE, Dawson LJ, Syme G, Duncan L, Reid J. (2012) Evaluation of outcome measures for use in clinical practice for adults with musculoskeletal conditions of the knee: A systematic review. *Manual Therapy*, 17(2):100 – 118.
- Hsiao M, Owens BD, Burks R, Sturdivant RX, Cameron KL. (2010) Incidence of acute traumatic patellar dislocation among active-duty United States military service members. *Am J Sports Med.*, 38:1997-2004.
- Imrie R. (2004). Demystifying disability: A review of the international classification of functioning, disability and health. *Sociology of Health & Illness*, 26(3): 287–305.
- Ingram JG, Fields SK, Yard EE, Comstock RD. (2008) Epidemiology of knee injuries among boys and girls in US high school athletics. *Am J Sports Med.*, 36:1116 – 22.

Irrgang JJ, Anderson AF, Boland AL, Harner CD, Kurosaka M, Neyret P, et al. (2001) Development and validation of the international knee documentation committee subjective knee form. *American Journal of Sports Medicine*, 29 (5): 600–613.

Jhun H-J, Sung N-J, Kim SY (2013) Knee Pain and Its Severity in Elderly Koreans: Prevalence, Risk Factors and Impact on Quality of Life. *Journal of Korean Medical Science*, 28(12):1807-1813.

Jinks C, Jordan K P, Blagojevic M and Croft P. (2008) Predictors of onset and progression of knee pain in adults living in the community. A prospective study. *Rheumatology*, 47:368–374

Jinks C, Jordan K, Croft P. (2006) Disabling knee pain—another consequence of obesity: results from a prospective cohort study. *BMC Pub Health*, 6:258.

Jinks C, Jordan K, Ong BN, Croft P. (2004) A brief screening tool for knee pain in primary care (KNEST). 2. Results from a survey in the general population aged 50 and over. *Rheumatology*, 43:55–61

Jinks C, Lewis M, Ong BN, Croft P. (2001) A brief screening tool for knee pain in primary care 1 validity and reliability *Rheumatology*, 40 (5): 528–536.

Johnson DS, Smith RB. (2001) Outcome measurement in the ACL deficient knee. What's the score? *Knee*, 8:51–7.

Jones GT, Harkness EF, Nahit ES, McBeth J, Silman AJ, Macfarlane GJ. (2007) Predicting the onset of knee pain: Results from a 2-year prospective study of new workers. *Ann Rheum Dis.*, 66:400–6.

Jones JC, Burks R, Owens BD, Sturdivant RX, Svoboda SJ, Cameron KL.(2012) Incidence and Risk Factors Associated with Meniscal Injuries Among Active-Duty US Military Service Members. *Journal of Athletic Training*, 47(1):67-73.

Jordan JM, Helmick CG, Renner JB, et al. (2007b) Prevalence of knee symptoms and radiographic and symptomatic knee osteoarthritis in African Americans and Caucasians: The Johnston County Osteoarthritis Project. *J Rheumatol.*, 34(1):172-180.

Jordan K, Clarke AM, Symmons DP, Fleming D, Porcheret M, Kadam UT, Croft P. (2007a) Measuring disease prevalence: a comparison of musculoskeletal disease using four general practice consultation databases. *Br J Gen Pract.*, **57**:7-14.

Jordan KP, Kadam UT, Hayward R, Porcheret M, Young C, Croft P. (2010) Annual consultation prevalence of regional musculoskeletal problems in primary care3: an observational study. *BMC Musculoskeletal Disorder*, 11:144.

Karlson CW and Rapoff MA. (2009). Attrition in randomized controlled trials for Paediatric chronic conditions. *Journal Paediatric Psychology*, 34(7):782 – 793.

Kawado M, Hinotsu S, Matsuyama Y, Yamaguchi T, Hashimoto S, Ohashi Y. (2003) A comparison of error detection rates between the reading aloud method and the double data entry method. *Controlled Clinical Trials*, 24 (5):560–569.

Kerry SM, Bland JM. (1998) The intra-cluster correlation coefficient in cluster randomization. *BMJ*, 316:1455–1460.

Kew S. (2010) Text messaging: an innovative method of data collection in medical research. *BMC Research Notes*. 3:342. doi: 10.1186/1756-0500-3-342.

Ki FY, Liu JP, Wang W, Chow SC. (1995) The impact of outlying subjects on decision of bio-equivalence. *J Biopharm Stat.*, 5:71–94.

Kirkley A, Griffin S, Whelan D (2007) The development and validation of a quality of life-measurement tool for patients with meniscal pathology: the western Ontario Meniscal Evaluation Tool (WOMET). *Clinical Journal of Sports Medicine*, 17 (5):349–356.

Kuczmarski MF, Kuczmarski RJ, Najjar M. (2001) Effects of age on validity of self-reported height, weight, and body mass index: Findings from the Third National Health and Nutrition Examination Survey, 1988–1994. *J Am Diet Association*, 101:28–34.

Kuikka PI, Pihlajamäki HK, Mattila VM. (2011) Knee injuries related to sports in young adult males during military service – Incidence and risk factors. *Scand J Med Sci Sports*, Doi: 10.1111/j.1600-0838.2011.01397

Kumahara H, Schutz Y, Ayabe M, et al. (2004) The use of uniaxial accelerometry for the assessment of physical-activity-related energy expenditure: a validation study against whole-body indirect calorimetry. *The British journal of nutrition*, 91:235–43.

Kutner M H, Nachtsheim C J, Neter J. (2004) *Applied Linear Regression Models*, 4th Ed. McGraw-Hill Irwin.

Kvist J, Ek A, Sporrstedt K, Good L. (2005) Fear of re-injury: a hindrance for returning to sports after anterior cruciate ligament reconstruction. *Knee Surg Sports Traumatol Arthrosc.*, 13: 393–397.

Lankhorst N E, Bierma-zeinstra S M A, Middelkoop M V. (2012) Risk Factors for Patellofemoral Pain Syndrome: A Systematic Review. *J Orthop Sports Phys Ther*, 42(2):81-94. doi:10.2519/jospt.2012.3803.

Lankhorst NE, van Middelkoop M, Crossley KM, Bierma-Zeinstra SMA, Oei EHG, Vicenzino B, Collins NJ (2015) Five to eight year course and prognosis of patellofemoral pain: A multicentre observational analysis. Accepted for publication in *Br J of Sports Med*.

Laprade JA, Culham EG. (2002) A self-administered pain severity scale for patellofemoral pain syndrome. *Clinical Rehabilitation*, 16 (7):780–788.

Lee J, Song J, Hootman J M, Semanik P A, Chang RW, Sharma L, Dunlop D D. (2013). Obesity and Other Modifiable Factors for Physical Inactivity Measured by Accelerometer in Adults with Knee Osteoarthritis: Data from the Osteoarthritis Initiative (OAI). *Arthritis Care & Research*, 65(1):53–61. <http://doi.org/10.1002/acr.21754>

Lephart SM, Perrin DH, Fu FH, et al. (1992) Relationship between selected physical characteristics and functional capacity in the anterior cruciate ligament-insufficient athlete. *J Orthop Sports Phys Ther*. 16:174–181.

Ling J, Fransen M, Kang X, Kang X, Li H, Ke Y, Wang Z, Zhang Y, Su S. (2010) Marked disability and high use of nonsteroidal anti-inflammatory drugs associated with knee osteoarthritis in rural China: a cross-sectional population-based survey. *Arthritis Research & Therapy*, 12(6):R225. doi:10.1186/ar3212.

Lipman RS, Covi L, Shapiro AK. (1979) The Hopkins Symptom Checklist (HSCL) – factors derived from the HSCL-90. *J Affective Disorders* 1: 9–24.

- Little D, Thompson JW, Dubois LG, Ruch DS, Moseley MA, Guilak F. (2014) Proteomic Differences between Male and Female Anterior Cruciate Ligament and Patellar Tendon. Awad HA, ed. PLoS ONE. 9(5):e96526. doi:10.1371/journal.pone.0096526.
- Lohmander LS. (2004) Long-term risks for knee osteoarthritis in soccer. In International Football (Soccer) and Sports Medicine. Edited by Mandelbaum B, Doe J. American Orthopaedic Society for Sports Medicine and Federation Internationale de Football Association Medical Assessment and Research Center.
- Lohmander, L.S., Ostenberg, A., Englund, M., Roos, H. (2004) High prevalence of knee osteoarthritis, pain, and functional limitations in female soccer players twelve years after anterior cruciate ligament injury. *Arthritis & Rheumatism*, 50:3145-3152.
- Lois K, Kumar S, Williams N, Birrell L. (2011) Can self-reported height and weight be relied upon? *Occupational Medicine (London)* 61 (8):590-592.
- Long JS, Freese J. (2014) Regression Models for Categorical Dependent Variables using Stata. 3rd Ed. College Station, TX, Stata Press.
- Loudon JK, Jenkins W, Loudon KL. (1996) The relationship between static posture and ACL injury in female athletes. *J Orthop Sports Phys Therapy*. 24:91–7.
- Louw, Q., A., Manilall, J., Grimmer, K., A. (2008) Epidemiology of knee injuries among adolescents: a systematic review. *British Journal of Sports Medicine*, 42:2-10.
- Lucas SR. (2014a). Beyond the Existence Proof: Ontological Conditions, Epistemological Implications, and In-Depth Interview Research. *Quality & Quantity*, 48: 387-408.

- Lysholm J, Gillquist J. (1982) Evaluation of knee ligament surgery results with special emphasis on use of a scoring scale. *American Journal of Sports Medicine*, 10:150–4.
- Maddison R, Mhurchu CN, Jiang Y, Vander HS, Rodgers A, Lawes CM, Rush E. (2007) International physical activity questionnaire (IPAQ) and New Zealand physical activity questionnaire (NZPAP): A doubly labelled water validation. *Int J Behav Nutr Phys Activity*, 4:62.
- Majewski, M., Habelt, S., Steinbruck, K. (2006) Epidemiology of athletic knee injuries: A 10-years study. *The Knee*, 13(3):184-188.
- Marcellus L. (2004) Are we missing anything? Pursuing research on attrition. *Canadian Journal of Nursing Research*, 36:82-98.
- Marmot M. (2010) *Fair Society, Healthy Lives: Strategic review of health inequalities in England post 2010*. London: University College London Institute of Health Equity.
- Marx RG, Menezes A, Horovitz L, Jones EC, Warren RF. (2003) A comparison of two time intervals for test-retest reliability of health status instruments. *Journal of*
- Matthews CE, Ainsworth BE, Thompson RW, Bassett DR Jr. (2002) Sources of variance in daily physical activity levels as measured by an accelerometer. *Med Sci Sports Exercise*, 34:1376-81.
- Mavridis D, Moustaki I. (2008) Detecting outliers in factor analysis using the forward search algorithm. *Multivariate Behavioral Research*, 43 (3):453–475.
- McAllister, D R, Tsai A M, Dragoo J L, et al. (2003) Knee function after anterior cruciate ligament injury in elite collegiate athletes *American Journal of Sports Medicine*, 31:560-563.

McLellan F. (2002) Obesity rising to alarming levels around the world. *Lancet*, 359:1412

Mercer SW, Gunn J, Bower P, Wkye S, Guthrie B. (2012) Managing patients with mental and physical multi-morbidity. *BMJ* 345:e5559.

Merskey H, Bogduk N. (1994) Classification of chronic pain: descriptions of chronic pain syndromes and definitions of pain terms. 2nd Edition WA, International Association for the study of Pain.

Milgrom C, Finestone A, Shlamkovitch N, Giladi M, Radin E. (1996) Anterior knee pain caused by overactivity: a long term prospective followup. *Clin Orthop Relat Res.*, 256–260.

Milgrom C, Kerem E, Finestone A, Eldad A, Shlamkovitch N. (1991) Patellofemoral pain caused by over-activity. A prospective study of risk factors in infantry recruits. *J Bone Joint Surg.*, 73A:1041–1043.

Miranda H, Viikari-Juntura E, Martikainen R, Riihimki H. (2002) A prospective study on knee pain and its risk factors. *Osteoarthritis Cartilage*, 10:623–30.

Mokkink LB, Terwee CB, Patrick DL, Alonso J, Stratford PW, Knol DL, Bouter LM, Veta HCW. (2010) The COSMIN study reached international consensus on taxonomy, terminology, and definitions of measurement properties for health-related patient-reported outcomes. *J Clin Epidemiology*, 63:737–45.

Mountcastle SB, Posner M, Kragh JF Jr, Taylor DC. (2007) Gender differences in anterior cruciate ligament injury vary with activity: epidemiology of anterior cruciate ligament injuries in a young, athletic population. *Am J Sports Med.*, 35 (10):1635–1642.

- Moustaki M, Pitsos N, Dalamaga M, Dessypris N, Petridou E. (2005) Home and leisure activities and childhood knee injuries. *Injury*, 36:644–50.
- Muraki S, Akune T, Oka H, Mabuchi A, En-Yo Y, Yoshida M, Saika A, Nakamura K, Kawaguchi H, Yoshimura N. (2009) Association of occupational activity with radiographic knee osteoarthritis and lumbar spondylosis in elderly patients of population-based cohorts: A large-scale population-based study. *Arthritis & Rheumatism*, 61:779–786. doi: 10.1002/art.24514.
- Murphy L, Schwartz TA, Helmick CG, et al. (2008) Lifetime risk of symptomatic knee osteoarthritis. *Arthritis Rheum*. 59(9):1207–13.
- Murray CJL, Richards MA, Newton JN, Fenton KA, Anderson HR, Atkinson C, et al. (2013) UK health performance: findings of the Global Burden of Disease Study 2010. *Lancet*, 381(9871):997–1020.
- Muthuri S G, McWilliams DF, Doherty M, Zhang W. (2011) History of knee injuries and knee osteoarthritis estimated through a meta-analysis of observational studies. *Osteoarthritis and Cartilage*, 19:1286 – 1293.
- Myers R. (1994) *Classical and Modern Regression with Applications*. 2nd Ed. MA, Boston, PWS-KENT Publishing Company.
- Myklebust G, Bahr R. (2005) Return to play guidelines after anterior cruciate ligament surgery. *British Journal of Sports Medicine*, 39 (3): 127–131.
- National Institute for Health and Care Excellence (2006, amended 2014) *Obesity: identification, assessment and management*, London, UK.

National Institute for Health and Clinical Excellence (2008) *National Collaborating Centre for Chronic Conditions Osteoarthritis: national clinical guideline for care and management in adults*. London, UK.

National Joint Registry. (2015) 12th Annual Report.
<http://www.hqip.org.uk/public/cms/253/625/24/95/2015-9-11%20NJR%20Online%20Annual%20Report%202015%20compressed.pdf?realName=Ey3Qcl.pdf>

National Obesity Observatory (2009) Body Mass Index as a measure of obesity. Oxford. http://www.noo.org.uk/uploads/doc789_40_noo_BMI.pdf

Nguyen, UDT, Zhang, Y, Zhu, Y, Niu, J, Zhang, B, and Felson, D. (2011) Increasing Prevalence of Knee Pain and Symptomatic Knee Osteoarthritis: Survey and Cohort Data .Ann Intern Med., 155(11):725-732.

Oakes JL, McCandless P, Selfe J. (2009) Exploration of current evidence base for the incidence and prevalence of Patellofemoral pain syndrome. Physical Therapy Reviews, 14 (6) 382-387.

Ogden CL, Carroll MD, Curtin LR et al. (2006) Prevalence of overweight and obesity in the United States, 1999-2004. JAMA, 295:1549–1555.

Ogden J and Clementi C. (2010) The Experience of Being Obese and the Many Consequences of Stigma. Hindawi Publishing Corporation Journal of Obesity Volume 2010, Article ID 429098, 9 pages doi:10.1155/2010/429098.

Ohmann C, Kuchinke W, Canham S, Lauritsen J, Salas N, Schade-Brittinger C, et al. (2011) Standard requirements for GCP-compliant data management in multinational clinical trials. Trials, 12: 85.

- Oyeyemi AL, Bello UM, Philemon ST, Aliyu HN, Majidadi RW, Oyeyemi AY. (2014) Examining the reliability and validity of a modified version of the International Physical Activity Questionnaire, long form (IPAQ-LF) in Nigeria: a cross-sectional study. *BMJ Open*, 4(12):e005820. doi:10.1136/bmjopen-2014-005820.
- Palastanga N, Field D, Soames R. (2006) *Anatomy and Human Movement: Structure and Function* 5th Edition. Edinburgh. Butterworth Heinemann.
- Parkkari J, Pasanen K, Mattila V M, Kannus P, Rimpela A. (2008) The risk for a cruciate ligament injury of the knee in adolescents and young adults: a population-based cohort study of 46 500 people with a 9 year follow-up. *Br J Sports Med.*, 42:422–426. doi:10.1136/bjsm.2008.046185
- Peach CA, Carr AJ, Loughlin J. (2005) Recent advances in the genetic investigation of osteoarthritis. *Trends Mol Med.*, 11: 186–91
- Peat G, McCarney R, Croft P. (2001) Knee pain and osteoarthritis in older adults: a review of community burden and current use of primary health care. *Annals of the Rheumatic Diseases*, 60(2):91-97. doi:10.1136/ard.60.2.91.
- Peduzzi P, Concato J, Kemper E, Holford TR, Feinstein AR. (1996) A simulation study of the number of events per variable in logistic regression analysis. *J Clin Epidemiology*, 49:1373-1379.
- Peixoto Mdo R, Benicio MH, Jardim PC. (2006) Validity of self-reported weight and height: The Goiania study. *Braz Rev Saude Publica.*, 40:1065–1072.
- Pereira D, Peleteiro B, Araujo J, Branco J, Santos RA, Ramos E (2011) The effect of osteoarthritis definition on prevalence and incidence estimates: a systematic review. *Osteoarthritis Cartilage*, 19:1270-1285.

Petersen L, Schnohr P, Sørensen T I. (2004) Longitudinal study of the long term relation between physical activity and obesity in adult. *International Journal of Obesity Related Metabolic Disorders*, 28(1):105-12

Petersson IF, Boegard T, Saxne T, Silman AJ, Svensson B. (1997) Radiographic osteoarthritis of the knee classified by the Ahlback and Kellgren & Lawrence systems for the tibiofemoral joint in people aged 35-54 years with chronic knee pain. *Ann Rheum Dis.*, 56(8):493-6

Phyomaung PP, Dubowitz J, Cicuttini FM, Fernando S, Wluka AE, Raaijmaakers P, Wang Y, Urquhart DM. (2012) Are depression, anxiety and poor mental health risk factors for knee pain? A systematic review. *BMC Musculoskeletal Disorders*, 15:10 doi: 10.1186/1471-2474-15-10.

Pincus T, Burton AK, Vogel S, Field AP. (2002) A systematic review of psychological factors as predictors of chronicity/disability in prospective cohorts of low back pain. *Spine (Phila Pa 1976)* 27(5): E109–E120.

Pollard CD, Sigward SM, Ota S, Langford K, Powers CM. (2006) The influence of in-season injury prevention training on lower-extremity kinematics during landing in female soccer players. *Clin J Sport Med.*, 16:223–227.

Prieto-Alhambra D, Judge A, Javaid MK, Cooper C, Diez-Perez A and Arden KN. (2013) Incidence and risk factors for clinically diagnosed knee, hip and hand osteoarthritis: influences of age, gender and osteoarthritis affecting other joints. *Ann Rheum Dis.*, 0:1–6.

Prince SA, Adamo KB, Hamel ME, Hardt J, Gorber SC, and Tremblay M. (2008) A comparison of direct versus self-report measures for assessing physical activity in

adults: a systematic review. *International Journal of Behavioral Nutrition and Physical Activity*, 5:56 doi: 10.1186/1479-5868-5-56

Rathleff MS, Skuldbol SK, Rasch MN, Roos EM, Rasmussen S, et al. (2013) Care-seeking behaviour of adolescents with knee pain: a population-based study among 504 adolescents. *BMC Musculoskeletal Disorders*, 14: 225. doi: 10.1186/1471-2474-14-225

Ratzlaff C R and Liang M H. (2010) Prevention of injury-related knee osteoarthritis: opportunities for the primary and secondary prevention of knee osteoarthritis. *Arthritis Research & Therapy*, 12:215 <http://arthritis-research.com/content/12/4/215>

Rauh MJ, Macera CA, Trone DW, Reis JP, Shaffer RA. (2010) Selected static anatomic measures predict overuse injuries in female recruits. *Military Medicine*, 175:329 - 335.

RCGP Birmingham Research Unit Weekly Returns Service Annual Prevalence Report 2007. Birmingham

Reynolds-Haertle RA, McBride R. (1992) Single vs. double data entry in CAST. *Controlled Clinical Trials*, 13 (6):487–494.

Richmond SA, Fukuchi RK, Ezzat A, Schneider K, Schneider G, Emery CA. (2013) Are joint injury, sport activity, physical activity, obesity, or occupational activities predictors for osteoarthritis? A systematic review. *J Orthop Sports Phys Therapy*, 43 (8): 515 – 524.

Rodgers M, Sowden A, Petticrew M, Arai L, Roberts H, Britten N, Popay J. (2009) Testing methodological guidance on the conduct of narrative synthesis in systematic

reviews: effectiveness of interventions to promote smoke alarm ownership and function. *Evaluation*, 15:49–73.

Rodriguez-Merchan CE. (2014) Knee instruments and rating scales designed to measure outcomes. *J Orthop Traumatology*, 13(1): 1-6 doi: [10.1007/s10195-011-0177-4](https://doi.org/10.1007/s10195-011-0177-4)

Roos E M, Engelhart L, Ranstam J, Anderson A F, Irrgang J J, Marx R G, Davis A M. (2011). ICRS Recommendation Document: Patient-Reported Outcome Instruments for Use in Patients with Articular Cartilage Defects. *Cartilage*, 2(2):122–136. <http://doi.org/10.1177/1947603510391084>

Roos EM, Lohmander LS. (2003) Knee injury and Osteoarthritis Outcome Score (KOOS): from joint injury to osteoarthritis. *Health Quality Life Outcomes*, 1:64.

Roos EM. (2005) Joint injury causes knee osteoarthritis in young adults. *Current Opinion in Rheumatology*. 17(2):195-200.

Roos H, Lauren M, Adalberth T, et al. (1998) Knee osteoarthritis after meniscectomy: prevalence of radiographic changes after twenty-one years, compared with matched controls. *Arthritis Rheum.*, 41:687-693.

Rowland ML. (1990) Self-reported weight and height. *America J Clinical Nutrition*, 52:1125–1133.

Sá K N, de Mesquita Pereira C, Souza R C, Baptista A F, Lessa I. (2011) Knee Pain Prevalence and Associated Factors in a Brazilian Population Study. *Pain Medicine*, 12: 394–402. doi: 10.1111/j.1526-4637.2011.01063.

Salavati M, Akhbari B, Mohammadi F, Mazaheri M, Khorrami M. (2011) Knee injury and Osteoarthritis Outcome Score (KOOS): reliability and validity in competitive

athletes after anterior cruciate ligament reconstruction. *Osteoarthritis Cartilage*, 19:406–10.

Schulz MS, Russe K, Weiler A, Eichhorn HJ, Strobel MJ. (2003) Epidemiology of posterior cruciate ligament injuries. *Arch Orthop Trauma Surg.*, 123: 186–191.

Selfe J, Dey P, Richards J, Cook N, Chohan A, Payne K, Masters R. (2015) Do people who consciously attend to their movements have more self-reported knee pain? An exploratory cross-sectional study. *Clinical Rehabilitation*, 29(1):95-100.

Senn CY and Desmarais S. (2001) Are our recruitment practices for sex studies working across gender? The effect of topic and gender of recruiter on participation rates of university men and women, *The Journal of Sex Research*, 38:2, 111-117, DOI: 10.1080/00224490109552078. <http://dx.doi.org/10.1080/00224490109552078>

Sharma L, Hayes KW, Felson DT, et al. (1999) Does laxity alter the relationship between strength and physical function in knee osteoarthritis? *Arthritis Rheum.* 42 :25–32. Sharma SK. (2011) Importance of case definition in epidemiological studies. *Neuroepidemiology*, 37 (2) 141 -2.

Sharma L, Cahue S, Song J, et al. (2003) Physical functioning over three years in knee osteoarthritis: Role of psychosocial, local mechanical, and neuromuscular factors. *Arthritis Rheum*, 48:3359–70.

Shields M, Gorber SC, Tremblay MS. (2008) Estimates of obesity based on self-report versus direct measures. *Health Rep.*, 19:61–76.

Shultz SJ, Sander TC, Kirk SE, Perrin DH. (2005) Sex differences in knee joint laxity change across the female menstrual cycle. *The Journal of sports medicine and physical fitness.* 45(4):594-603.

Sigward SM, Powers CM. (2006) The influence of gender on knee kinematics, kinetics and muscle activation patterns during side-step cutting. *Clin Biomech.*, 21:41–48.

Silvers HJ, Mandelbaum BR. (2007) Prevention of anterior cruciate ligament injury in the female athlete. *Br J Sports Med.*, 41(Suppl 1):i52–9.

Singh AK, Kalaivani M, Krishnan A, Aggarwal PK, Gupta SK. (2014) Prevalence of Osteoarthritis of Knee Among Elderly Persons in Urban Slums Using American College of Rheumatology (ACR) Criteria. *Journal of Clinical and Diagnostic Research : JCDR.* 8(9):JC09-JC11. doi:10.7860/JCDR/2014/7763.4868.

Small M L. (2009). "‘How many cases do I need?’ On science and the logic of case selection in field-based research." *Ethnography*, 10: 5–38.

Smith, F.W., Rosenlund, E.A., Aune, A.K., MacLean, J.A., Hillis, S.W. (2004) Subjective functional assessments and the return to competitive sport after anterior cruciate ligament reconstruction. *British Journal of Sports Medicine*, 38:279-284.

Søgaard AJ, Bjelland I, Tell GS, Røysamb E. (2003) A comparison of the CONOR Mental Health Index to the HSCL-10 and HADS. Measuring mental health status in the Oslo Health Study and the Nord-Trøndelag Health Study. *Norsk J Epidemiologi* 13:279-84.

Soni A, Kiran A, Hart D J, Leyland K M, Goulston L, Cooper C, Javaid M K, Spector T D, Arden NK. (2012) Prevalence of reported knee pain over twelve years in a community-based cohort. *Arthritis & Rheumatism*, 64: 1145–1152.

Spring B, Sohn M-W, Locatelli S M, Hadi S, Kahwati L, Weaver F M. (2014) Individual, facility, and program factors affecting retention in a national weight

management program. BMC Public Health, 14:363.

<http://www.biomedcentral.com/1471-2458/14/363>

Spring B, Sohn MW, Locatelli SM, Hadi S, Kahwati L, Weaver FM. (2014) Individual, facility, and program factors affecting retention in a national weight management program. BMC Public Health, 14:363.

Stang A. (2010) Critical evaluation of the Newcastle-Ottawa scale for the assessment of the quality of nonrandomized studies in meta-analyses. Europe Journal of Epidemiology 25 (9) 603 – 605.

Stovitz SD, Pardee PE, Vazquez G, Duval S, Schwimmer JB. (2008) Musculoskeletal pain in obese children and adolescents. Acta Paediatric, 97:489-493.

Strand BH, Dalgard OS, Tambs K, Rognerud M. (2003) Measuring the mental health status of the Norwegian population: a comparison of the instruments SCL-25, SCL-10, SCL-5 and MHI-5 (SF-36). Nordic J Psychiatry, 57: 113-8.

Streiner DL and Norman GR. (2008) Health Measurement Scales: A practical guide to their development and use. 4th Edition. Oxford. Oxford University Press.

Sutton R. (2012) Anthropometric measures, overweight and obesity. Chapter 10. Health Survey for England 2011. The Stationary Office, London.

Tammelin, T., Laitinen, J., Nayha, S. (2004) Change in the level of physical activity from adolescence into adulthood and obesity at the age of 31 years. International Journal of Obesity, 28(6)775-782.

The IPAQ group. International physical activity questionnaire. 2014. <http://www.ipaq.ki.se/scoring.pdf> (accessed 21 May 2014).

Thibault H, Contrand B, Saubusse E, Baine M, & Maurice-Tison S. (2010) Risk factors for overweight and obesity in French adolescents: Physical activity, sedentary behavior and parental characteristics. *Nutrition*, 26 (2):192-200.

Thijs Y, De Clercq D, Roosen P, Witvrouw E. (2008) Gait-related intrinsic risk factors for patellofemoral pain in novice recreational runners. *Br J Sports Med.*, 42(6):466–71.

Thijs Y, Van Tiggelen D, Roosen P, De Clercq D, Witvrouw E. (2007) A prospective study on gait-related intrinsic risk factors for patellofemoral pain. *Clin J Sport Med.*, 17: 437– 445.

Thurston RC, Sowers MR, Sternfeld B, et al. (2009) Gains in body fat and vasomotor symptom reporting over the menopausal transition: The Study of Women's Health across the Nation. *Am J Epidemiology*, 170:766–774.

Tremblay M. (2004) The need for directly measured health data in Canada. *Can J Public Health* 95:165–168.

Uhorchak JM, Scoville CR, Williams GN, Arciero RA, St Pierre P, Taylor DC. (2003) Risk factors associated with noncontact injury of the anterior cruciate ligament: a prospective four-year evaluation of 859 West Point cadets. *Am J Sports Med.*, 31:831–842.

Urquhart DM, Soufan C, Teichtahl AJ, Wluka AE, Hanna F, Cicuttini FM. (2008) Factors that may mediate the relationship between physical activity and the risk for developing knee osteoarthritis. *Arthritis Res Ther.*, 10(1):203.

- Urquhart DM, Tobing JF, Hanna FS, Berry P, Wluka AE, Ding C, Cicuttini FM. (2011) What is the effect of physical activity on the knee joint? A systematic review. *Med Sci Sports Exercise*, 43(3):432–442.
- Urwin M, Symmons D, Allison T, Brammah T, Busby H, Roxby M. (1998) Estimating the burden of musculoskeletal disorders in the community: the comparative prevalence of symptoms at different anatomical sites, and the relation to social deprivation. *Ann Rheum Dis*, 57:649–655.
- Utting MR, Davies G, Newman JH. (2005) Is anterior knee pain a predisposing factor to patellofemoral osteoarthritis? *Knee*, 12:362-365.
- Vahasarja V. (1995) Prevalence of chronic knee pain in children and adolescents in northern Finland. *Acta Paediatric*, 84:803–805.
- Van den Broeck J and Brestoff JR, Eds. (2013) *Epidemiology: Principles and Practical Guidelines*. London, Springer Science + Business Media.
- Van den Broeck J, Argeseanu Cunningham S, Eeckels R, Herbst K. (2005) Data Cleaning: Detecting, Diagnosing, and Editing Data Abnormalities. *PLoS Medicine*, 2(10):e267.
- van der Waal JM, Bot S D M, Terwee C B, van der Windt D A W M, Schellevis F G, Bouter L M, Dekker J. (2006) The incidences of and consultation rate for lower extremity complaints in general practice. *Ann Rheum Dis.*, 65:809–815. doi: 10.1136/ard.2005.0
- van Dijk CN, van der Tempel WM.(2008) Patellofemoral pain syndrome. *BMJ*, 337:a1948.

- van Poppel MNM, Chinapaw MJM, Mekkink LB, van Mechelen W, Terwee CB. (2010) Physical activity questionnaires for adults: A systematic review of measurement properties. *Sports Medicine*, 40:565–600.
- Van Tiggelen D, Cowan S, Coorevits P, Duvigneaud N, Witvrouw E. (2009) Delayed vastus medialis obliquus to vastus lateralis onset timing contributes to the development of patellofemoral pain in previously healthy men. *American Journal of Sports Medicine*, 37(6):1099–1105.
- VanderZee KI, Sanderman R, Heyink J. (1996) A comparison of two multidimensional measures of health status: the Nottingham Health Profile and the RAND 36-Item Health Survey 1.0. *Qual Life Res.*, 5:165–174.
- Vasan RS, Pencina MJ, Cobain M, Freiberg MS, D'Agostino RB. (2005) Estimated risks for developing obesity in the Framingham Heart Study. *Ann Intern Medicine*, 143:473–480.
- Vauhnik R, Morrissey MC, Rutherford OM, Turk Z, Piliš IA, Perme MP. (2011) Rate and risk of anterior cruciate ligament injury among sportswomen in Slovenia. *J Athletic Training*, 46(1):92-98.
- Vignon E, Valat JP, Rossignol M, Avouac B, Rozenberg S, Thoumie P, Avouac J, Nordin M, Hilliquin P. (2006) Osteoarthritis of the knee and hip and activity: a systematic international review and synthesis (OASIS). *Joint Bone Spine*, 73(4):442–455.
- Villanueva EV. (2001) The validity of self-reported weight in US adults: a population based cross-sectional study. *BMC Public Health*, 1:11. [PubMed: 11716792]

Vittinghoff et al. (2012) Regression methods in Biostatistics: Linear, Logistic, Survival, and Repeated Measure Models. 2nd Ed. New York, Springer.

Vogt PW, Johnson BR. (2011) Dictionary of Statistics & Methodology: A Nontechnical Guide for the Social Sciences. 4th Edition London Sage Publication.

von Porat A, Roos EM, Roos H. (2004) High prevalence of osteoarthritis 14 years after an anterior cruciate ligament tear in male soccer players-a study of radiographic and patient-relevant outcomes. *Ann Rheum Dis*, 63:269-273.

Wada K, Tamakoshi K, Tsunekawa T, et al. (2005) Validity of self-reported height and weight in a Japanese workplace population. *Int J Obesity*, 29:1093–1099.

Waldén M, Hägglund M, Ekstrand J. (2006) High risk of new knee injury in elite footballers with previous anterior cruciate ligament injury. *British Journal of Sports Medicine*, 40:158-162.

Walden M, Hägglund M, Magnusson H, Ekstrand J. (2011) Anterior cruciate ligament injury in elite football: a prospective three-cohort study. *Knee Surg Sports Traumatol Arthrosc*, 19:11–19.

Wearing SC, Hennig EM, Byrne NM, Steele JR, Hills AP. (2006) Musculoskeletal disorders associated with obesity: A biomechanical perspective. *Obes Rev*, 7:239–50.

Webb R, Brammah T, Lunt M, Urwin M, Allison T, Symmons D. (2004) Opportunities for prevention of clinically significant knee pain: Results from a population-based cross sectional survey. *J Public Health*, 26:277–84.

Wells G, Brodsky L, O'Connell D, Robertson J, Peterson V, Welch V, et al. (2003) Evaluation of the Newcastle-Ottawa Scale (NOS): an assessment tool for evaluating the quality of non-randomized studies [abstract]. Barcelona, Spain.

Wells GA, Shea B, O'Connell D, Peterson J, Welch V, Losos M, Tugwell P. (2009) The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses.

http://www.ohri.ca/programs/clinical_epidemiology/oxford.htm

White E, Armstrong B.K, Saracci R. (2008) Principles of Exposure Measurement in Epidemiology: Collecting, Evaluating, and Improving Measures of Disease Risk Factors. 2nd Edition Oxford.

Wilson KC, Evan-Smith E, Oelman BJ. (1983) A study of patellofemoral plain in a junior infantry training unit. Journal of the Royal Army Medical Corps, 129 (2):82-87.

Winkler W E. (2004). Methods for evaluating and creating quality data. Information Systems, 29, 531–550.

Witvrouw E, Lysens R, Bellemans J, Cambier D and Vanderstraeten G. (2000) Intrinsic risk factors for the development of Anterior Knee Pain in an athletic population: A two-year prospective study. American Journal of Sports Medicine, 28(4): 480-489.

Wood L, Muller S, Peat G. (2011) The epidemiology of patellofemoral disorders in adulthood: a review of routine general practice morbidity recording. Prim Health Care Res Dev., 12 (2)157-64

Woodford-Rogers B, Cyphert L, Denegar CR. (1994) Risk factors for anterior cruciate ligament injury in high school and college athletes. *J Athl Train.* 29:343–6.

Woolf AD, Akesson K. (2001) Understanding the burden of musculoskeletal conditions. The burden is huge and not reflected in national health priorities. *BMJ*, 322:1079 – 80.

World Health Organisation (2006) Global Database on Body Mass Index: an interactive surveillance tool for monitoring nutrition transition. Geneva, Switzerland.
<http://apps.who.int/bmi/index.jsp>

World Health Organisation (2010) Global Recommendations on Physical Activity for Health. Available at:
http://whqlibdoc.who.int/publications/2010/9789241599979_eng.pdf?ua=1

World Health Organization (2001). International classification of functioning, disability and health (ICF). Geneva, Switzerland.
<http://www.who.int/classifications/icf/en/>

World Health Organization Scientific Group. (2003) The Burden of Musculoskeletal Conditions at the Start of the New Millennium. Geneva

Wright EA, Katz JN, Cisternas MG, Kessler CL, Wagenseller A, Losina E. (2010) Impact of Knee Osteoarthritis on Health Care Resource Utilization in a US Population-Based National Sample Med Care. 48(9): 785–791.
doi:10.1097/MLR.0b013e3181e419b1

Yang J, Marshall SW, Bowling JM, Runyan CW, Mueller FO, Lewis MA. (2005) Use of discretionary protective equipment and rate of lower extremity injury in high school athletes. *Am J Epidemiology*, 161(6):511– 9.

Yannakoulia M, Panagiotakos DB, Pitsavos C, Stefanadis C. (2006) Correlates of BMI misreporting among apparently healthy individuals: the ATTICA study. *Obesity* (Silver Spring), 14:894–901.

Yoshimura N, Nishioka S, Kinoshita H, Hori N, Nishioka T, Ryujin M, Mantani Y, Miyake M, Coggon D, Cooper C. (2004) Risk factors for knee osteoarthritis in Japanese women: heavy weight, previous joint injuries, and occupational activities. *J Rheumatology*, 31(1):157-162.

Zhai G, Blizzard L, Srikanth V, Ding C, Cooley H, Cicuttini F, Jones G. (2006) Correlates of knee pain in older adults: Tasmanian older adult cohort study. *Arthritis & Rheumatism*, 55: 264–271.

Zhai G, Cicuttini F, Ding C, Scott F, Garner P, Jones G. (2007) Correlates of knee pain in younger subjects. *Clin Rheumatology*, 26:75-80.

Appendix A: Final search strategy and results for CINAHL database using EBSCO platform

No	Query	Results
1	(MH "Prospective Studies") OR "cohort studies" OR (MH "Case Control Studies")	209, 536
2	(MH "Anterior Cruciate Ligament") OR "anterior cruciate ligament" OR (MH "Anterior Cruciate Ligament Injuries")	4, 796
3	(MH "Patellofemoral Pain Syndrome") OR (MH "Knee Injuries, Articular Cartilage") OR "knee pain" OR (MH "Knee Joint") OR "patellofemoral disorders" OR "patellar dysfunction"	7, 676
4	(MH "Chondromalacia Patella") OR "chondromalacia patellae"	68
5	2 or 3 or 4	11, 659
6	1 and 5	2, 329
7	(MH "Osteochondritis") OR "Osgood Schlatter" OR (MH "Osteochondritis Dissecans") OR "osteochondritis dissecans" OR (MH "Arthritis, Juvenile Rheumatoid") OR (MH "Arthritis, Rheumatoid") OR (MH "Arthritis") OR "arthritis rheumatoid"	17, 892
8	6 not 7	2, 246

Table 2.1 Final search strategy and results MEDLINE database using EBSCO platform.

Item	Query	Results
1	(MH "Cohort Studies") OR (MH "Case-Control Studies") OR (MH "Prospective studies")	555, 625
2	(MH "Anterior Cruciate Ligament") OR (MH "Knee Injuries") OR (MH "Knee Joint") OR "knee pain" OR (MH "Patellofemoral Pain Syndrome") OR "knee problem" OR "patellofemoral disorders" OR "patellar dysfunction" OR (MH "Knee")	57, 290
3	(MH "Chondromalacia Patellae") OR "chondromalacia patellae"	299
4	2 or 3	57, 445
5	1 and 4	4, 160
6	(MH "Osteochondrosis") OR "Osgood-Schlatter" OR (MH "Osteoarthritis, Knee") OR "osteoarthritis, knee" OR (MH "Osteoarthritis") OR (MH "Osteochondritis Dissecans") OR "osteocondritis dissecans"	35, 095
7	5 not 6	3, 301
8	(MH "Arthritis, Rheumatoid") OR (MH "Arthritis, Juvenile Rheumatoid")	83, 083
9	7 not 8	3, 227

Final search strategy and results for EMBASE database using OVID platform

#	Query	Results
1	Cohort. tw.	686, 488
2	(cohort adj (study or studies)). tw.	212, 900
3	Exp case control studies/	72, 891
4	Exp cohort studies/	125, 347
5	Case control. tw.	157, 464
6	Cohort analy\$.tw.	12, 831
7	Retrospective.tw.	663, 445
8	1 or 2 or 3 or 4 or 5 or 6 or 7	1, 361, 058
9	Exp anterior cruciate ligament/	7, 439
10	Exp knee injuries/	20, 432
11	Exp knee joint/	37, 223
12	Knee joint.tw.	32, 045
13	(knee adj (injury or injuries)).tw.	6, 659
14	Exp patellofemoral pain syndrome/	531
15	(patellofemoral adj (pain or disorder)).tw.	2, 164
16	Anterior knee pain.tw.	2, 767
17	Chondromalacia patellae.tw.	557
18	9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17	87, 613
19	8 and 18	7, 248
20	Exp osteochondritis dissecans/	1, 791
21	Rheumatoid arthritis	121, 376
22	20 or 21	123, 121
23	19 not 22	7, 140

Final search strategy and results for AMED database using EBSCO platform

#	Query	Results
1	Cohort study	2, 277
2	Prospective study	4, 069
3	Case control study	605
4	1or 2 or 3	5, 960
5	Anterior cruciate ligament injury	381
6	Anterior cruciate ligament	1, 675
7	Knee injuries	1, 613
8	Knee joint	4, 022
9	Knee pain	829
10	Knee problem	87
11	Patellofemoral pain syndrome	296
12	Patellofemoral pain	429
13	Patellar dislocation	22
14	Knee	9, 902
15	5 or 6 or 7 or 8 or 9 or10 or 11 or 12 or 13 or 14	10, 296
16	4 and 15	502
17	Osgood Schlatter	10
18	Arthritis	3, 819
19	Osteochondrosis	21
20	Osteochrondritis dissecans	53
21	17 or 18 or 19 or 20	3, 897
24	16 not 21	380

Final search strategy and results for SPORTDIScus database using EBSCO platform

#	Query	Results
1	Cohort studies	3, 256
2	Prospective studies	6, 675
3	Case control studies	1, 249
4	1 or 2 or 3	9, 803
5	Anterior cruciate ligament injuries	1, 876
6	Anterior cruciate ligament	6, 416
7	Knee injuries	4, 876
8	Knee joint	6, 293
9	Knee pain	1, 880
10	Knee problem	459
11	Patellofemoral pain syndrome	715
12	Patellofemoral disorders	74
13	Patellar dysfunction	4
14	Knee	30, 145
15	5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14	32, 313
16	4 and 15	1, 502
17	Osgood Schlatter	127
18	Arthritis	3, 675
19	Rheumatoid arthritis	1, 115
20	Rheumatoid	1, 150
21	Osteochondrosis	693
22	Osteochondritis dissecans	1
23	17 or 18 or 19 or 20 or 21 or 22	4, 438
24	16 not 23	1, 422

Appendix B: Newcastle-Ottawa Quality Assessment Scale

Newcastle-Ottawa Quality Assessment Scale for Cohort Studies.

Note: A study can be awarded a maximum of one star ([within the Selection and Outcome categories. A maximum of two stars can be given for Comparability.

Selection

1) Representativeness of the exposed cohort

- a) truly representative of the average _____ (describe) in the community ☐
- b) somewhat representative of the average _____ in the community [
- c) selected group of users, eg nurses, volunteers
- d) no description of the derivation of the cohort

2) Selection of the non-exposed cohort

- a) drawn from the same community as the exposed cohort ☐
- b) drawn from a different source
- c) no description of the derivation of the non-exposed cohort

3) Ascertainment of exposure

- a) secure record (eg surgical records) ☐
- b) structured interview ☐
- c) written self-report
- d) no description

4) Demonstration that outcome of interest was not present at start of study

- a) yes ☐
- b) no

Comparability

1) Comparability of cohorts on the basis of the design or analysis

- a) study controls for _____ (select the most important factor) ☐
- b) study controls for any additional factor [

indicate specific control for a second important factor.)

Outcome

1) Assessment of outcome

- a) independent blind assessment ☐
- b) record linkage ☐
- c) self-report
- d) no description

2) Was follow-up long enough for outcomes to occur

- a) yes (select an adequate follow up period for outcome of interest) ☐
- b) no

3) Adequacy of follow up of cohorts

- a) complete follow up - all subjects accounted for ☐
- b) subjects lost to follow up unlikely to introduce bias - small number lost - > _____ % (select an adequate %) follow up, or description provided of those lost) _
- c) follow up rate < _____ % (select an adequate %) and no description of those lost

- d) no statement

Newcastle-Ottawa Quality Assessment Scale for Case-Control Studies

Note: A study can be awarded a maximum of one star for each numbered item within the Selection and Exposure categories. A maximum of two stars can be given for Comparability.

Selection

- 1) Is the case definition adequate?
 - a) yes, with independent validation ☐
 - b) yes, eg record linkage or based on self-reports
 - c) no description
- 2) Representativeness of the cases
 - a) consecutive or obviously representative series of cases ☐
 - b) potential for selection biases or not stated
- 3) Selection of Controls
 - a) community controls ☐
 - b) hospital controls
 - c) no description
- 4) Definition of Controls
 - a) no history of disease (endpoint) ☐
 - b) no description of source

Comparability

- 1) Comparability of cases and controls on the basis of the design or analysis
 - a) study controls for _____ (Select the most important factor.) ☐
 - b) study controls for any additional factor ☐indicate specific control for a second important factor.)

Exposure

- 1) Ascertainment of exposure
 - a) secure record (eg surgical records) ☐
 - b) structured interview where blind to case/control status ☐
 - c) interview not blinded to case/control status
 - d) written self report or medical record only
 - e) no description
- 2) Same method of ascertainment for cases and controls
 - a) yes ☐
 - b) no
- 3) Non-Response rate
 - a) same rate for both groups ☐
 - b) non respondents described
 - c) rate different and no designation

Appendix C: Data Extraction Form for Systematic Review on Risk factors for Knee Problem.

Record number:

Author/ Year:

Date of extraction:

1. Study Design:

Cohort Retrospective study ☐

Cohort Prospective study ☐

Case-control study ☐

2. Study Population:

2.1 Description of Study Population:

.....

Hospital ☐

Community ☐

College/University ☐

Military ☐

Sport ☐

Other(s), Please state.....

Country:

Type of Cohort:

Gender:

Male

Female

Mixed

2.3 Activity level: Reported

Not reported

Definition of activity:

How active was the cohort?

Was the activity level classified? Yes No

2.4 Body mass index (BMI): Reported Not reported

Range:

Mean (Standard Deviation):

Was it classified? Yes No

2.5 Sedentary behaviour / Physical inactivity: Reported Not reported

Definition of sedentary behaviour / physical inactivity:
.....
.....

What is the level of sedentary behaviour / physical inactivity among the cohort?
.....

Was the activity level classified? Yes No

2.6 Socioeconomic status: Reported Not reported

What is the socioeconomic status of the cohort?

2.7 Others:
.....
.....
.....

3. Inclusion criteria:

3.1 Is the age between 18 – 40 years old? Yes / No. If No what

3.2 Age of Participants

Range:Not reported

Mean (Standard Deviation):

3.3 If the range is <18 is there inform on the age bracket stated on the Protocol of the review? Yes No

If yes please state the range:

4. Exclusion criteria:

I) Were the outcome(s) as a result of previous knee problem or treatment given, rather than primarily as a result of an exposure to the stated risk factor? Yes / No / Not applicable

5. **Exposures:**

	Exposure	How it was classified	How it was measured
1	Basic military training		

6. **Outcome:**

Outcome stated	Definition of outcome	How was it measured?

6.1 **Total number of Participants:**

	Actual sample size recruited.	Actual sample number participated in the study.	Actual number excluded.	Reasons for the exclusion

Table show assessment of Exposure against outcome(s) measured.

Exposure (E)	Outcome (O)	Time Interval between E & O	Was the exposure being investigated as independent risk factor, a confounding factor or a mediating factor?	Unadjusted OR/RR	What confounders/ mediating variable were taken into account in the adjusted analysis	Adjusted OR/RR	Sample size used in the analysis for Exposed.	Sample size used in the analysis for Non-exposed.

Appendix D: List of articles excluded from the review and the rationale

Author	Title of the article	Reason for exclusion
Heir & Eide 1996	Age, body composition, aerobic fitness and health condition as risk factors for musculoskeletal injuries in conscripts.	This paper has been ordered Having went through the paper individually we decided to include it as it met the criteria outline in the protocol
Boling et al. 2009	A prospective investigation of biomechanical risk factors for patellofemoral pain syndrome. The joint undertaking to monitor and prevent ACL injury (JUMP-ACL) cohort.	This is a conference paper I have retrieved the main paper.
Gelber et al. 1999	Body mass index in young men and the risk of subsequent knee and hip osteoarthritis.	There was no evidence of outcome or exposure stated in the protocol for the age bracket we are interested in.
Ristić et al. 2010	Causes of anterior cruciate ligament injuries.	This paper conducted cross-sectional study.
Brennan et al. 2010	Does an increase in body mass index over 10 years affect knee structure in a population-based cohort study of adult women?	Paper fails to report analysis on the age group 18 to 40 years old.
Schulz et al. 2003	Epidemiology of posterior cruciate ligament injuries.	This paper conducted cross-sectional study.

Fransen et al. 2011	Hip and knee pain: role of occupational factors.	This paper was a review not case-control nor cohort study report.
Gelber et al. 2000	Joint injury in young adults and risk for subsequent knee and hip osteoarthritis.	The participants in this study have injury at the baseline.
Stefanyshyn et al. 2006	Knee angular impulse as a predictor of patellofemoral pain in runners.	There was no analysis on group aged 18 to 40 years old.
Felson et al. 2007	Correlation of the Development of Knee Pain With Enlarging Bone Marrow Lesions on Magnetic Resonance Imaging.	This paper conducted cross-sectional study.
Haapasalo et al. 2007	Knee Injuries in Leisure-Time Physical Activities: A Prospective One-Year Follow-Up of a Finnish Population Cohort.	There was no analysis on group aged 18 to 40 years old.
Sá et al. 2011	Knee Pain Prevalence and Associated Factors in a Brazilian Population Study.	This paper conducted cross-sectional study.
Stovitz et al. 2008	Musculoskeletal pain in obese children and adolescents.	This paper conducted cross-sectional study.
Wood et al. 2011	The epidemiology of patellofemoral disorders in adulthood: a review of routine general practice morbidity recording.	This paper conducted cross-sectional study.

Berry et al. 2010	The relationship between body composition and structural changes at the knee.	Paper fails to report participant's everyday activities. There was no analysis on the group aged 18 to 40 years.
Macfarlane et al. 2011	The relationship between body mass index across the life course and knee pain in adulthood: results from the 1958 birth cohort study.	This paper conducted cross-sectional study.
Miranda et al. 2002	A prospective study on knee pain and its risk factors.	Lack of information on risk factors on subgroup 18 – 40 years of age (as stated in the protocol of the review) within the results and analysis of the study.
Ruedl et al. 2012	Leg dominance is a risk factor for noncontact Anterior cruciate ligament injuries in female recreational skiers.	This paper conducted cross-sectional study.
Hootman et al. 2002	Epidemiology of musculoskeletal injuries among sedentary and physically active adults.	Outcome of interest was not clear.
Owens et al. 2007	Incidence of anterior cruciate ligament injury among active duty US military servicemen and servicewomen. Mil Med. 172 (1) 90 -91.	Present of previous history of knee injury
Sulsky et al. 2002	Risk factors for occupational knee related disability among enlisted women in the US Army. Occup Environ Med. 59 (9) 601 – 607.	Absence of outcome of interest from the analysis

Nielsen & Yde 1991	Epidemiology of acute knee injuries: a prospective hospital investigation. J Trauma. 31 (12) 1644 – 1648.	Presence of outcome of knee disorders before follow up
Parkkari et al. 2008	The risk for a cruciate ligament injury of the knee in adolescents and young adults: a population-based cohort study of 46500 people with a 9 year follow up.	This study lacks analysis on the age group 18 to 40 years old.

**Appendix E: Letter of approval and
amendment of this study from the university
Ethic committee**



17 January 2013

Paola Dey /Chukwuemeka Ibeachu
School of Postgraduate Medicine and Dental Education
University of Central Lancashire

Dear Paola / Chukwuemeka

Re: STEM Ethics Committee Application
Unique Reference Number: STEM 25

The STEM ethics committee has granted approval of your proposal application '**Knee problems in young adults**'.

Please note that approval is granted up to the end of project date or for 5 years, whichever is the longer. This is on the assumption that the project does not significantly change, in which case, you should check whether further ethical clearance is required.

We shall e-mail you a copy of the end-of-project report form to complete within a month of the anticipated date of project completion you specified on your application form. This should be completed, within 3 months, to complete the ethics governance procedures or, alternatively, an amended end-of-project date forwarded to roffice@uclan.ac.uk quoting your unique reference number.

Yours sincerely

Tal Simmons
Chair
STEM Ethics Committee

25 March 2013

Paola Dey / Chukwuemeka Ibeachu
School of Postgraduate Medicine and Dental Education
University of Central Lancashire

Dear Paola / Chukwuemeka

Re: STEM Ethics Committee Application
Unique Reference Number: STEM 25_amendment

The STEM Ethics Committee has approved your proposed amendment to your application
'Knee problems in young adults'.

Yours sincerely

Tal Simmons
Chair
STEM Ethics Committee

15 August 2014



Paola Dey / Chukwuemeka Ibeachu
School of Medicine & Dentistry
University of Central Lancashire

Dear Paola / Chukwuemeka

Re: STEM Ethics Committee Application
Unique Reference Number: STEMH 025_amendment

The STEMH Ethics Committee has approved your proposed amendment to your application
'Knee problems in young adults'.

Yours sincerely

A handwritten signature in black ink, appearing to read "KRB" followed by a stylized flourish.

Kevin Butt
Vice-Chair
STEMH Ethics Committee

Appendix F: Poster used in recruitment of this study

 School of Postgraduate
Medical and Dental
Education

Volunteers Needed!!!

ARE YOU BETWEEN 18 AND 39 YEARS?

ARE STAFF OR STUDENT OF UCLAN?

**We need volunteers to look at how weight and
activity affects the knee**

We need people with and without knee problems

**All volunteers will be asked to complete a questionnaire now
and in twelve months' time**

Each questionnaire will take no more than 15 minutes to complete.

**JOIN NOW
RECRUITMENT IN
PROGRESS**



**For more information about enrolling into this study,
please contact:**

**Chukwuemeka Ibeachu (Emeka) Greenbank Building Room 321;
Email: cibeachu@uclan.ac.uk Telephone: 01772 895565**

[illegible]

Appendix G: Information sheet



Why do young adults get knee problems?

You are invited to take part in a research study looking at why young adults get knee problems among students and staff within the University of Central Lancashire, City campus Preston. Before you decide whether to take part it is important for you to understand why the research is being done and what it will involve. We need people without knee problems and those with knee problems. Please take time to read the following information carefully, discuss it with friends or relatives if you wish. Ask me if there is anything that is not clear or if you would like more information. Take your time to decide whether or not you wish to take part.

What is the purpose of this research?

We are undertaking this study to help us:

- estimate how common knee problems are in young adults
- explore the relationship between body mass index (BMI), physical activity, sedentary behaviour, and knee problems in young adults.
- explore how the severity of knee problems change over time

Why have I been chosen?

You have been chosen because you are between 18 – 39 years old and you are a student or staff member of the university. We are interested in people with knee problems and people without knee problems.

Do I have to take part?

NO, it is up to you to decide whether or not to take part. If you decide to take part, you are still free to withdraw up and until the last assessment.

Who is doing this research?

The study is carried out by Chukwuemeka Ibeachu a PhD research student in the School of Postgraduate Medical and Dental Education supervised by Professor Paola Dey (School of Medical and Dental Education); Professor James Selfe (School of Sport, Tourism and Outdoor), and Dr Chris Sutton (School of Health) at the University of Central Lancashire, City campus, Preston. The research has been approved by the University STEM research ethics committee.

What will I have to do if I take part?

We will first do a short check to see if you are eligible to take part. You need to be over 18 years but no more than 39 years and a student or staff member of the university. Your doctor shouldn't have told you that you have arthritis and you should not have severe problems affecting your walking other than a problem with your knees. If you are eligible and still want to take part, you will be asked to complete brief questionnaires that will take approximately of 15 - 30 minutes of your time, and contain questions about your knee, physical activity levels, sports activities, and how you feel generally. We will also measure your weight and height. This will usually be done either in the movement laboratory in Brook Building or in a screened off area in my office in Greenbank Building or any screened off area within the University buildings whichever you are comfortable with.

If you are uncomfortable with your height or weight being measured, you can report what you think it is. You will be asked to provide your contact details.

You will be asked to come back in twelve months' time. I will contact you twice to remind you about coming back. I will also contact you after about 6 months to let you know about study progress and then I will contact you in about 11 months' time to arrange the second assessment. This will be similar to the first assessment and will last approximately 10 - 20 minutes.

Who will see the information I give?

Only the supervisory team and I will see the information. This research will be conducted following University of Central Lancashire ethical guidelines and legal practice. Any information given will be used only for the purposes of the project; it will not be passed on to any other agencies. All information given will remain **strictly confidential**.

What happens to your confidential information?

We will keep your contact details separate to the questionnaire data. Your contact details will be kept in lockable filing cabinets. There will be a unique code that links the two. After the final assessment, we will destroy your contact details and the data will be completely anonymised. Personal data will not be transferred externally at any time. All data will be destroyed after 5 years of completion of this study.

What happens if I do not want to participate or if I change my mind about taking part?

You can withdraw from the study up until the final assessment. After the final assessment, we will destroy your contact details and it will not be possible to withdraw your data from the study after this time.

What are the possible benefits of taking part?

It is unlikely to benefit you personally, but the knowledge acquired from the study will inform strategic planning, development and implementation of interventions to prevent the public health burden of longer term outcome of knee problems in the general population.

What are the possible disadvantages and risks of taking part?

There are no particular risks. The questionnaire will take a short time to complete. However, you are welcome to discuss any concerns that you may have with the research student and if needed the number of someone to talk to further can be provided.

What will happen to the results of the research study?

Results are intended to be used in my thesis, published in scientific journals, to be presented at conferences and to support applications for research funding for future studies. If you would be interested in receiving a summary report of the findings at the end of the study period please indicate on the consent form in the box provided.

How can I get further information?

First of all you can speak with Chukwuemeka Ibeachu, Greenbank building room 321; email: cibeachu@uclan.ac.uk. Telephone: 01772895565. If you phone and I am not there, please leave a message on the voicemail. Please keep a copy of this information sheet so you can contact me if you need to do so.

What happens if there is a problem?

If you have any concerns with any aspect of this study, please contact my Director of Studies: Professor Paola Dey, email: mpdey@uclan.ac.uk. Telephone: 01772 892782. If you are still not happy, we can provide you with details of the Head of School.

Thank you for taking the time to read this information

Appendix H: Consent form

Project title: Study of knee problems in young adults

Research student: Chukwuemeka Ibeachu. School of Postgraduate Medicine & Dental Education, GreenBank Building Room 321. Email: cibeachu@uclan.ac.uk

Please
Initial
box

- 1 I thereby confirm that I have read and understand the information sheet version 1.3 18092012 for the above study and have had the opportunity to ask questions, and have had these answered satisfactorily.
- 2 I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason, without my medical care or legal rights being affected.
- 3 I consent that the research student can contact me in future for the purpose of this study
- 4 I consent to the collected data being used for analysis, presentation, and publication
- 5 Data Protection: I agree to the University processing personal data that I have supplied. I agree to the processing of such data for any purposes connected with the Research Project as outlined to me. Knowing all the facts, I agree to take part in the above study.

☐☐☐☐☐

Name of Participant

Signature of participant

Date

Name of the person
taking consent

Signature of person taking
consent

Date

If you would like me to send you an overview of this findings of this study please cross the box and write your correspondence address below

☐

1 copy for the participant, 1 copy for the research student

Appendix I: AU Outlook Poster

Volunteers Needed!!! Are you between 18 and 39 years? We need volunteers to look at how weight and activity affects the knee. We need people with and without knee problems. All volunteers will be asked to complete a questionnaire now and in twelve months' time. Each questionnaire will take no more than 30 minutes to complete.

**For more information about enrolling into this study, please contact:
Chukwuemeka Ibeachu (Emeka) (PhD Student) Greenbank Building
Room 321; Email: cibeachu@uclan.ac.uk Telephone: 01772 895565**

Appendix J: Newsletter send to the participants to maintain their interest in the study and increase retention



Newsletter

Why do young adults have knee problems?

I hope you remember me; I am Emeka Ibeachu a PhD student of the School of Medicine and Dentistry. You kindly volunteered for a PhD study title “Why do young adults get knee problems?” earlier this year. I would like to use this opportunity to say a big thank you for taking part. With your help I have now recruited 314 volunteers.

Please, remember that I will be contacting you again in a few months (in 2014) to complete the second questionnaire. This is very important because I want to know what has happened to you over the 12 months.

If your contact details have changed, or will change before 2014 in any way please let me know. In meantime, if there is anything I can do please let me know. Thank you again for your time.



For any information concerning this study,
please contact:
Chukwuemeka Ibeachu (Emeka) Greenbank Building
Room 321; Email: cibeachu@uclan.ac.uk
Telephone: 01772 895565



Appendix K: Email send to participants during follow up study

Hello,

Do you remember that sometime last year you enrolled into a study with the above title? The study aims to inform the development of the design of a prospective study to explore the relationship between knee problems, obesity, physical activity, and sedentary behaviour in young adults. It will enable measurement of how many young adults get knee problems, when they get it, and how much it affects them.

You were told then that I will contact you in around 11 months' time to arrange for re-assessment. It is now time for the reassessment. You can make an appointment with me to complete the questionnaire. To make the appointment is simple, contact me by phone or email and let me know the time and date you free to come in and I will confirm that with you. I am at the office Monday to Thursday all day (9:30 am to 4:00pm) or, if you cannot make any of those days, I can arrange a meeting on Friday. Alternatively if you would prefer I could ring you and do the questionnaire over the phone – please let me have your telephone number and best time to ring.

If this is not possible, you can fill in the questionnaire attached and either drop it in to Harrington Building Room 133 where there will be a sealed box for you to put the questionnaires in or email it back to me at (cibeachu@uclan.ac.uk). If you are going to email it back, please make sure you are accurate in using the correct email address for your response so it does not go to the wrong person. I can advise you of an encryption password to aid privacy. Up to three telephone reminders will be made between 2 days and 3 weeks following the email if there has been no response.

There is a prize draw. If you would like to be entered, please indicate your interest within the questionnaire. Once you have completed and returned the questionnaire to the research student you will automatically enter the prize draw if you have indicated your interest on the questionnaire. There is:

One 1st prizes of a £50 Amazon voucher

Two 2nd prizes of a £25 Amazon voucher

Five 3rd prizes of a £10 Amazon voucher

Please be informed that should you indicate interest in the prize draw, you are giving me permission to hold your contact details to enable me to contact you should you be a winner. Your details will be destroyed after this purpose is served. For your information, your contact details will be kept separate from the questionnaire. You will be informed through email if you win any of the prizes above.

For any enquiry contact Chukwuemeka Ibeachu at School of Medicine and Dentistry, UCLAN, Harrington Building Room 133, Telephone: 01772 895565, cibeachu@uclan.ac.uk

Appendix L: Questionnaire used at baseline assessment



**School of Postgraduate Medical and
Dental Education**

Project title: Why do young adults have knee problems?

Name of Investigator: Chukwuemeka Ibeachu (PhD student)

Supervisory Team:

Professor Paola Dey

Professor James Selfe

Dr Chris Sutton

Participant's Contact Details

Name:

Email:

Telephone:

Mobile phone

Completed by:

Date:

I am a PhD student interested in knee problems in young adults. The aim of this research is to inform the development of the design of a prospective study to explore the relationship between knee problems, obesity, physical activity, and sedentary behaviour in young adults. It will enable measurement of how many young adults get knee problems, when they get it, and how much it affects them. I would be very grateful if you could spare some minutes to complete this questionnaire. It will take between 15 and 30 minutes.

The questionnaire is split into a number of sections. The first section I will ask you and the rest I will ask you to complete. These other sections are about how you feel, about your physical activities and about any knee problems. You may feel some of the questions are quite repetitive but please try and answer all the questions to the best of your ability. If you are struggling with any question please let the investigator know, so he can help you.

Section 1: About you and your weight and height

1.1 How old are you? _____ Years

1.2 Are you?

☐ Male

☐ Female

1.3 What is your current weight (in light clothing, without shoes) in either Kg or in stones and lbs?

Kg or Stones lbs

1.4 What is your height in metres and centimetres or in feet and inches?
feet inches Metres centimetres or

.

1.5 I am now going to take your height and weight measurements. If you have any problem with this please let me know.

	Height (centimetres)	Weight (Kg)
--	----------------------	-------------

Measured value		
----------------	--	--

I will now ask you to fill in the rest of the questionnaire yourself. Please ask me if you have any queries or do not understand anything.

Section 2: This section asks you questions about generally how you feel. Below is a list of symptoms & complaints that people sometimes have.

Please underline or circle the one that apply to you, remember only one response for each question is allowed. Please do not skip any question. Thank you.

2.1	Sudden fear for no reason	Not at all distressed	A little distressed	Quite a bit distressed	Extremely distressed
2.2	Afraid or anxious	Not at all distressed	A little distressed	Quite a bit distressed	Extremely distressed
2.3	Faint or dizzy	Not at all distressed	A little distressed	Quite a bit distressed	Extremely distressed
2.4	Tense or harassed	Not at all distressed	A little distressed	Quite a bit distressed	Extremely distressed
2.5	Guilty	Not at all distressed	A little distressed	Quite a bit distressed	Extremely distressed
2.6	Sleeplessness	Not at all distressed	A little distressed	Quite a bit distressed	Extremely distressed
2.7	Dejected	Not at all distressed	A little distressed	Quite a bit distressed	Extremely distressed
2.8	Useless, of little worth	Not at all distressed	A little distressed	Quite a bit distressed	Extremely distressed
2.9	That everything is a burden	Not at all distressed	A little distressed	Quite a bit distressed	Extremely distressed

2.10	Hopelessness for the future	Not at all distressed	A little distressed	Quite a bit distressed	Extremely distressed
------	--------------------------------	--------------------------	------------------------	---------------------------	-------------------------

Section 3: Sporting activities

We would like to know if you participate in any sports, and if you do what type. The following is a list of different sports; please tick the box which represents best how often you have participated in each sport **over the last year**.

	Never	More than once a year but less than once a month	At least once a month but less than weekly	At least weekly
3.1 Dancing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.2 Gym/circuit training	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.3 Cricket	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.4 Cycling	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.5 Badminton	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.6 Football	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.7 Rugby	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.8 Hockey	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.9 Running / jogging / cross country	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.10 Tennis	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.11 Squash	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.12 Netball	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.13 Basketball	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.14 Aerobics	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.15 Swimming	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.16 Judo, Karate, other martial arts	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.17 Other	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Section 4: Physical Activity Levels

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the **vigorous** and **moderate** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal.

PART 1: JOB-RELATED PHYSICAL ACTIVITY

The first section is about your work. This includes paid jobs, farming, volunteer work, course work, and any other unpaid work that you did outside your home. Do not include unpaid work you might do around your home, like housework, yard work, general maintenance, and caring for your family. These are asked in Part 3.

4.1. Do you currently have a job or do any unpaid work outside your home?

☐

Yes

☐

No



Skip to PART 2: TRANSPORTATION

The next questions are about all the physical activity you did in the **last 7 days** as part of your paid or unpaid work. This does not include traveling to and from work.

4.2. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, heavy construction, or climbing up stairs **as part of your work**? Think about only those physical activities that you did for at least 10 minutes at a time.

_____ **days per week**

☐

No vigorous job-related physical activity **→ Skip to question 4.4**

4.3. How much time did you usually spend on one of those days doing **vigorous** physical activities as part of your work?

_____ **hours per day**

_____ **minutes per day**

4.4. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads **as part of your work**? Please do not include walking.

_____ **days per week**

☐ No moderate job-related physical activity ➡ **Skip to question 4.6**

4.5. How much time did you usually spend on one of those days doing **moderate** physical activities as part of your work?

_____ **hours per day**
_____ **minutes per day**

4.6. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time **as part of your work**? Please do not count any walking you did to travel to or from work.

_____ **days per week**

☐ No job-related walking ➡ **Skip to PART 2: TRANSPORTATION**

4.7. How much time did you usually spend on one of those days **walking** as part of your work?

_____ **hours per day**
_____ **minutes per day**

PART 2: TRANSPORTATION PHYSICAL ACTIVITY

These questions are about how you traveled from place to place, including to places like work, stores, movies, and so on.

4.8. During the **last 7 days**, on how many days did you **travel in a motor vehicle** like a train, bus, car, or tram?

_____ **days per week**

☐ No traveling in a motor vehicle ➡ **Skip to question 4.10**

4.9. How much time did you usually spend on one of those days **traveling** in a train, bus, car, tram, or other kind of motor vehicle?

_____ **hours per day**
_____ **minutes per day**

Now think only about the **bicycling** and **walking** you might have done to travel to and from work, to do errands, or to go from place to place.

4.10. During the **last 7 days**, on how many days did you **bicycle** for at least 10 minutes at a time to go **from place to place**?

_____ **days per week**

☐

No bicycling from place to place



Skip to question 4.12

4.11. How much time did you usually spend on one of those days to **bicycle** from place to place?

_____ **hours per day**

_____ **minutes per day**

4.12. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time to go **from place to place**?

_____ **days per week**

☐

No walking from place to place



***Skip to PART 3:
HOUSEWORK, HOUSE MAINTENANCE, AND CARING FOR FAMILY***

4.13. How much time did you usually spend on one of those days **walking** from place to place?

_____ **hours per day**

_____ **minutes per day**

PART 3: HOUSEWORK, HOUSE MAINTENANCE, AND CARING FOR FAMILY

This section is about some of the physical activities you might have done in the **last 7 days** in and around your home, like housework, gardening, yard work, general maintenance work, and caring for your family.

4.14. Think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, chopping wood, shoveling snow, or digging **in the garden or yard**?

_____ **days per week**

☐

No vigorous activity in garden or yard



Skip to question 4.16

4.15. How much time did you usually spend on one of those days doing **vigorous** physical activities in the garden or yard?

_____ hours per day
_____ minutes per day

4.16. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** activities like carrying light loads, sweeping, washing windows, and raking **in the garden or yard**?

_____ days per week

☐

No moderate activity in garden or yard ➡ **Skip to question 4.18**

4.17. How much time did you usually spend on one of those days doing **moderate** physical activities in the garden or yard?

_____ hours per day
_____ minutes per day

4.18. Once again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** activities like carrying light loads, washing windows, scrubbing floors and sweeping **inside your home**?

_____ days per week

☐

No moderate activity inside home ➡ **Skip to PART 4:
RECREATION, SPORT AND LEISURE-TIME PHYSICAL ACTIVITY**

4.19. How much time did you usually spend on one of those days doing **moderate** physical activities inside your home?

_____ hours per day
_____ minutes per day

PART 4: RECREATION, SPORT, AND LEISURE-TIME PHYSICAL ACTIVITY

This section is about all the physical activities that you did in the **last 7 days** solely for recreation, sport, exercise or leisure. Please do not include any activities you have already mentioned.

4.20. Not counting any walking you have already mentioned, during the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time **in your leisure time**?

_____ days per week

☐

No walking in leisure time ➡ **Skip to question 4.22**

4.21. How much time did you usually spend on one of those days **walking** in your leisure time?

_____ hours per day
_____ minutes per day

4.22. Think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **vigorous** physical activities like aerobics, running, fast bicycling, or fast swimming **in your leisure time**?

_____ days per week

☐

No vigorous activity in leisure time



Skip to question 4.24

4.23. How much time did you usually spend on one of those days doing **vigorous** physical activities in your leisure time?

_____ hours per day
_____ minutes per day

4.24. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** physical activities like bicycling at a regular pace, swimming at a regular pace, and doubles tennis **in your leisure time**?

_____ days per week

☐

No moderate activity in leisure time



Skip to PART 5: TIME SPENT SITTING

4.25. How much time did you usually spend on one of those days doing **moderate** physical activities in your leisure time?

_____ hours per day
_____ minutes per day

PART 5: TIME SPENT SITTING

The last questions are about the time you spend sitting while at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading or sitting or lying down to watch television. Do not include any time spent sitting in a motor vehicle that you have already told me about.

4.26. During the **last 7 days**, how much time did you usually spend **sitting** on a **weekday**?

_____ hours per day
_____ minutes per day

4.27. During the **last 7 days**, how much time did you usually spend **sitting** on a **weekend day**?

_____ hours per day
_____ minutes per day

Section 5: Knee problems

We are interested in finding out about the health status of your knee. The following questions will ask you about the presence or absence of knee pain or any other knee problems, and its impact to your health as a whole.

5.1. Have you **ever** been to a doctor because of knee problems? (Please place a cross in one box only).

Yes ☐ No ☐

5.2. Have you had pain or problems in **the last year** in or around the knee? (Please place a cross in one box only).

Yes ☐ No ☐

If you answered no to Question 5.2, you have now completed the questionnaire. Please give the questionnaire back to the person that gave it to you. Thank you for your time.

If you have answered yes to Question 5.2, please continue to question 5.3.

5.3. In which knees have you had pain or problems? (Please place a cross in one box only)

- ☐ Left knee only
- ☐ Right knee only
- ☐ Both knees

5.4. Have you had surgery to your knee? (Including arthroscopy, keyhole surgery, camera in your knee) (Please place a cross in one box only)

- ☐ No
- ☐ Yes, Left knee only
- ☐ Yes, Right knee only
- ☐ Yes, Both knees

5.5. Have you ever had a knee cap that has gone out of joint (dislocated)? (Please place a cross in one box only)

- ☐ No
- ☐ Yes, Left knee only
- ☐ Yes, Right knee only

☐ Yes, Both knees

5.6. Since starting with your knee problem, does your knee **ever swell up**? (Please place a cross in one box only)

☐ No

☐ Yes, Left knee only

☐ Yes, Right knee only

☐ Yes, Both knees

5.7. Have you had pain and discomfort for **more than one month**? (Please place a cross in one box only)

☐ No

☐ Yes, Left knee only

☐ Yes, Right knee only

☐ Yes, Both knees

5. 8a. Because of your knee problems would you suffer from pain or difficulty with **sitting for a long time**? (Please place a cross in one box only)

☐ No

☐ Yes, Left knee

☐ Yes, Right knee

☐ Yes, Both knees

5.8b. Because of your knee problems would you suffer from pain or difficulty with **going up stairs**? (Please place a cross in one box only)

- ☐ No
- ☐ Yes, Left knee
- ☐ Yes, Right knee
- ☐ Yes, Both knees

5.8c. Because of your knee problems would you suffer from pain or difficulty with **going downstairs**? (Please place a cross in one box only)

- ☐ No
- ☐ Yes, Left knee
- ☐ Yes, Right knee
- ☐ Yes, Both knees

5.8d. Because of your knee problems would you suffer from pain or difficulty with **squatting**? (Please place a cross in one box only)

- ☐ No
- ☐ Yes, Left knee
- ☐ Yes, Right knee
- ☐ Yes, Both knees

5.8e. Because of your knee problems would you suffer from pain or difficulty with **standing for long periods**? (Please place a cross in one box only)

- ☐ No
- ☐ Yes, Left knee
- ☐ Yes, Right knee
- ☐ Yes, Both knees

5.8f. Because of your knee problems would you suffer from pain or difficulty with **walking on a level surface?** (Please place a cross in one box only)

- ☐ No
- ☐ Yes, Left knee
- ☐ Yes, Right knee
- ☐ Yes, Both knees

5.8g. Because of your knee problems would you suffer from pain or difficulty with **getting up out of a chair?** (Please place a cross in one box only)

- ☐ No
- ☐ Yes, Left knee
- ☐ Yes, Right knee
- ☐ Yes, Both knees

5.8h. Because of your knee problems would you suffer from pain or difficulty with **kneeling?** (Please place a cross in one box only)

- ☐ No
- ☐ Yes, Left knee
- ☐ Yes, Right knee
- ☐ Yes, Both knees

5.8i. Because of your knee problems would you suffer from pain or difficulty with **walking on uneven surfaces?** (Please place a cross in one box only)

- ☐ No
- ☐ Yes, Left knee
- ☐ Yes, Right knee
- ☐ Yes, Both knees

5.8j. Because of your knee problems would you suffer from pain or difficulty with **walking down slopes?** (Please place a cross in one box only)

- ☐ No
- ☐ Yes, Left knee
- ☐ Yes, Right knee
- ☐ Yes, Both knees

5.8k. Because of your knee problems would you suffer from pain or difficulty with **walking up slopes?** (Please place a cross in one box only)

- ☐ No
- ☐ Yes, Left knee
- ☐ Yes, Right knee
- ☐ Yes, Both knees

5.8l. Because of your knee problems would you suffer from pain or difficulty with **hopping?** (Please place a cross in one box only)

- ☐ No
- ☐ Yes, Left knee
- ☐ Yes, Right knee
- ☐ Yes, Both knees

5.8m. Because of your knee problems would you suffer from pain or difficulty with **jumping?** (Please place a cross in one box only)

- ☐ No
- ☐ Yes, Left knee
- ☐ Yes, Right knee
- ☐ Yes, Both knees

5.8n. Because of your knee problems would you suffer from pain or difficulty with **running?** (Please place a cross in one box only)

- ☐ No
- ☐ Yes, Left knee
- ☐ Yes, Right knee
- ☐ Yes, Both knees

We are now going to ask you some questions about each knee. Starting with your **right** knee.

5.9a. Thinking about your **right** knee, what do you consider is your **main problem** with your knee? (Please place a cross in one box only)

- ☐ Pain or discomfort
- ☐ Locking
- ☐ Giving way or feeling like it will give way
- ☐ No problem in this knee

5.9b. Thinking about your **right** knee, did your current knee problem come on (Please place a cross in one box only)

- ☐ Because of a sudden injury e.g. twist, fall or accident that you needed to see a doctor about
- ☐ Gradually over a period of time
- ☐ Neither gradually nor because of a sudden injury
- ☐ Not sure, can't remember
- ☐ No problem in this knee

Now we are going to ask you some questions about your **left** knee.

5.10a. Thinking about your **left** knee, what do you consider your **main problem** with your knee? (Please place a cross in one box only)

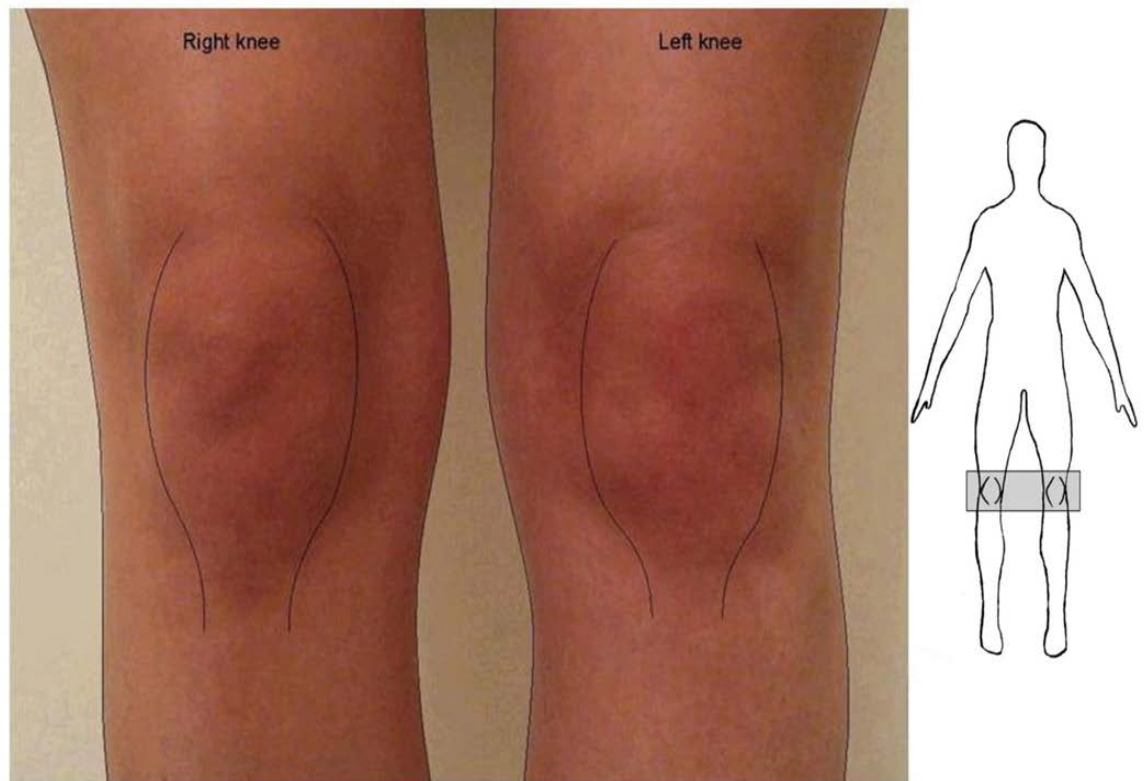
- ☐ Pain or discomfort
- ☐ Locking
- ☐ Giving way or feeling like it will give way
- ☐ No problem in this knee

5.10b. Thinking about your **left** knee, did your current knee problem come on (Please place a cross in one box only)

- ☐ Because of a sudden injury e.g. twist, fall or accident that you needed to see a doctor about
- ☐ Gradually over a period of time
- ☐ Neither gradually nor because of a sudden injury
- ☐ Not sure, can't remember

☐ No problem in this knee

5.11. Please take a moment to think about where you get your knee pain. We would like you to imagine that this is a picture of your knees. Please use small crosses to mark where you feel your knee pain on this Diagram. You can use several crosses if needed.



If you feel pain in the **back** of your **right** knee, tick here ☐

If you feel pain in the **back** of your **left** knee, tick here ☐

www.photographickneepainmap.com

5.12. Considering both your knees which would you say is the knee that gives you most problems?

- ☐ Always right
- ☐ Usually right
- ☐ Right and left equally
- ☐ Usually left
- ☐ Always left

Please continue on the next page. The next set of questions may look a bit like the ones you have answered already but they are about the symptoms you have had over the last 7 days.

Section 6 Knee symptoms over the last 7 days

This part of the questionnaire asks for your view about your knee. This information will help us keep track of how you feel about your knee and how well you are able to perform your usual activities.

Answer every question by ticking the appropriate box, only one box for each question. If you are unsure about how to answer a question, please give the best answer you can.

Symptoms

These questions should be answered thinking of your knee symptoms during the **last week**.

6.1a. Do you have swelling in your knee?	Rarely	Sometimes	Often	Always	Never
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

6.1b. Do you feel grinding, hear clicking or any other type of noise when your knee moves?

Rarely	Sometimes	Often	Always	Never
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

6.1c. Does your knee catch or hang up when moving?	Rarely	Sometimes	Often	Always	Never
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

6.1d. Can you straighten your knee fully?	Often	Sometimes	Rarely	Never	Always
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

6.1e Can you bend your knee fully?	Often	Sometimes	Rarely	Never	Always
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Stiffness

The following questions concern the amount of joint stiffness you have experienced during the **last week** in your knee. Stiffness is a sensation of restriction or slowness in the ease with which you move your knee joint.

6.1 How severe is your knee joint stiffness after first wakening in the morning?	None <input type="checkbox"/>	Mild <input type="checkbox"/>	Moderate <input type="checkbox"/>	Severe <input type="checkbox"/>	Extreme <input type="checkbox"/>
6.2. How severe is your knee stiffness after sitting, lying or resting later in the day?	None <input type="checkbox"/>	Mild <input type="checkbox"/>	Moderate <input type="checkbox"/>	Severe <input type="checkbox"/>	Extreme <input type="checkbox"/>

Pain

6.3. How often do you experience knee pain?	Never <input type="checkbox"/>	Monthly <input type="checkbox"/>	Weekly <input type="checkbox"/>	Daily <input type="checkbox"/>	Always <input type="checkbox"/>
---	-----------------------------------	-------------------------------------	------------------------------------	-----------------------------------	------------------------------------

What amount of knee pain have you experienced the **last week** during the following activities?

6.4. Twisting/pivoting on your knee	None <input type="checkbox"/>	Mild <input type="checkbox"/>	Moderate <input type="checkbox"/>	Severe <input type="checkbox"/>	Extreme <input type="checkbox"/>
6.5. Straightening knee fully	None <input type="checkbox"/>	Mild <input type="checkbox"/>	Moderate <input type="checkbox"/>	Severe <input type="checkbox"/>	Extreme <input type="checkbox"/>
6.6. Bending knee fully	None <input type="checkbox"/>	Mild <input type="checkbox"/>	Moderate <input type="checkbox"/>	Severe <input type="checkbox"/>	Extreme <input type="checkbox"/>
6.7. Walking on flat surface	None <input type="checkbox"/>	Mild <input type="checkbox"/>	Moderate <input type="checkbox"/>	Severe <input type="checkbox"/>	Extreme <input type="checkbox"/>
6.8. Going up or down stairs	None <input type="checkbox"/>	Mild <input type="checkbox"/>	Moderate <input type="checkbox"/>	Severe <input type="checkbox"/>	Extreme <input type="checkbox"/>
6.9. At night while in bed	None <input type="checkbox"/>	Mild <input type="checkbox"/>	Moderate <input type="checkbox"/>	Severe <input type="checkbox"/>	Extreme <input type="checkbox"/>

6.10. Sitting or lying	None <input type="checkbox"/>	Mild <input type="checkbox"/>	Moderate <input type="checkbox"/>	Severe <input type="checkbox"/>	Extreme <input type="checkbox"/>
------------------------	----------------------------------	----------------------------------	--------------------------------------	------------------------------------	-------------------------------------

6.11. Standing upright	None <input type="checkbox"/>	Mild <input type="checkbox"/>	Moderate <input type="checkbox"/>	Severe <input type="checkbox"/>	Extreme <input type="checkbox"/>
------------------------	----------------------------------	----------------------------------	--------------------------------------	------------------------------------	-------------------------------------

Function, Daily living

The following questions concern your physical function. By this we mean your ability to move around and to look after yourself. For each of the following activities please indicate the degree of difficulty you experienced in the **last week** due to your knee.

6.12. Descending stairs	None <input type="checkbox"/>	Mild <input type="checkbox"/>	Moderate <input type="checkbox"/>	Severe <input type="checkbox"/>	Extreme <input type="checkbox"/>
-------------------------	----------------------------------	----------------------------------	--------------------------------------	------------------------------------	-------------------------------------

6.13. Ascending stairs	None <input type="checkbox"/>	Mild <input type="checkbox"/>	Moderate <input type="checkbox"/>	Severe <input type="checkbox"/>	Extreme <input type="checkbox"/>
------------------------	----------------------------------	----------------------------------	--------------------------------------	------------------------------------	-------------------------------------

For each of the following activities please indicate the degree of difficulty you have experienced in the **last week** due to your knee.

6.14. Rising from sitting	None <input type="checkbox"/>	Mild <input type="checkbox"/>	Moderate <input type="checkbox"/>	Severe <input type="checkbox"/>	Extreme <input type="checkbox"/>
---------------------------	----------------------------------	----------------------------------	--------------------------------------	------------------------------------	-------------------------------------

6.15. Standing	None <input type="checkbox"/>	Mild <input type="checkbox"/>	Moderate <input type="checkbox"/>	Severe <input type="checkbox"/>	Extreme <input type="checkbox"/>
----------------	----------------------------------	----------------------------------	--------------------------------------	------------------------------------	-------------------------------------

6.16. Bending to floor/pick up an object	None <input type="checkbox"/>	Mild <input type="checkbox"/>	Moderate <input type="checkbox"/>	Severe <input type="checkbox"/>	Extreme <input type="checkbox"/>
--	----------------------------------	----------------------------------	--------------------------------------	------------------------------------	-------------------------------------

6.17. Walking on flat surface	None <input type="checkbox"/>	Mild <input type="checkbox"/>	Moderate <input type="checkbox"/>	Severe <input type="checkbox"/>	Extreme <input type="checkbox"/>
-------------------------------	----------------------------------	----------------------------------	--------------------------------------	------------------------------------	-------------------------------------

6.18. Getting in/out of car	None <input type="checkbox"/>	Mild <input type="checkbox"/>	Moderate <input type="checkbox"/>	Severe <input type="checkbox"/>	Extreme <input type="checkbox"/>
-----------------------------	----------------------------------	----------------------------------	--------------------------------------	------------------------------------	-------------------------------------

6.19. Going shopping	None <input type="checkbox"/>	Mild <input type="checkbox"/>	Moderate <input type="checkbox"/>	Severe <input type="checkbox"/>	Extreme <input type="checkbox"/>
----------------------	----------------------------------	----------------------------------	--------------------------------------	------------------------------------	-------------------------------------

6.20. Putting on socks/stockings	None <input type="checkbox"/>	Mild <input type="checkbox"/>	Moderate <input type="checkbox"/>	Severe <input type="checkbox"/>	Extreme <input type="checkbox"/>
----------------------------------	----------------------------------	----------------------------------	--------------------------------------	------------------------------------	-------------------------------------

6.21. Rising from bed	None <input type="checkbox"/>	Mild <input type="checkbox"/>	Moderate <input type="checkbox"/>	Severe <input type="checkbox"/>	Extreme <input type="checkbox"/>
6.22. Taking off socks/stockings	None <input type="checkbox"/>	Mild <input type="checkbox"/>	Moderate <input type="checkbox"/>	Severe <input type="checkbox"/>	Extreme <input type="checkbox"/>
6.23. Lying in bed (turning over, maintaining knee position)	None <input type="checkbox"/>	Mild <input type="checkbox"/>	Moderate <input type="checkbox"/>	Severe <input type="checkbox"/>	Extreme <input type="checkbox"/>
6.24. Getting in/out of bath	None <input type="checkbox"/>	Mild <input type="checkbox"/>	Moderate <input type="checkbox"/>	Severe <input type="checkbox"/>	Extreme <input type="checkbox"/>
6.25. Sitting	None <input type="checkbox"/>	Mild <input type="checkbox"/>	Moderate <input type="checkbox"/>	Severe <input type="checkbox"/>	Extreme <input type="checkbox"/>
6.26. Getting on/off toilet	None <input type="checkbox"/>	Mild <input type="checkbox"/>	Moderate <input type="checkbox"/>	Severe <input type="checkbox"/>	Extreme <input type="checkbox"/>

For each of the following activities please indicate the degree of difficulty you have experienced in the **last week** due to your knee.

6.27. Heavy domestic duties (moving heavy boxes, scrubbing floors, etc.)	None <input type="checkbox"/>	Mild <input type="checkbox"/>	Moderate <input type="checkbox"/>	Severe <input type="checkbox"/>	Extreme <input type="checkbox"/>
6.28. Light domestic duties (cooking, dusting, etc.)	None <input type="checkbox"/>	Mild <input type="checkbox"/>	Moderate <input type="checkbox"/>	Severe <input type="checkbox"/>	Extreme <input type="checkbox"/>

Function, sports and recreational activities

The following questions concern your physical function when being active on a higher level. The questions should be answered thinking of what degree of difficulty you experienced during the **last week** due to your knee.

6.29. Squatting	None <input type="checkbox"/>	Mild <input type="checkbox"/>	Moderate <input type="checkbox"/>	Severe <input type="checkbox"/>	Extreme <input type="checkbox"/>
6.30. Running	None <input type="checkbox"/>	Mild <input type="checkbox"/>	Moderate <input type="checkbox"/>	Severe <input type="checkbox"/>	Extreme <input type="checkbox"/>
6.31. Jumping	None <input type="checkbox"/>	Mild <input type="checkbox"/>	Moderate <input type="checkbox"/>	Severe <input type="checkbox"/>	Extreme <input type="checkbox"/>
6.32. Twisting/pivoting on your injured knee	None <input type="checkbox"/>	Mild <input type="checkbox"/>	Moderate <input type="checkbox"/>	Severe <input type="checkbox"/>	Extreme <input type="checkbox"/>
6.33. Kneeling	None <input type="checkbox"/>	Mild <input type="checkbox"/>	Moderate <input type="checkbox"/>	Severe <input type="checkbox"/>	Extreme <input type="checkbox"/>

Quality of Life

- | | | | | | |
|---|--|-------------------------------------|--|--------------------------------------|--|
| 6.34. How often are you aware of your knee problem? | Never
<input type="checkbox"/> | Monthly
<input type="checkbox"/> | Weekly
<input type="checkbox"/> | Daily
<input type="checkbox"/> | Constantly
<input type="checkbox"/> |
| 6.35. Have you modified your lifestyle to avoid potentially damaging activities to your knee? | Not at all
<input type="checkbox"/> | Mildly
<input type="checkbox"/> | Moderately
<input type="checkbox"/> | Severely
<input type="checkbox"/> | Totally
<input type="checkbox"/> |
| 6.36. How much are you troubled with lack of confidence in your knee? | Not at all
<input type="checkbox"/> | Mildly
<input type="checkbox"/> | Moderately
<input type="checkbox"/> | Severely
<input type="checkbox"/> | Extremely
<input type="checkbox"/> |
| 6.37. In general, how much difficulty do you have with your knee? | None
<input type="checkbox"/> | Mild
<input type="checkbox"/> | Moderate
<input type="checkbox"/> | Severe
<input type="checkbox"/> | Extreme
<input type="checkbox"/> |

Thank you for taking your time to complete this questionnaire. Please hand it back to the person that gave it to you. You will be contacted in 12 months to do the questionnaire again. Thank you.