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Randomised controlled trial of the cost-effectiveness of water-based therapy for lower limb osteoarthritis

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The research reported in this monograph was commissioned by the HTA Programme as project number 96/32/99. The contractual start date was in April 2000. The draft report began editorial review in May 2004 and was accepted for publication in March 2005. As the funder, by devising a commissioning brief, the HTA Programme specified the research question and study design. The authors have been wholly responsible for all data collection, analysis and interpretation, and for writing up their work. The HTA editors and publisher have tried to ensure the accuracy of the authors' report and would like to thank the referees for their constructive comments on the draft document. However, they do not accept liability for damages or losses arising from material published in this report.

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Abstract

Randomised controlled trial of the cost-effectiveness of water-based therapy for lower limb osteoarthritis

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Objectives: To determine the efficacy of community water-based therapy for the management of lower limb osteoarthritis (OA) in older patients.

Design: A pre-experimental matched-control study was used to estimate efficacy of water-based exercise treatment, to check design assumptions and delivery processes. The main study was a randomised controlled trial of the effectiveness of water-based exercise (treatment) compared with usual care (control) in older patients with hip and/or knee OA. The latter was accompanied by an economic evaluation comparing societal costs and consequences of the two treatments.

Setting: Water exercise was delivered in public swimming pools in the UK. Physical function assessments were carried out in established laboratory settings.

Participants: 106 patients (93 women, 13 men) over the age of 60 years with confirmed hip and/or knee OA took part in the preliminary study. A similar, but larger, group of 312 patients (196 women, 116 men) took part in the main study, randomised into control (159) and water exercise (153) groups.

Interventions: Control group patients received usual care with quarterly semi-structured telephone interview follow-up only. The intervention in the main study lasted for 1 year, with a further follow-up period of 6 months.

Main outcome measures: Pain score on the Western Ontario and McMaster Universities OA index (WOMAC). Additional outcome measures were included to evaluate effects on quality of life, cost-effectiveness and physical function measurements.

Results: Short-term efficacy of water exercise in the management of lower limb OA was confirmed, with effect sizes ranging from 0.44 [95% confidence interval (CI) 0.03 to 0.85] on WOMAC pain to 0.76 (95% CI 0.33 to 1.17) on WOMAC physical function. Of 153 patients randomised to treatment, 82 (53.5%) were estimated to have complied satisfactorily with their treatment at the 1-year point. This had declined to 28 (18%) by the end of the 6-month follow-up period, during which support for the intervention had been removed and those wishing to continue exercise had to pay their own costs for maintaining their exercise treatment. High levels of co-morbidity were recorded in both groups. Nearly two thirds of all patients had a significant other illness in addition to their OA. Fifty-four control and 53 exercise patients had hospital inpatient episodes during the study period. Water exercise remained effective in the main study but overall effect size was small, on WOMAC pain at 1 year, a reduction of about 10% in group mean pain score. This had declined, and was non-significant, at 18 months. Mean cost difference estimates showed a saving in the water exercise group of £123–175 per patient per annum and incremental cost-effectiveness ratios ranged from £3838 to £5951 per quality-adjusted life-year (QALY). Net reduction in pain was achieved at a net saving of £135–175 per patient per annum and the ceiling valuation of £580–740 per unit of WOMAC pain reduction was favourably low.

Conclusions: Group-based exercise in water over 1 year can produce significant reduction in pain and improvement in physical function in older adults with lower limb OA, and may be a useful adjunct in the management of hip and/or knee OA. The water-exercise programme produced a favourable cost–benefit outcome, using reduction in WOMAC pain as the measure of benefit. Further research is suggested into other similar public health interventions. Investigation is also needed into how general practice can best be supported to facilitate access to participants for research trials in healthcare, as well as an examination of the infrastructure and workforce capacities for physical activity delivery and the potential extent to which healthcare may be supported in this way. More detailed research is required to develop a

better understanding of the types of exercise that will work for the different biomechanical subtypes of knee and hip OA and investigation is needed on access and environmental issues for physical activity programmes for older people, from both a provider and a participant perspective, the societal costs of the different approaches to the management of OA and longer term trends in outcome measures (costs and effects).

Contents

List of abbreviations

1RM	one repetition maximum
AIMS	Arthritis Impact Measurement Scales
ANCOVA	analysis of covariance
ANOVA	analysis of variance
BMI	body mass index
CACE	complier average causal effect
CEAC	cost-effectiveness acceptability curve
CI	confidence interval
CV	coefficient of variation
EQ-5D	EuroQol 5 Dimensions
EQ-VAS	EuroQol Visual Analogue Scale
ES	effect size
FM	Fenton Manor (pool)
GLM	generalised linear model
HAQ	Health Assessment Questionnaire
HRG	Healthcare Resource Group
HR_{max}	maximum achievable heart rate
ICC	intraclass correlation coefficient
ICER	incremental cost-effectiveness ratio
IQR	interquartile range
ITT	intention-to-treat
LH	left hamstrings
LQ	left quadriceps
MAR	missing at random
MCID	minimal clinically important difference
MVC	maximum voluntary contraction
NP	Newcastle under Lyme (pool)
ns	not significant
NSAID	non-steroidal anti-inflammatory drug
OA	osteoarthritis
OGU	obstetrics, gynaecology and urinary tract
Q3	third quartile cut-off point
QALY	quality-adjusted life-year
RA	rheumatoid arthritis
RCT	randomised controlled trial
RH	right hamstrings
ROM	range of motion
RQ	right quadriceps
SD	standard deviation
SEM	standard error of measurement
SEM%	standard error of measurement expressed as a percentage of the group mean for the measure
SF-36	Short Form 36
SP	Shelton (pool)

Continued

List of abbreviations *continued*

SPSS	Statistical Package for the Social Sciences
TP	Tunstall (pool)
VAS	visual analogue scale
$V\mathrm{O}_{2\mathrm{max}}$	maximal aerobic power
WOMAC	Western Ontario and McMaster Universities osteoarthritis index

All abbreviations that have been used in this report are listed here unless the abbreviation is well known (e.g. NHS), or it has been used only once, or it is a non-standard abbreviation used only in figures/tables/appendices in which case the abbreviation is defined in the figure legend or at the end of the table.

Executive summary

Objectives

The objectives of the present study were:

- to determine the efficacy of community water-based therapy for the management of lower limb osteoarthritis (OA) in older patients: does the treatment work if taken by the recipients?
- to assess the cost-effectiveness of such an approach: is the treatment effective and is it cost-effective in practice?
- to establish the implications of delivering and sustaining a community-based water exercise programme for older patients with lower limb OA.

Methods

Design

A pre-experimental matched-control study was used to estimate efficacy (over 12 weeks only) of water-based exercise treatment, to check design assumptions and delivery processes. This was followed by the main study, a randomised controlled trial (under pragmatic conditions pertaining to general practice and community settings in North Staffordshire, UK) of the effectiveness of water-based exercise (treatment) compared with usual care (control) in older patients with hip and/or knee OA. The latter was accompanied by an economic evaluation comparing societal costs and consequences of the two treatments.

Setting

Water exercise was delivered in public swimming pools. Five different venues were used, one in the preliminary and four in the main study. Patients were prescribed group sessions twice weekly from a total choice of three (preliminary study) or ten (main study). Physical function assessments were carried out in established laboratory settings.

Participants

One-hundred and six patients (93 women, 13 men) over the age of 60 years with confirmed hip and/or knee OA took part in the preliminary study. A similar, but larger, group of 312 patients (196 women, 116 men) took part in the main study, randomised into control (159) and water exercise (153) groups. Participants in the main study were recruited from a combination of general practice registers (246) and advertisement in the local press (66).

Interventions

Randomisation was performed according to a computer-generated random number sequence by a member of the research team who was blinded to any patient details other than their name. Control group patients received usual care with quarterly semi-structured telephone interview follow-up only. The intervention in the main study lasted for 1 year, with a further follow-up period of 6 months. Each water exercise session lasted for approximately 1 hour and included: warm-up, strengthening, range of motion, stretch, cardiovascular conditioning, balance and coordination exercises and/or swimming.

Main outcome measures

Pain score on the Western Ontario and McMaster Universities OA index (WOMAC) was the main outcome measure to judge efficacy and effectiveness. Additional outcome measures were included to evaluate effects on quality of life (the Short Form 36), general health status (EuroQol Visual Analogue Scale and 5 Dimension) and activities of daily living (hamstrings and quadriceps strength, 8-foot walk, stair climb and descent). Healthcare resource use for the economic evaluation was obtained from a combination of patient questionnaire and interview at 1 year and review of patients' notes. Hospital episodes were obtained from locally maintained patient databases. Cost-effectiveness was evaluated from the incremental cost-effectiveness ratios (difference in mean cost divided by difference in mean effect in the two groups), derived from 1000 random samples from the set of individual cost and effect estimates from the study participants (non-parametric bootstrap sampling). Cost-effectiveness acceptability curves were constructed to provide ceiling valuations for comparison with other healthcare resource use options. Primary analysis was performed on an intention-to-treat basis, with last available measurement carried forward.

Patients were not blinded to treatment allocation, but all assessors and data entry were blinded to group allocation using the following process. All questionnaires were marked only with a patient code and were processed by a research administrator without knowledge of group allocation. Physical function measurements were performed by the same independent researchers in the Sports Performance Centre, Staffordshire University, who had no knowledge of group allocation. Coding was only revealed after all data had been entered, checked and validated and before interim (for monitoring and reporting purposes) and final analysis.

Results

Short-term efficacy of water exercise in the management of lower limb OA was confirmed, with effect sizes ranging from 0.44 [95% confidence interval (CI) 0.03 to 0.85] on WOMAC pain to 0.76 (95% CI 0.33 to 1.17) on WOMAC physical function.

Of 312 (153 treatment, 159 control) patients randomised in the main trial, 231 (74%) [111 (72.5%) treatment, 120 (75.5%) control] provided follow-up assessment data at the 1-year assessment point and 213 (68%) [100 (65%) treatment, 113 (71%) control] provided follow-up assessment data at the 18-month assessment point. Of 153 patients randomised to treatment, 82 (53.5%) were estimated to have complied satisfactorily with their treatment at the 1-year point. This had declined to 28 (18%) by the end of the 6-month follow-up period, during which support for the intervention had been removed and those wishing to continue exercise had to pay their own costs for maintaining their exercise treatment.

High levels of co-morbidity were recorded in both groups. Nearly two thirds of all patients had a significant other illness in addition to their OA. Fifty-four control and 53 exercise patients had hospital inpatient episodes during the study period.

Water exercise remained effective in the main study but overall effect size was small, [mean group difference = 0.89, effect size = 0.25 (95% CI 0.02 to 0.47), $p = 0.031$] on WOMAC pain at 1 year, a reduction of about 10% in group mean pain score. This had declined, and was non-significant, at 18 months.

Ancillary analysis yielded a complier average causal effect estimate for those who complied with their treatment of 1.65 (95% CI 0.13 to 3.17) WOMAC pain units, which was similar to that found in the 12-week pilot study

Mean cost difference estimates showed a saving in the water exercise group of £123–175 per patient per annum and incremental cost-effectiveness ratios ranged from £3838 to £5951 per quality-adjusted life-year (QALY), although it was not possible to determine a ceiling valuation (with 95% confidence) for comparison with competing approaches.

Net reduction in pain was achieved at a net saving of £135–175 per patient per annum, even after allowing for marginal costs of providing the exercise programme, and the ceiling valuation of £580–740 per unit of WOMAC pain reduction was favourably low.

Conclusions

Group-based exercise in water over 1 year can produce significant reduction in pain and improvement in physical function in older adults with lower limb OA, and may be a useful adjunct in the management of hip and/or knee OA. Wide variation in both the individual costs and the utility measures, combined with small effect sizes, limited the power of the project to detect a difference between the groups on QALY-based analyses, but the water-exercise programme produced a favourable cost–benefit outcome, using reduction in WOMAC pain as the measure of benefit.

Implications for healthcare

- Water exercise is an efficacious form of treatment for lower limb OA.
- Similar treatment effects were found in this longer term exercise study as have been reported for pharmacological interventions.
- There was no evidence either in favour of or against exercise in water compared with other forms of physical activity or strengthening programme for lower limb OA.
- Effect sizes were small but, since the intervention can be delivered, at least potentially, on a population basis, the benefit to the health service could be valuable.
- Exercise needs to be sustained to maintain the benefit.
- Current levels of support for water exercise programmes for older patients are inadequate to sustain adherence in this conservative method of management. Thus, advocacy or exercise advice alone is unlikely to lead to uptake in this patient group.

Recommendations for research

The following recommendations for further research are suggested:

- More pragmatic research into public health interventions of the nature of that undertaken in this project is justified. To ease the additional research burden on any one community, to facilitate recruitment and to enhance the generalisability of the findings, it would be better if this could be multicentre and across multiple regions. The commissioning process could facilitate such collaboration by adopting a two-stage process: first, to assemble the expert group and potential collaborating centres and then to design and deliver the trial.
- Better and more cost-effective mechanisms need to be developed to obtain representative samples for public health interventions. Based on the experience encountered on this project, one research question (and, presumably, resource issue) that needs to be addressed is how best can general practice be supported to facilitate access to participants for research trials in healthcare?
- Infrastructure and workforce capacities for physical activity delivery and the potential extent to which healthcare may be supported in this way need to be determined.
- More detailed research is required to develop a better understanding of the types of exercise that will work for the different biomechanical subtypes of knee and hip OA. The stage of the disease process might also need to be taken into account since it is feasible that mechanical loading may work in the early and intermediate stages of the disease but may not do so in the later stages, when the structural integrity of the cartilage–bone interface has been lost.
- More research is needed on access and environmental issues for physical activity programmes for older people, from both a provider and a participant perspective.
- If evidence is to drive decisions on the appropriate mix of treatment options then more longitudinal data are needed on the societal costs of the different approaches to the management of OA and longer term trends in outcome measures (costs and effects). The body of evidence relating to conservative or public health interventions such as that evaluated here is particularly sparse.

Chapter 1
Introduction

Osteoarthritis

Osteoarthritis (OA) is a group of overlapping but distinct diseases, which may have different aetiologies but with similar biological, morphological and clinical outcomes. The disease process not only affects the articular cartilage, but involves the entire joint, including the subchondral bone, support ligaments, capsule, synovial membrane and periarticular muscles. The American College of Rheumatology (ACR) currently defines the disorder as a "heterogeneous group of conditions that lead to joint symptoms and signs which are associated with defective integrity of articular cartilage, in addition to related changes in the underlying bone at the joint margins".[1]

Cartilage loss is the most obvious change in the OA joint, which is slowly degraded with a concomitant decrease in the content of proteoglycans. The level of collagenase in the cartilage increases with advancing severity of the disease and the cartilage loses its compressive stiffness and elasticity. Before the loss of cartilage mass and proteoglycan depletion, marked biosynthetic repair activity of the chondrocytes may lead to an increased proteoglycan concentration associated with thickening of the cartilage. This hypertrophic repair is commonly seen in the earlier stages of OA and, thus, it is misleading to describe OA as a "wear and tear degenerative" disease.[2]

Symptoms typically include localised joint pain and joint stiffness (especially after a period of inactivity, e.g. sitting for a while) and, in particular, joint stiffness for 20–30 minutes' duration on waking in the morning. Patients often complain of 'popping' or 'cracking' joints (crepitus) and this is most common in knee OA. Lower extremity OA may cause impaired ambulation, mobility and reduced exercise tolerance. Hip and knee pain limit mobility and independence and also lead to muscle atrophy, weakness and contracture (both flexion and extension). Patients with progressive OA of the hip or knee will experience increasing difficulty with activities of daily living, leading to an overall reduction in physical fitness. Furthermore, physical inactivity often contributes to weight gain, greater mechanical loading on the affected joint(s) and further reduced activity, all of which can contribute to depression, social isolation and a vicious spiral of health degeneration.

Prevalence and burden of OA

OA is the most common joint disorder worldwide and the most common cause of disability in the UK.[3] The prevalence of OA at different anatomical sites varies, depending on whether the condition is defined by clinical symptoms, radiological findings or a combination of both. Although the hands, neck and lower back are also affected, it is the joints of the knee and hip that cause the greatest burden on healthcare. Knee OA is approximately five times more prevalent than hip OA and occurs most commonly in people over 65 years of age. In England and Wales between 1.3 and 1.75 million people are affected by OA.[4] In addition, OA is the leading cause for consultation with a GP (3.02 million in 2000)[5] and is the most common reason for total hip and knee joint replacement.[6] From UK figures, around 10% of patients aged between 65 and 74 years consult their doctor about OA in the course of one year.[6] Gender also influences the prevalence of OA. Isolated hand and knee OA are more common in women, whereas hip disease is more prevalent in men.[7,8]

From surveys conducted in UK populations, Peat and colleagues[9] report that 10% of those aged over 55 have knee OA. Surveys undertaken in Bristol[10] and Nottingham[11] reported an estimated annual prevalence of 25% and 28%, respectively, for knee pain in older adults. A survey of musculoskeletal disorders in Greater Manchester (Tameside) reported a prevalence of knee pain of between 21 and 35% in men and women aged over 45 years.[12] A recent survey undertaken in North Staffordshire of men and women aged over 50 years registered with a GP reported the 12-month period prevalence of pain 'in or around the knee' at 44% in males and 49% in females in 6462 respondents (average age of 65.4 ± 10.10 years).[13] In a follow-up study, 23% of this cohort reported severe pain or severe difficulty with physical function, using the

self-report Western Ontario and McMaster Universities (WOMAC) osteoarthritis index.[14] Among responders with knee pain, 33% reported visiting their GP about this in the past 12 months. Jinks and colleagues[13] give an estimate of 15% of adults in the general population aged over 50 who consult their GP because of knee pain in a 1-year period.

The incidence and prevalence of OA increase with age in both males and females. The fact that incidence increases with age, coupled with the increase in the ageing population, means that OA, which already is a significant healthcare problem, will become even more of a burden in the future. The economic burden of a disease comprises direct costs (e.g. drugs, medical care) and indirect costs (e.g. premature mortality, disability). Although there are few published data on societal costs for OA alone, the annual costs for musculoskeletal disorders [rheumatoid arthritis (RA)] have been estimated as up to 2.5% of gross national product for countries including the UK, France and Canada.[15] Conservative treatments (and preventive measures) that are relatively easy to administer in a cost-effective way are required to help to reduce this burden.

Aetiopathology of OA

There is no unifying disease process that defines OA. In some instances, severe joint injury or repeated high stress or strain on the joint may be the precipitating factor. In other cases, the disease may be widespread and, therefore, by implication, systemic in origin. More often than not, the disease is caused by a combination of an inherited predisposition with the disease process being triggered by local biomechanical imbalance or insult.

Felson and colleagues[16] provide a useful overview of the disease and its risk factors. The research proposed here focuses on the mechanical environment of the joint (proprioception, laxity), loading of articular cartilage (dynamic loading, range of motion exercise) and halting or redressing the loss of muscle strength (disuse atrophy, imbalance and joint-supporting muscles, tendons and ligaments), particularly of the quadriceps muscle complex: areas that are amenable to improvement within a water exercise programme. Dynamic compression of cartilage, as well as distributing nutrients and enhancing lubrication of the whole joint, has been shown to induce the synthesis of important matrix proteins such as proteoglycans and collagen.[17] Relatively small increases in quadriceps strength have been predicted to decrease the odds of developing OA of the knee.[18]

Effectiveness and cost-effectiveness of interventions

Lower limb OA is highly prevalent and is associated with both substantial loss in quality of life and substantial management costs. Moreover, these costs are projected to rise markedly as a result of greater longevity and increasing numbers of people in the population who are overweight and sedentary.

There is a wide choice of options for the management of the disease, ranging from low-cost, 'population-wide' measures such as patient education and general lifestyle guidance, through to high-cost, 'restricted-availability' measures such as total joint replacement. Given the importance of the problem in national health terms, it is perhaps surprising that there have been relatively few studies in the UK comparing the cost-effectiveness of different treatment options. Lord and colleagues[19] conducted an economic evaluation of a primary care-based education programme for patients with OA of the knee. This provides a useful data set of the societal costs of managing knee OA in the London area. However, there remains a paucity of cost and treatment effect data from UK populations. This renders it difficult to make decisions about the most appropriate mix of services with which to manage the disease burden. Segal and colleagues[20] illustrate what might be achieved with an evidence-based priority-setting model, in which they compare several options for the prevention and management of OA. Such approaches are only as good as the data on which they are based, a limitation conceded by Segal and co-workers. Hence, a secondary aim of the research reported here was to collect, and make available to researchers, a good quality set of cost and effect data relating to the management of OA in an older UK population.

Rationale for physical activity: mechanobiology of the joint

Physical activity acts upon joints, cartilage, tendons and ligaments by increasing the energy metabolism of the tissues and their strength. Mechanical forces modulate morphology and structure of skeletal tissue, including bone, cartilage, ligament and tendon. A mechanical stimulus produces a

biological signal for cells to differentiate or adapt. Thus, load-bearing tissues are maintained and adapt in direct response to the mechanical stimuli placed upon them. In general, it is thought that increased blood flow and mixing of synovial fluid induced by range of motion exercises disperse the inflammatory exudates from the joint cavity, lessening the effects of local loading. Chondrocyte cells within the articular cartilage recognise mechanical signals, their magnitude and frequency.[21] Low physiological levels of tensile compressive strains are anti-inflammatory and activate anabolic pathways, whereas excessive loading, especially shear loading, initiates cartilage damage. This may be part of a molecular basis for the benefits of moderate exercise-based therapies for OA. Direct evidence for biochemical changes in joint fluid after a 12-week programme of isometric quadriceps exercise was presented in a recent study by Miyaguchi and colleagues,[22] who reported significant reduction in perceived pain concomitant with positive changes in joint viscosity and chondroitin sulphate levels comparable to 'normal' joints.

Normally, in the unloaded state the opposing joint surfaces are incongruent. Under load, deformation occurs, maximising contact area and minimising stress. Joint cartilage is avascular and essentially obtains its nutrition from synovial fluid. Deformation of the cartilage provides a hydrostatic lubrication mechanism which is essential for optimal nutrition of the cartilage. Adequate nutrition depends on the pump effect of synovial fluid with alternate compression and decompression of cartilage. In arthrosis of the hip, degenerative changes in joint cartilage are most pronounced in the areas of the femoral head that are *not* in continuous contact with the acetabulum.[23]

In the hip joint, the critical load that leads to complete cartilage contact is approximately 50% of body weight. Loads of this magnitude can be reached by standing or walking. In the sitting or lying position, compressive forces on the joint are insignificant. One might hypothesise that if men and women put their limbs through the full range of movement and were physically active for the majority of the time, all parts of the hip joint would be subject to regular use.[24]

Mechanisms protecting the joint from stress

The major mechanical load on articular cartilage of the knee and hip joint results from the contraction of the muscles that stabilise or move the joint. Although articular cartilage is highly resistant to microdamage associated with these impact forces, repetitive impact loading can lead to joint failure. In normal walking, three to four times body weight is transmitted through the knee joint and, during a knee bend squat, the patellofemoral joint can be subjected to loads of ten times body weight. Protective mechanisms are needed to help absorb mechanical load of the articular cartilage. Additional protection is provided by the subchondral bone, ligaments and periarticular muscles. The cancellous subchondral bone serves as a shock absorber that absorbs energy and protects the overlying cartilage.[25] Active shock-absorbing mechanisms also involve proprioception and the use of muscles and tendons in 'negative work' that is, in bracing the joint for impending impact. Muscles can absorb a large amount of energy. Indeed, most of the muscle activity generated during walking is used not to propel the body forwards but to absorb energy to decelerate the body. Muscle atrophy (which often occurs in patients with OA), therefore, will reduce the effectiveness of the muscles as a shock-absorbing mechanism. The subchondral bone undergoes greater impact stress and may begin to fracture. Over time this may progress. A significant increase in the number of microfractures may be detrimental to joint function and prevent the joint from deforming 'normally'. The resultant effect is to concentrate the strain at sites on the articular cartilage. Eventually the cartilage is degraded and fails. The periarticular muscle is of importance in attenuating shock to the joint. Thus, declines in physical activity levels in patients with OA could lead to muscle atrophy and periarticular muscle weakness, resulting in the further degradation of the joint. Instability and muscle weakness allow distortion of weight-bearing forces and load bearing, which worsens the condition.[26] Attenuation of impact by neuromuscular mechanisms depends on an adequate mass of conditioned muscle and the ability to generate force rapidly for a counteracting contraction. To optimise a patient's capacity to protect the joint from sudden impact loading, exercises that focus on improving concentric and eccentric strength and endurance at functional speeds should be included in any rehabilitation programme.

Physical activity interventions in OA of the lower limb

As for other methods for the management of OA, the primary goals of exercise treatment are to

reduce pain and minimise disability. Thus, the main objectives of any exercise programme for OA are to:

- improve general physical function: reduce joint pain, increase joint range of motion (ROM), improve muscle strength and endurance, and normalise gait
- protect the OA joint from further damage by reducing stress on the joint, attenuating forces and improving joint biomechanics
- prevent disability and poor health secondary to physical inactivity by increasing daily levels of activity and increasing overall fitness.

The effects of physical activity in patients with OA and RA have been evaluated in three systematic reviews published by the Cochrane Library.[27–29] These are summarised briefly below.

Exercise for OA of the hip or knee

In this review,[27] a wide range of land-based therapeutic exercise programmes was assessed. Only two studies (100 participants) of exercise for hip OA met the inclusion criteria and 17 studies (2562 participants) for knee OA. Of these 19 studies, only seven studies provided intention-to-treat (ITT) analysis. The authors pooled the results and estimated a standardised mean difference of 0.39 [95% confidence interval (CI) 0.30 to 0.47] for pain and 0.31 (95% CI 0.23 to 0.39) for self-reported physical function. The effect sizes of these benefits were small but comparable to reported estimates for pharmacological treatments. The reviewers concluded that land-based therapeutic exercise is of benefit for reducing pain and improving physical function for those suffering knee OA, but that there were not enough studies to evaluate the efficacy of exercise for OA of the hip.

Intensity of exercise for the treatment of OA

Despite the fact that therapeutic exercise programmes are commonly recommended for those with OA, it is not known which types of exercise are most beneficial for reducing pain and improving physical function. There is relatively little information on specific types of exercise to use, for example whether isometric strength exercises are more effective than ROM and flexibility exercises for reducing lower limb joint pain, or whether water-based exercise is of more benefit for those suffering from chronic knee pain, and land-based exercise more appropriate for patients with mild/moderate pain. Issues relating to optimal frequency, duration, intensity and type of exercise remain unknown. A systematic review to evaluate the effectiveness of exercise of differing intensities in people with OA[28] found only one randomised controlled trial (RCT) that met the specified inclusion criteria. This study, involving 39 patients, found no statistically significant differences between high and low intensity aerobic exercise in measures of functional status, gait, pain and aerobic function.[30]

Balneotherapy (bathing in water) for RA and OA

The weight-relieving property of immersion in water allows easier movement with less pain for many patients with RA and OA. In water, exercises can be undertaken that may be too painful to execute on land. Although bathing in water has been used since at least Homeric times, the effectiveness of balneotherapy in the management of patients with OA and RA is subject to considerable debate. Some researchers attribute the benefits of water therapy to biomechanical changes (joint unloading) and others to physiological changes such as increased diuresis and haemodilution. It may be that the combination of reduced gravity, hydrostatic force and warm water temperature per se contribute to pain relief in the joints.

A Cochrane review of balneotherapy for RA and OA reviewed ten RCTs assessing the effectiveness of treatment.[29] Only four of the ten trials included patients with OA and none was conducted in local community swimming pools. The authors concluded that the scientific evidence for balneotherapy was weak owing the poor methodological quality of the studies identified and small sample size, but reported that most of the trials showed positive findings. The authors suggest that further randomised studies using larger study populations, appropriate allocation concealment and analysis on an ITT basis should be undertaken.

Rationale for the choice of a community-based water exercise programme

Hydrotherapy treatment in its strictest sense involves specialist exercises in a hydrotherapy pool, which is maintained at temperatures between 33 and 37°C, supervised by a physiotherapist and usually in a hospital setting. Hydrotherapy treatment requires referral by a GP or physiotherapist. The length of treatment varies but, for OA, typically involves two to three 30-minute sessions a week for 3–4 weeks. Longer

term access to a hydrotherapy pool is unusual and there are often difficulties in accessing treatment (long waiting lists). Patients are advised to continue with their exercise programme once discharged. However, the costs of constructing, installing, equipping, maintaining and running a hydrotherapy pool are high. Running costs will vary depending on the size of the hydrotherapy pool, the staff required and the number of patients using the pool. Thus, patient throughput is limited partly because of the high costs of maintaining a hydrotherapy pool and also because of the limitations in pool size.

However, the growth in the incidence and costs of treating OA in an ageing society[31] may prompt healthcare providers and purchasers to reconsider water therapy as a public health provision, especially if this can be shown to be cost-effective, is widely accessible and offers potential for prevention. Public swimming pools may offer a solution to the accessibility criterion, but their effectiveness and cost-effectiveness in the management of lower limb osteoarthritis have not been tested.

Objectives of the present study

In recent years, 'aquarobics', offered in leisure centres and community swimming pools has become a popular mode of exercise. Classes are often attended by those suffering from joint problems. However, neither the effectiveness nor the cost-effectiveness of community-based water therapy for OA has been evaluated in an RCT in the UK. The potential value to the NHS, therefore, remains unknown.

The present research aimed to determine:

- the efficacy of community water-based therapy for the management of lower limb OA (i.e. does the treatment work if taken by the recipients?)
- the cost-effectiveness of such an approach (i.e. is the treatment, when considered on an appropriate population basis, effective and is it cost-effective?)
- the implications of delivering and sustaining a community-based water exercise programme for older patients with lower limb OA.

The proposed research was conducted in two parts: (1) a pre-experimental, matched-control group design to estimate the efficacy of water-based therapy and to check design assumptions and water exercise delivery processes for (2) the main study, an RCT of the effectiveness of water therapy for OA of the hip and knee and an economic evaluation of this approach compared with usual care for older (>60 years) patients with OA of the hip or knee. Part 1 was conducted in Sheffield, UK, and part 2 in North Staffordshire, UK, the change in location for the main study being necessitated by the transfer of the lead researchers from South Yorkshire to North Staffordshire.

The pilot study is presented in Chapter 2, the main RCT in Chapters 3 and 4, the economic analysis in Chapter 5 and the implications for delivery and sustainability of water exercise in Chapter 6. The main findings and implications of the research are summarised in Chapter 7.

Chapter 2

Pilot study

Objectives: confirmation of effects and checking of design assumptions

The main RCT was preceded by a preliminary study which was conducted to confirm the expected effect of water exercise on perceived pain and to check design and delivery assumptions. This pilot study used a pre-experimental design where the water exercise intervention group was compared with a matched control group. Group allocation was not randomised.

Methods

Population and sample

Participants were recruited from patients over 60 years of age living in Sheffield, UK. The eligibility criteria were (1) aged at least 60 years, (2) current symptoms of pain and stiffness in knee(s) and/or hip(s), (3) X-ray evidence or written confirmation of knee and/or hip OA from the GP, rheumatologist or orthopaedic surgeon, (4) no knee or hip surgery in the past 3 months, and (5) no knee or hip surgery scheduled during the 3-month study period. Subjects were excluded if they (1) were currently receiving hydrotherapy or physiotherapy or regularly participating in exercise (defined as exercising more than once per week for 20 minutes or longer), or (2) had a medical condition or other problem that precluded regular participation in water-based exercise (acute intermittent illness, unstable cardiac disease, myocardial infarction or stroke in the past 3 months, urinary infection or incontinence, open wounds or skin disease, advanced chronic obstructive pulmonary disease, paralysis, severe disability or dementia). Patients were recruited through advertisement in the local newspaper and from rheumatology and orthopaedic clinics at the Royal Hallamshire Hospital and the Northern General Hospital in Sheffield.

Data collection and procedures

Age, gender, weight and height were recorded for each participant. Body mass index (BMI) was calculated from the weight in kilograms divided by the square of the height in metres. The WOMAC questionnaire was used as the primary outcome measure to assess perceived changes in pain, physical function and stiffness. Physical function was assessed directly using a battery of measures: timed 8-foot walk, timed ascent and descent of a flight of four stairs, knee and hip flexion and quadriceps isometric strength.

Physical performance measures were adapted from measures used previously to assess lower limb function in older patients.[32] In the eight-foot walk, a distance of 8 feet (2.4 m) was marked out, with an additional 2 feet (0.6 m) at either end, to assess 'natural' walking speed. Patients were asked to 'walk to the other end of the marked area at natural walking speed just as if walking down the street to do your shopping'. Each participant was hand-timed for two repeated walks and the faster of the two times was recorded.

The timed stair tests involved ascending and descending a set of four steps. The steps, which had wooden handrails, had a rise of 15 cm, a run of 26.5 cm and width of 76 cm, with a 76.5×76 cm platform at the top. Participants were asked to use their normal action in ascending and descending stairs and to complete the task as quickly as possible. The task was hand-timed from the point of departure to the time of striking the top step (ascent) or floor (descent), respectively. Each participant completed the test twice and the faster of the two trials was used for analysis.

Flexibility of both knee and hip joints was assessed using a standard goniometer. The greater trochanter–lateral femoral condyle and the head of fibula–lateral malleolus lines were used for the measurement of knee flexion. To measure hip flexion, the patient was asked to lie in the supine position. The central pivot of the goniometer was placed on the lateral iliac crest with the stationary arm aligned through the greater trochanter and femur. The moving arm was placed along the femur through the lateral condyle. Measurements were taken with the patient's hip actively flexed towards the chest. Flexibility was recorded for right and left legs separately, the higher of two trials being used for analysis.

Maximal isometric quadriceps strength was measured with the knee flexed at right-angles.

TABLE 1 *Subject characteristics: pilot study groups*

	Exercise (n = 66)	Control (n = 40)	p-Value
Age (years)	68.8 (6.37)	69.9 (5.16)	0.35
Duration of OA (years)	11.3 (10.89)	13.6 (11.18)	0.12
BMI (kg m^{-2})	29.0 (5.03)	28.8 (5.74)	0.72
Gender			
Female	60	33	0.33
Male	6	7	
Affected joint(s)			
Knee	32	20	0.37
Hip	11	3	
Both	23	17	

Note. Values quoted in the first three rows are mean and standard deviation (SD).

A padded strap was attached just above the patient's ankle and this was connected to a strain gauge myometer (MIE Ltd, UK) beneath a standard physiotherapy couch. Participants were instructed to fold their arms across their chest and to exert maximal force for 2–3 seconds, breathing out on exertion. Three trials with each leg with a rest period of 1 minute between trials were recorded, the highest value being used for analysis. Torque (Nm) was calculated by multiplying the force recorded by the length of the lever arm (distance between lateral joint line and centre line of strap).

Interventions

Water exercise group

The water exercise programme consisted of twice-weekly sessions lasting for approximately 1 hour. The exercises were undertaken in a community swimming pool where the water temperature was maintained at around 29°C and the water depth was approximately 1.4 m. Each session was attended by approximately 20 participants and was facilitated by specially trained swimming instructors using a standard five-phase exercise protocol consisting of warm-up, joint ROM exercises, muscle strengthening, coordination and balance exercises, and general cardiovascular conditioning exercises.

Control group

The control group received education leaflets produced by the Arthritis and Rheumatism Council (UK) and the Arthritis Foundation (USA). No further support was provided by the research team.

Results

Participant flow

One-hundred and twenty-five subjects responded to a local newspaper article asking for volunteers with OA to take part in a programme of water exercise. All 125 subjects were sent a screening questionnaire to assess eligibility; 75% returned the screening questionnaire (n = 94), of which 79 were eligible and had written confirmation of OA from their doctor. These subjects were then invited onto the programme. However, 13 of these subjects did not attend any exercise session. A total of 66 patients (52%), 60 women and six men, participated in at least one exercise session. A separate group of 40 control subjects was recruited following a similar process. These 40 subjects with OA were monitored over the same 3-month period to provide an estimate of changes of the variables of interest in a similar group of OA patients not receiving the exercise intervention.

Baseline data

Baseline descriptive data for the two pilot phase groups are shown in *Table 1*. Hypertension and diabetes were noted as significant co-morbidities in both groups.

There were no statistically significant differences between the groups, although there were more women in both groups and fewer subjects with hip disease only, especially in the control group.

Outcomes and estimation of effects

Baseline and postintervention outcome measures and within-group effect sizes (ESs) are compared in *Table 2*.

The between-groups comparisons of WOMAC indices and physical function measures after 12 weeks of water exercise intervention are summarised in *Table 3*.

The effect sizes for the three WOMAC dimensions and the three timed walk measures showed

TABLE 2 *Comparison of WOMAC indices and physical function measures at baseline and 12 weeks (pilot study)*

	Exercise					Control				
	Baseline		12 weeks		ES	Baseline		12 weeks		ES
WOMAC indices (n = 59 exercise, n = 39 control)										
Pain	10.2	3.25	7.54	4.55	0.67*	9.5	3.75	9.3	2.85	0.06
Physical function	34.17	11.05	25.84	13.43	0.68*	34.51	10.37	35.02	9.86	–0.05
Stiffness	4.92	1.56	3.58	1.58	0.85*	4.52	1.52	4.32	1.34	0.14
Physical function measures (n = 51 exercise, n = 35 control)										
Eight-foot walk (s)	2.74	0.79	2.89	0.8	–0.19*	2.83	.6	3.45	1.23	–0.64*
Stair ascent (s)	3.78	2.28	3.36	1.41	0.22*	3.86	1.66	4.21	1.84	–0.2*
Stair descent (s)	3.73	2.05	3.29	1.62	0.24*	3.99	1.87	4.29	2.16	–0.15*
Isometric strength (Nm)										
Right quadriceps	38.38	19.53	41.64	26.17	0.14	41.31	25.05	38.18	22.19	–0.13
Left quadriceps	39.44	20.49	39.01	20.48	–0.02	39.48	22.63	36.88	24.37	–0.11
Knee flexion (R) (°)	118.67	13.63	120.2	11.66	0.12	116.85	19.45	116.5	18.91	–0.02
Knee flexion (L) (°)	119.68	20.9	121.3	17.13	0.08	119.75	17.36	119.3	15.11	–0.03
Hip flexion (R) (°)	86.32	18.5	87.23	12.44	0.06	84.88	17.22	85.03	17.46	0.01
Hip flexion (L) (°)	89.17	21.31	90.5	13.45	0.07	90.93	16.57	89.01	15.41	–0.12

* Significant within-group effect ($p < 0.05$).

TABLE 3 *Between-groups comparison of WOMAC indices and physical function measures after 12 weeks of intervention*

	Effect size	95% CI	*p*-Value
WOMAC indices (n = 59 exercise, n = 39 control)			
Pain	0.44	0.03 to 0.85	0.026
Physical function	0.76	0.33 to 1.17	0.0003
Stiffness	0.5	0.08 to 0.9	0.0191
Physical function measures (n = 51 exercise, n = 35 control)			
Eight-foot walk (s)	0.56	0.12 to 0.99	0.025
Stair ascent (s)	0.53	0.09 to 0.96	0.029
Stair descent (s)	0.54	0.1 to 0.97	0.028
Isometric strength (Nm)			
Right quadriceps	0.14	–0.29 to 0.57	>0.05
Left quadriceps	0.1	–0.34 to 0.53	>0.05
Knee flexion (R) (°)	0.25	–0.19 to 0.68	>0.05
Knee flexion (L) (°)	0.12	–0.31 to 0.55	>0.05
Hip flexion (R) (°)	0.15	–0.28 to 0.58	>0.05
Hip flexion (L) (°)	0.1	–0.33 to 0.53	>0.05

moderate improvements in the water exercise group. However, the confidence intervals for these pilot study estimates were broad.

Adverse events

Two participants in the water exercise group reported slipping and sustaining minor bruising either by the poolside or in the changing room. No other adverse events were reported.

Findings from pilot study

The main findings from the pilot phase were:

- A short-term moderate beneficial effect (mean difference = 1.76 WOMAC pain units, ES = 0.44, 95% CI = 0.03 to 0.85) of water exercise on WOMAC pain was confirmed.
- Water exercise was well tolerated by the patients.
- No difficulties with the water exercises were reported, but some patients incurred minor

bruises when slipping on the poolside or in changing rooms.
- Most patients had at least some difficulty in getting into and out of the swimming pool.
- Average compliance was 74% over the 12 weeks.
- Little or no change was observed in either strength measures or ROM measures.
- The battery of physical function tests was simple to perform and took just over 1 hour per patient to complete.
- The latter was felt to be too long for a large-scale pragmatic trial and, thus, the ROM measures (which were the most time-consuming to perform and were awkward for the participants) were dropped from the main trial.
- The self-report questionnaires were perceived to be easy to understand and to complete, with few missing data items.

Limitation of the pilot study

The primary aims of the pilot study were: (1) to check the process for the recruitment of patients, (2) to check the process for the implementation of the water exercise programme and its acceptability to participants (which at the time of executing this phase of the project was unknown in the UK); (3) to confirm a short-term moderate efficacy of water exercise in the management of lower limb OA; and (4) to check assumptions about the likely compliance with treatment. It would have been better to have randomised at the level of the individual (as had been the original intention). However, it became clear immediately that recruitment of practices and participants, although not intrinsically difficult, was to be a more protracted process than had been envisaged at the outset. To have randomised at the level of the individual in the pilot study would have added considerably to the cost of the project and would have delayed the availability of the research findings by several months. The researchers elected to compromise on the design of phase 1 by concentrating on process, while obtaining an estimate of the short-term (12 weeks) efficacy of water exercise.

Chapter 3
Methods

Participants

Participants were recruited from general practices in the North Staffordshire area and were aged over 60 years. Patients were deemed eligible for inclusion in the trial if they answered 'yes' to the following two questions: 'Do you have pain in the affected joint on most days of the month?' and 'Is the affected joint stiff first thing in the morning or after a period of sitting?' The latter question was used because morning stiffness or stiffness after a period of sitting is a very common symptom in lower limb OA. Diagnosis and treatment of OA were confirmed by the patient's GP. Each subject was further screened before baseline testing and randomisation by a member of the research team experienced in working with patients with lower limb OA. Subjects were excluded if any of the following criteria applied: currently on a waiting list for joint replacement or other surgery, currently receiving hydrotherapy or regularly participating in exercise (defined as more than once per week for 20 minutes or more), having a medical condition that precluded water-based exercise (heart attack in the past 3 months, hip/knee replacement in the past 6 months, stroke in the past 2 months, angina, urinary infection or incontinence, open wounds or skin disease, advanced chronic obstructive pulmonary disease, paralysis or dementia). The project was approved by the local research ethics committee and all participants gave their informed written consent (Appendix 1).

Recruitment

A key determinant of the success of a clinical trial is the recruitment and retention of a study sample of adequate size, adequately representing the population of interest. The choice of recruitment strategy depends on many factors, such as the prevalence of the condition of interest, inclusion and exclusion criteria, the setting, participants' perceptions of the proposed treatments and the sample size required. The options considered for recruitment in the present trial were: (1) recruitment directly from the general practice database, (2) a mass media campaign, (3) clinic-based referral, (4) mass telephone contact, and (5) advertisement in a local newspaper. Option (1) was selected as it was felt that this would facilitate recruitment of a sample representative of the patient population of interest, facilitate access to potential recruits (from GP databases) and to follow-up data on treatment, be appropriate from the patient's perspective, since the initial contact would be through the GP, and suit a staggered recruitment strategy by local area.

Sixty-seven GPs in North Staffordshire were contacted and asked whether they wished to participate in the research. Of these, 16 agreed to provide their support. Details of the research and a screening questionnaire (Appendices 1 and 2) were sent to 10,584 patients. This process yielded a sample of 246 patients, insufficient to meet the requirements of the study design. Thus, a further cohort of patients was recruited in response to an article appearing in the most popular local newspaper (print run 82,000). After screening and confirmation of lower limb OA, this yielded a further 66 patients, giving a total of 312 participants.

Settings

The group water exercise intervention was performed in public swimming baths located in four inner-city communities in Stoke-on-Trent (three areas: Shelton, Fenton and Tunstall) and Newcastle under Lyme, North Staffordshire. Self-report questionnaires were posted (with stamped address return envelope) to participants for completion in their own homes. Physical function measurements were carried out in the Sport, Health and Exercise laboratories at Staffordshire University, Stoke-on-Trent. Focus group sessions (process evaluation) were carried out at the exercise venues or in large teaching rooms at Staffordshire University, and interviews (cost and consequences structured questionnaire) were completed in small interview rooms at Staffordshire University.

Interventions

Water exercise intervention

The American Geriatrics Society provides guidelines for exercise for older adults with OA pain.[33] These guidelines present evidence showing that light-to-moderate-intensity physical activity

TABLE 4 *Guidelines for exercise for older adults with OA*

Exercise	Intensity	Volume	Frequency
Flexibility: static stretch	Stretch to subjective sensation of resistance	1 stretch per key muscle group; hold position for 5–15 s	Once per day
Flexibility: longer term	Stretch to full range of motion	3–5 stretches per key muscle group; hold position for 20–30 s	3–5 times per week
Strength: resistance, isometric	Low–moderate: 40–60% MVC	1–10 submaximal contractions involving key muscle group; hold contraction for 1–6 s	Once per day
Isotonic	Low: 40% 1RM Moderate: 40–60% 1RM High: >60% 1RM	10–15 repetitions 8–10 repetitions 6–8 repetitions	2–3 times per week
Endurance: aerobic	Low–moderate: 40–60% of VO_{2max}/HR_{max}	Accumulation of 20–30 minutes	3–5 times per week

HR_{max}, age-predicted heart rate maximum (based on 220 – age); 1RM, one repetition maximum (a measure of isotonic or dynamic strength); MVC, maximal voluntary contraction (a subjective measure of isometric strength); VO_{2max}, maximal aerobic capacity (the maximum rate at which oxygen can be utilised by exercising muscle, a measure of aerobic fitness).

can play a major role in preventing and possibly reversing declines in health caused by OA and recommend that, by encouraging exercise to help to reduce the physical impairments and co-morbidities, improvements in patients' quality of life will accrue. The guidelines go on to state, "Developing an exercise program aimed at alleviating pain and improving overall physical fitness is especially important …". Despite these guidelines, most physicians give general advice only for 'physical therapy and exercise'. The recommendations for appropriate exercise are summarised in *Table 4*.

The exercise programme was designed to ensure that each of the classes received the same treatment, within the constraints of individual ability or contraindications, and that the exercises were specific to the hips and knees and appropriate for this population. Exercise sessions were led by specially trained instructors. Each session lasted for approximately 1 hour and included the following components: warm-up, lower limb strengthening, lower limb ROM, lower limb stretches, general cardiovascular conditioning, general balance and coordination, free use of floats/individual exercises/swimming. These exercises were aimed specifically at improving ROM in the affected joints and in strengthening the muscles, tendons and ligaments that support them. Balance and coordination exercises were included to promote stability and several partner and group exercises were included to build teamwork and social cohesion. The exercise programme included an element of progression every 6–8 weeks by increasing the number of repetitions and/or making the exercises more advanced, for instance by using floats to increase resistance. Participants were asked to attend at least two sessions per week throughout the year of intervention. Allowing for breaks such as holidays, this amounted to 84 sessions. Ten regular sessions were maintained, covering the four centres included in the study.

Co-intervention in controls

Control subjects were contacted quarterly by telephone by the same researcher following the same structured interview format (Appendix 3). These interviews were conducted primarily to monitor symptoms and changes in the control group over the intervention period and, in particular, to monitor changes in exercise behaviour or treatment.

Delivery of exercise intervention

Facilitators for the water exercise programme were recruited from qualified swimming instructors employed by Stoke-on-Trent City Council, Leisure Services Department. All were certified lifeguards and had a current Amateur Swimming Association teacher's certificate. Three of the initial cohort of seven instructors also had experience of leading exercise classes for older people, either on land or in water. All facilitators underwent a weekend-long training programme specifically designed for the delivery of exercise in water for older people. (Davey RC. Exercise for the elderly: a manual for training in the specialist teaching of water exercise for older adults with osteoarthritis. Staffordshire

University: Faculty of Health & Sciences; 2002, unpublished). The training programme provided background information to the study and to OA. Basic guidelines for the provision of appropriate exercises, and progression, for older people, who may be disabled or unaccustomed to exercise or have significant other illness such as cardiovascular disease or diabetes, were then covered. This was followed by a second day on the practical aspects of delivery, including sample exercises and session programmes.

Classes were established at each venue sequentially, in the order Shelton, Fenton, Newcastle under Lyme and Tunstall, over a 6-month period between January 2001 and July 2001. Each class, thus, began with a coherent group of subjects (matched by a coincident group of control subjects) who progressed together through the exercise programme. This design feature minimised problems associated with newcomers joining an established class. Newcomers and those returning (after a period of illness, extended vacation or in response to being contacted) were able to receive more individual support at the front of the class while the remainder continued their familiar exercises. For the first 3 months, classes were delivered by an instructor on the poolside and an assistant in the water. Once groups had become established, most sessions only had one instructor on the poolside with a shared lifeguard. Classes were offered on two or three sessions per week at each of the four venues. Class size was limited to a maximum of 30 participants. The water exercise intervention was provided over 1 year for all participants. No further supported intervention was offered after the 1-year point, although participants were able to continue of their own volition and at their own cost. All subjects were re-evaluated after a further 6 months had elapsed, that is, 18 months from the baseline assessment. The water exercise programme began with the first cohort of recruits in January 2001 and the final cohort completed their 1 year of intervention in September 2002. Collection of follow-up data was completed in March 2003.

Objectives

The primary objective was to test for a significant treatment effect of water exercise, compared with usual care, on pain (as measured by the WOMAC pain index) for patients over the age of 60 years currently receiving treatment for OA of the hip and/or the knee. The primary analysis was considered on an ITT basis, with last available measurement carried forward. The number of participants in the trial was chosen on the basis of best available estimates of effect size and treatment compliance, to allow the expected difference to be detected with a false-positive significance level of 0.01 and statistical power of 0.9.

Secondary analyses were conducted to test for effects of water exercise, compared with usual care, on WOMAC physical function and stiffness, health-related quality of life [Short Form 36 (SF-36) dimensions], health status (EuroQol) and mobility-related physical function measures in the same population.

Since compliance with treatment was not anticipated to be complete, ancillary analyses were conducted to estimate the effects of treatment on those actually treated. Complier average causal effect estimates were evaluated for all outcome measures (see section 'Subsidiary analysis by exercise adherence', p. 17).

Further exploratory analyses were carried out to compare changes in WOMAC pain in those who exercised regularly with those who did not, and to determine whether any characteristics of the participants measured at baseline could be used to differentiate between those who complied with treatment and those who did not.

Outcomes

Primary outcome measure: WOMAC osteoarthritis index

Joint pain and loss of physical function are the major consequences of OA for patients. Their measurements play an important role in evaluating the efficacy of therapeutic interventions. Most of the exercise trials for OA patients have used existing well-validated, disease-specific health status questionnaires to assess the effects of pain relief and functional improvement following exercise intervention.[34–38] These include the WOMAC OA index,[39] the Arthritis Impact Measurement Scales (AIMS)[40] or the revised AIMS-2,[41] and the Health Assessment Questionnaire (HAQ).[42]

In this study, the pain dimension on the WOMAC OA index was used as the main outcome measure. The WOMAC questionnaire is a well-validated, disease-specific health status questionnaire to assess the effects of pain and loss of physical function for patients with knee and/or hip OA.

This questionnaire is self-administered and consists of 24 questions (five pain, two stiffness and 17 physical function) each with five response categories (scored as 0 = none, 1 = mild, 2 = moderate, 3 = severe, 4 = extreme). For each dimension, a subscale score is calculated by simple summation of the assigned scores on the component items. Thus, the ranges of possible subscale scores for the three dimensions are pain 0–20, stiffness 0–8 and physical function 0–68, with higher scores representing poorer states of health. This has been shown to be reliable and valid for this patient group in the UK, and the most responsive in terms of standardised response means (in comparison with the SF-36 and EuroQol 5 Dimensions (EQ-5D)].[43] Recommended guidelines for administering and analysing the questionnaires were also followed.[44]

Secondary outcome measures

Quality of life comparison: the SF-36

A more holistic view of health-related quality of life in this patient group through the use of generic measures (not disease specific) such as the SF-36 may have a greater ability to assess side-effects or complications of treatments that are unrelated to the disease itself.[45] Research has provided some evidence of validity for the use of SF-36 in older patients with OA[46] and the responsiveness to health changes in relation to exercise treatments.[47] The SF-36 is perhaps the most commonly used general health status measure. It measures eight dimensions (the number of items making up the subscale is shown in parentheses): physical functioning (10), social functioning (2), role limitations due to physical problems (4), role limitations due to emotional problems (3), mental health (5), energy/vitality (4), pain (2) and general health perception (5). In addition, there is a single item giving information on change in health over the past year. Scores on each dimension are obtained by summing item responses and, with the use of a scoring algorithm, transforming these raw scores into a scale from 0 (poorest health) to 100 (excellent health). The SF-36 is a practical and valid instrument for use in the elderly population (community-dwelling).[48]

Health economic analysis: the EuroQol

Unidimensional indices of health status are used to compare different treatments and interventions. The EuroQol-Visual Analogue Scale (EQ-VAS) and the EQ-5D, the latter being the preferred method, have been widely used in health economic analysis alongside clinical trials.[49] The EQ-VAS is a visual analogue scale (ranging from 0 = worst imaginable health state to 1000 = best imaginable health state) assessing health status. The EQ-5D is a simple questionnaire assessing health status that may be used to generate utility scores to assist in health economic evaluation. Both measures have been used here.

Physical function measures

Patients with knee/hip OA have been found to have reduced general mobility, ROM of affected joints and muscle strength, compared with healthy age-matched control subjects.[50,51] Measures of these physical capacities are important determinants of physical impairment/disability in patients with lower limb OA. Although measures of self-reported physical function have been increasingly used in recent years, objective clinical measures have provided valuable information about the functional status of OA patients.[52] This especially applies to physical parameters such as muscle strength which are hard to estimate accurately from questionnaires.

Participants were tested for maximal isometric strength in the quadriceps and hamstrings muscle groups, timed over an 8-foot (0.61-m) walk and timed on the ascent and descent of four steps. Each subject took on average 10–12 minutes to complete all tests, providing three assessors were available.

Maximal isometric quadriceps and hamstrings strength

Subjects were asked to sit on a bench so that the back of the knee was in contact with the edge. The leg was then positioned so that the knee joint was at 90 degrees, with the lower leg hanging vertical. Force was recorded using a digital myometer and load cell unit (MIE Ltd, UK), anchored and attached via padded webbing to either the calf or shin for the measurement of hamstrings and quadriceps strength, respectively. Subjects were asked to breathe out on exertion (to avoid the Valsalva effect) and were instructed either to push or to pull against the unit, while keeping their arms folded and their back straight. Each maximal contraction was held for 2 seconds, with two trials performed on each leg. A rest period of 1 minute was provided between contractions, with the highest value from the two trials being recorded.

Stair ascent and descent

Each subject was instructed to ascend and descend a set of four stairs at their natural pace, without resting if possible. The stairs were constructed so that the participants could walk straight over them, without turning to come down. Each step

was 0.1 m high, 0.45 m long and 0.75 m wide, with handrails placed at either side of the stairs for safety (approximately 1 m from the top of each step). Time was recorded using pressure mats connected to a millisecond timer (Griffin, UK) set-up to time ascent and descent independently. The faster of two trials was recorded alongside additional information as to whether a walking aid was used or the handrail required.

Eight-foot walk
Each subject was instructed to walk from the start to the stop line at his or her 'usual' or 'natural' walking speed. The start line and end line for the walk were placed 2 feet (0.61 m) on either side of the electronic measurement gates. Subjects were allowed to walk aided or unaided, with details recorded in the results. Time taken to walk the distance was measured using electronic timing gates, with the best result from the two trials being recorded.

Methods used to enhance the quality of measurements

Reliability of self-report and direct physical function measures

Twenty-one subjects took part in a test–retest reliability study of the physical function and self-report measures. Subjects completed the self-report questionnaires immediately before performing the test battery of physical function measures on two occasions within 1 week. The mean difference, standard deviation of the difference, intraclass correlation coefficient, standard error of measurement (SEM),[53] SEM as a percentage of the mean and 95% confidence interval for the difference were calculated for each measure. Bland–Altman plots[54] were used to check all measures visually for systematic bias.

Process evaluation for the delivery of the community-based water exercise programme

Attendance
Attendance at all water exercise sessions for all patients was recorded throughout the intervention period through the completion of attendance registers at the beginning of each session. This process was supervised by a member of the research team who randomly attended the various sessions every 2–3 weeks and took a separate count to validate the accuracy of the registers. Days missed by participants were followed up wherever possible to discover reasons for non-attendance. Patients whose absences of more than 2 weeks were unexplained were followed up with a visit or telephone call from a member of the exercise group or research team (SME). Monthly tallies of attendance at each session were also maintained to facilitate comparison among the venues/sessions and to monitor trends in participation.

Dropouts
Participants who declared that they no longer wished to take part in the study were also followed up, as far as was feasible, to find out reasons for dropping out and to assess the impact of drop-out on study validity.

Delivery
Aspects related to the delivery of the programmes were assessed by focus group meetings and session observations conducted by one of the research team (SME) and by an exit questionnaire distributed to all participants at the end of the study (Appendix 4). Issues covered in this evaluation were: appropriateness of venues, qualities of the facilitators, access, pools, parking, transport, classes, exercises, psychosocial mix, enjoyment, perceived benefit and problems encountered.

Sample size requirements

The estimate from the pilot study yielded a reduction in the WOMAC pain index (the primary outcome measure) of 2.66 units (SD 3.67 units) for the subjects who participated regularly in the water exercise programme. Sample sizes for an ITT analysis were estimated based on an anticipated maximum loss of patients to follow-up of 50% over the longer 1-year period to be used in the main study. Sample size requirements were therefore based on the following assumptions: false-positive error rate 0.01, statistical power 0.9, mean difference to be detected 1.33 pain units (i.e. 50% dilution) and standard deviation for the difference of three pain units. This yielded a sample size requirement of 152 subjects in each arm of the study.

Randomisation: sequence generation

Randomisation was performed from a computer-generated random sequence. Participants were allocated to group according to this sequence only after they had been to baseline testing and had agreed to participate in the study, regardless of group allocation. The sequence was generated by one of the researchers (TC) and its length was designed to be just longer than the target number

of subjects, to give all participants an equal chance of being included in either study arm, and was generated using the RAND function in a standard Excel spreadsheet (Microsoft Corporation, USA) before recruitment of subjects. In some instances, husband and wife pairs satisfied the inclusion criteria. These were treated as a single unit for randomisation purposes and allocated to the group determined by the first drawn of each pair. On three occasions, this resulted in a change from the original sequence.

Randomisation: allocation concealment

Allocation of participants was performed by TC, who was blinded to any patient details other than their name (from a list of those eligible provided by the research administrator). Participants were then informed by the research administrator of their group allocation by letter and/or telephone follow-up. Only TC had access to the allocation sequence.

Randomisation implementation

The allocation sequence was generated a priori by TC, who also assigned participants to groups. Enrolment to the water exercise classes was carried out by SME and RD, with the assistance of the research administrator. Control subjects were enrolled by the research administrator.

Blinding

All questionnaires were marked only with a patient code and were processed by a research administrator without knowledge of group allocation. Physical function measurements were performed by the same independent researchers in the Sports Performance Centre, Staffordshire University, who had no knowledge of group allocation. Coding was only revealed after all data had been entered, checked and validated, and before interim (for monitoring and reporting purposes) and final analysis.

Statistical analysis

Data screening

Data were screened using the process outlined in Tabachnick and Fidell[55] according to the following protocol:

- Enter raw data (blinded to patient identity and group allocation).
- Independently check and verify (blinded to patient identity and group allocation).
- Screen data for out-of-range values, plausibility of means and standard deviations and number of univariate outliers (SPSS – FREQUENCIES, DESCRIPTIVES and EXPLORE).
- Examine the extent of and deal with missing values (SPSS – MVA).
- Check for non-linearity and heteroscedasticity of dependent–independent variable pairs [SPSS – GRAPH (SCATTER)].
- Check for normality of data distributions and consider data transformations (SPSS – EXPLORE).
- Identify and deal with univariate outliers.
- Identify and deal with multivariate outliers for combinations of variables to be used in analyses [SPSS – REGRESSION (Mahalanobis distances)].
- Check variables for multicollinearity (SPSS – REGRESSION).

Inferential analyses

Associations between continuous and quasi-continuous variables considered in the analysis were carried out using Pearson's correlation coefficient. Group differences between the outcome measures in the preliminary efficacy study were tested using the independent *t*-test.

Differences between distributions of categorical variables were tested using the χ^2 test. Effect sizes (ESs) for within-group or between-group comparison were estimated as the difference between the group means divided by the pooled pretreatment standard deviation.[56] Confidence limits for the effect size estimates were derived using the method proposed by Hedges and Olkin.[57] Based on Cohen's criteria,[58] ES around 0.2 was regarded as small, around 0.5 as moderate and greater than 0.8 as large.

Comparison of groups for primary outcome

Analysis of the main RCT data was performed on an ITT basis (with last available measurement carried forward unless data were missing at baseline) using a mixed ANOVA model (with treatment as the between-group factor and time as the within-group or repeated factor) with covariates where appropriate. With respect to the choice of covariates for each analysis, a thorough investigation was undertaken of the potential for other variables to make explanatory contributions in the models. In addition to the usual checks on

independence, reliability, normality, homogeneity of variance, outliers, multicollinearity and singularity, potential covariates had to satisfy the additional conditions of linearity of the relationship with the dependent variable for both groups and homogeneity of the regression slopes. Analysis based on analysis of covariance (ANCOVA) with baseline score as a covariate was also considered, but rejected for the following reasons. First, although baseline scores on the dependent variables are independent of group allocation (assuming that selection and randomisation have worked satisfactorily), there was no guarantee that subsequent scores would be independent of group (treatment) allocation; indeed, the expectation was that they would not. Strictly speaking, this threatens the homogeneity of regression requirement in ANCOVA. Second, this approach to analysis would analyse differences between the two groups, adjusted for baseline pain score. The authors could not be confident that the removal of shared variability associated with the baseline score as covariate would not also remove some of the effect of treatment on subsequent measures of the same dependent variable. Thus, the assumption of independence of this covariate and treatment could not be made.

Group differences after the 1-year intervention were also assessed using the independent *t*-test and 95% confidence intervals for the difference were estimated.

Comparison of groups for secondary outcomes

Comparison between groups for secondary outcomes (SF-36 dimensions, EuroQol and physical function measures) was also performed using the mixed ANOVA approach, again with covariates where appropriate. Mean differences, estimated effect sizes and significance for the group comparison were calculated for all outcome measures at each measurement point.

Subsidiary analysis by exercise adherence

The ITT estimate of effect size gives an estimate for the whole target population, irrespective of whether they received the treatment or not. An important subsidiary question, which may well be the more relevant question for the GP, is what is the effect of treatment in those who actually receive it? Dunn and colleagues,[59] following on from the seminal work of Angrist and colleagues[60] and Frangakis and Rubin,[61] have proposed an approach to analysis that allows estimation of the effect of the receipt of treatment in an RCT, where there is both non-compliance and loss of data to follow-up. The method derives the complier average causal effect (CACE) of treatment, which is an estimate of the difference in score for the compliers in the treatment group and that for the compliers in the control group (regardless of whether the outcome is actually observed). This topic of further analysis of RCT data is still in its infancy, remains controversial and is technically complex. Full exploration of the effects of treatment is beyond the scope of the present report. However, CACE estimates of treatment were calculated for each of the study outcome measures.

In this simplified analysis, it was assumed that treatment allocation does not influence outcome (the exclusion restriction assumption). Under this assumption, the mean outcome score for the non-compliers in the control group is the same as that for the non-compliers in the treatment group. If it is further assumed that the probability of data being missing is determined by observed compliance status (complier, non-complier or control) and that outcome data are missing at random (MAR, i.e. outcome is statistically independent of whether outcome is actually observed), the CACE estimate is given by:

$$\text{CACE} = [p_c\mu_{11} + (1 - p_c)\,\mu_{10} - \mu_0]/p_c$$

[equation (3), Dunn and colleagues[59]] (1)

where p_c is the proportion of compliers in the trial, μ_{11} is the mean outcome for the compliers in the treatment group, μ_{10} is the corresponding mean for the non-compliers and μ_0 is the mean for the controls.

Confidence intervals for this estimate may be obtained using the bootstrap resampling method.[62] Confidence intervals for the CACE estimate for the WOMAC pain and other selected outcomes only were calculated using a modification of the simple Excel spreadsheet application described by Hurley.[63]

All analysis was performed using the SPSS software package, version 11.0 or higher (SPSS, Chicago, IL, USA) or the Excel spreadsheet software (Microsoft, USA).

Chapter 4

Results: main randomised controlled trial

Participant flow

Recruitment and participant flow

Recruitment for the main effectiveness and cost-effectiveness evaluation began in October 2000 and ran through until August 2001, when all 153 patients randomised to the water exercise group had been allocated their prescribed exercise sessions. Patients were recruited to the study on a practice-by-practice basis and, for those in the water exercise group, the intervention began as soon as was feasible after baseline measurements had been completed. The pattern of recruitment is shown in *Figure 1*. Further details of the recruitment process have been published elsewhere.[64] Recruitment and participant flow throughout the study are illustrated in *Figure 2*.

Fourteen patients attended for baseline testing but withdrew from the study before being randomised. A further 87 potential participants did not attend for baseline testing and did not give a reason for their withdrawal at this stage; a prepaid reply slip was included with the invitation to attend for baseline testing and each participant was contacted by telephone or by post on two subsequent occasions to confirm arrangements (in case specific travel requirements were needed, since some funding was available to cover those with access problems). These 87 patients did not provide details of their reasons for withdrawal. In total, 312 patients were recruited between October 2000 and August 2001. The 1-year and the 18-month follow-up periods were completed in August 2002 and February 2003, respectively.

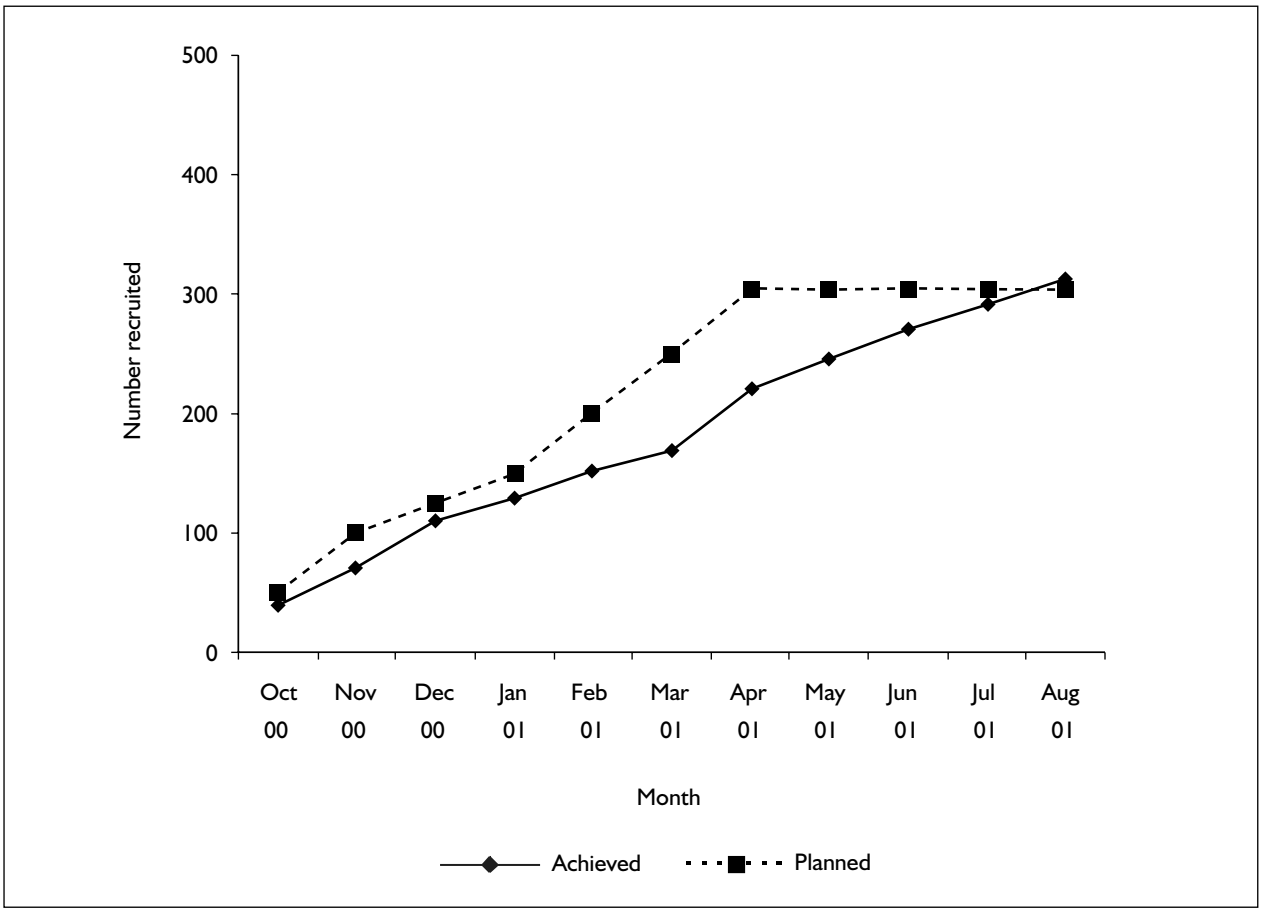

FIGURE 1 *Pattern of recruitment of patients to the study*

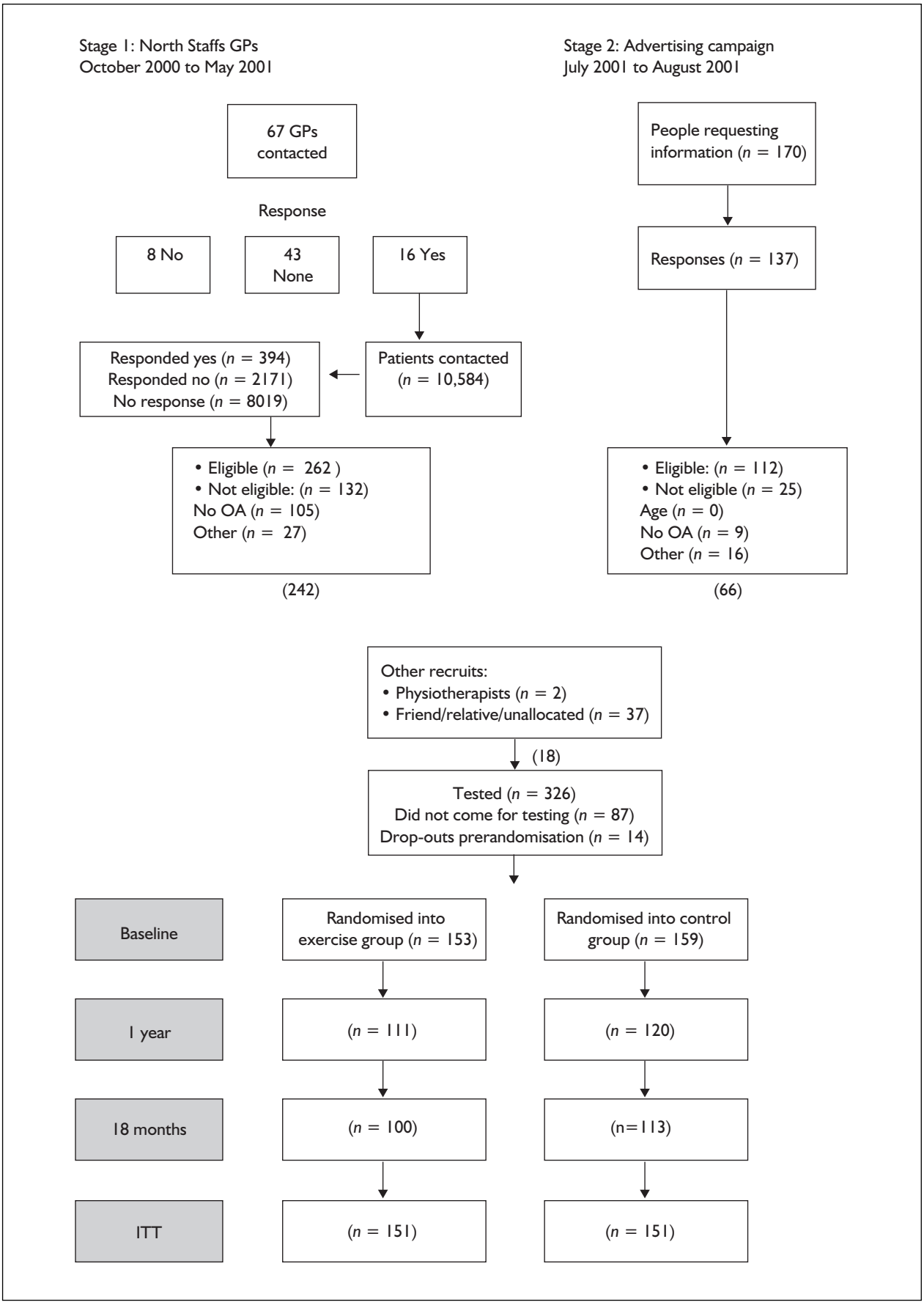

FIGURE 2 *Recruitment and participant flow throughout the study*

TABLE 5 *Comparison of baseline characteristics of those who completed the study with those who dropped out (a) during the 1-year intervention period and (b) during the further 6 months of follow-up*

(a)

	Completer			Dropout			
	Mean	**SD**	***n***	**Mean**	**SD**	***n***	***p*-Value**
Age (years)	69.53	5.98	231	70.34	7.92	80	ns
BMI (kg m^{-2})	29.67	5.08	231	30.02	5.11	81	ns
8-foot walk time (s)	3.36	1.94	231	3.50	2.29	81	ns
Right quadriceps strength (N)	147.55	115.57	228	156.48	103.88	81	ns
Right hamstrings strength (N)	74.44	51.28	227	77.55	57.16	80	ns
Left quadriceps strength (N)	144.62	114.25	230	150.85	108.71	80	ns
Left hamstrings strength (N)	70.63	50.43	229	66.99	49.81	80	ns
Timed stair ascent (s)	3.72	2.81	228	3.98	3.72	80	ns
Timed stair descent (s)	4.10	3.00	228	4.17	3.49	79	ns
WOMAC pain score	8.82	3.28	227	9.16	3.69	79	ns
WOMAC stiffness score	3.93	1.55	227	4.00	1.51	79	ns
WOMAC physical function score	30.38	11.83	221	31.11	13.32	74	ns

(b)

	Completer			Dropout			
	Mean	**SD**	***n***	**Mean**	**SD**	***N***	***p*-Value**
Age (years)	69.70	6.12	213	69.82	7.39	98	ns
BMI (kg m^{-2})	29.67	5.15	213	29.95	4.95	99	ns
8-foot walk time (s)	3.19	1.69	213	3.84	2.58	99	0.022
Right quadriceps strength (N)	155.16	118.75	211	138.56	97.41	98	ns
Right hamstrings strength (N)	76.75	49.81	209	72.05	58.82	98	ns
Left quadriceps strength (N)	150.92	115.47	212	136.08	106.34	98	ns
Left hamstrings strength (N)	72.17	48.51	211	64.35	53.57	98	ns
Timed stair ascent (s)	3.45	2.39	211	4.54	4.10	97	0.016
Timed stair descent (s)	3.80	2.71	211	4.82	3.82	96	0.019
WOMAC pain score	8.57	3.29	212	9.69	3.49	94	0.007
WOMAC stiffness score	3.81	1.57	211	4.25	1.43	95	0.019
WOMAC physical function score	29.40	11.75	206	33.25	12.85	89	0.013

ns, not significant.

The final ITT analysis was based on only 151 per group because some participants did not complete baseline assessments satisfactorily.

Dropout

Overall, 231 subjects (74%) completed the study up to the 1-year point. Forty-two subjects (27%) dropped out from the exercise group and 39 (25%) from the control group in this period. A further 18 participants withdrew during the 6-month follow-up period. At the 1-year point, the dropouts, as a group, were not statistically different to those who completed the study, on gender, age, BMI, baseline values or distribution of joint disease (*Tables 5* and *6*). However, at 18 months, those who dropped out had poorer scores on all three WOMAC indices and the three walking tests. All but three of the 99 dropouts were followed up to give reasons for not continuing participation. These are summarised in *Table 7*.

Attendance

The profile of attendance of patients in the water exercise group throughout the staggered intervention period is shown in *Figure 3*. This is broken down by session for each of the four venues used in *Figure 4*. Times for the ten weekly sessions were as follows: FM1, Monday, 14.50; FM2, Tuesday, 14.50; FM3, Wednesday, 09.00; SP4, Wednesday, 09.45; SP5, Thursday, 09.30; SP6, Sunday, 13.00; TP7, Monday, 15.00, TP8, Wednesday, 15.00; NP9, Monday, 10.00; NP10, Wednesday, 10.00. Compliance with the prescribed programme of exercise sessions, for those patients in the water exercise group who attended at least one session, is illustrated in *Figure 5*. The vertical

TABLE 6 *Cross-tabulations comparing completers with those who dropped out, by gender, group and number of joints affected (a) during the 1-year intervention period and (b) during the further 6 months of follow-up*

(a)

		Completer	Drop-out (1 year)	Total	*p*-Value
Gender	Female	148	48	196	ns
	Male	83	33	116	
	Total	231	81	312	
Group	Control	120	39	159	ns
	Exercise	111	42	153	
	Total	231	81	312	
No. of joints affected	1	69	18	87	ns
	2	109	45	154	
	3	18	9	27	
	4	35	9	44	
Total		231	81	312	

(b)

		Completer	Dropout (18 months)	Total	*p*-Value
Gender	Female	135	61	196	ns
	Male	78	38	116	
	Total	213	99	312	
Group	Control	113	46	159	ns
	Exercise	100	53	153	
	Total	213	99	312	
No. of joints affected	1	65	22	87	ns
	2	102	52	154	
	3	16	11	27	
	4	30	14	44	
Total		213	99	312	

TABLE 7 *Reasons given for dropout from the study*

Reason	During intervention		During further 6-month follow-up	
	Control	Exercise	Control	Exercise
Did not give reason	5	7	2	1
Too busy (family commitments, etc.)	8	6		
Disability or illness	8	15	3	2
Death	5	1		
Lost interest	5	7	2	2
Moved from area	7	3		
Afraid of water		2		
Unable to contact	1	1		
Unwilling to pay for treatment				6
Totals	39	42	7	11
	81		99	

axis shows the percentage of the group who attended at least the percentage of the prescribed number of exercise sessions shown on the horizontal axis. It should be noted that 23 patients (15%) in the water exercise group felt, or were, unable to attend any of the exercise sessions provided. These patients are not included in the analysis presented in *Figure 5*. Based on the data presented in *Figure 5*, overall compliance with the programme over the intervention period averaged

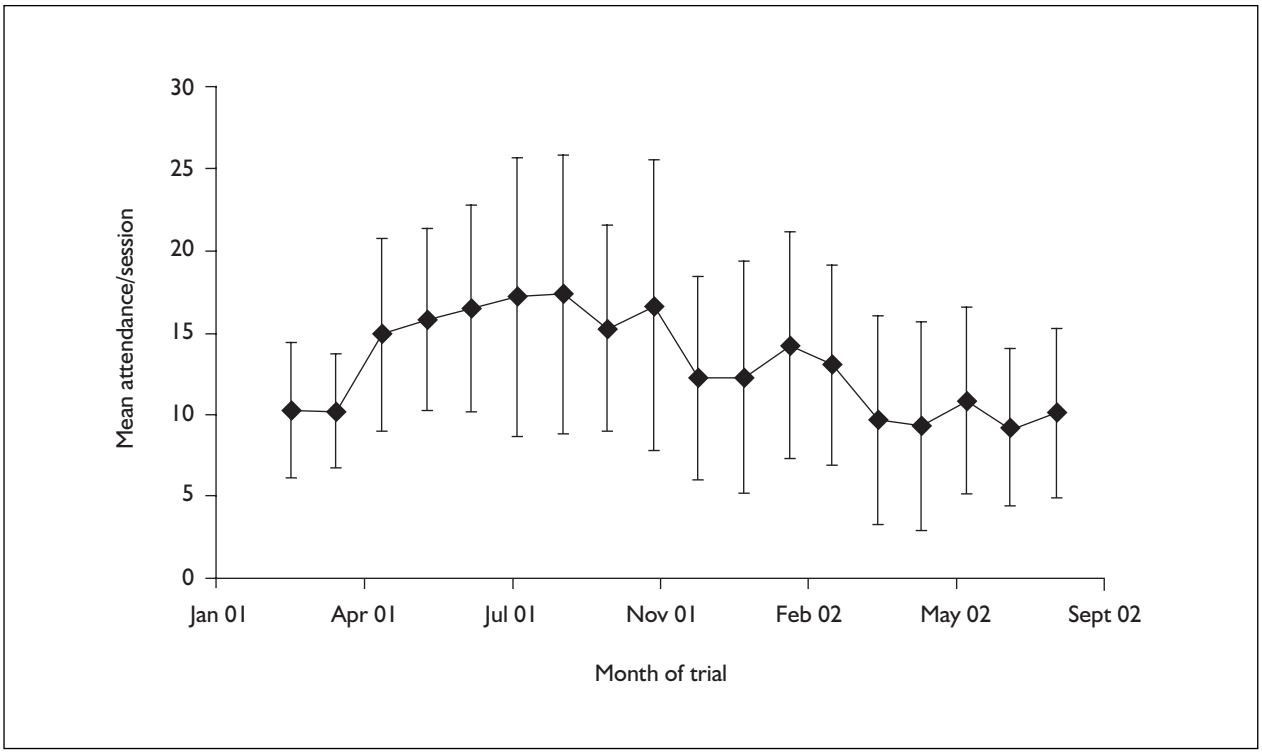

FIGURE 3 *Mean attendance per session throughout the trial period (error bars represent SD)*

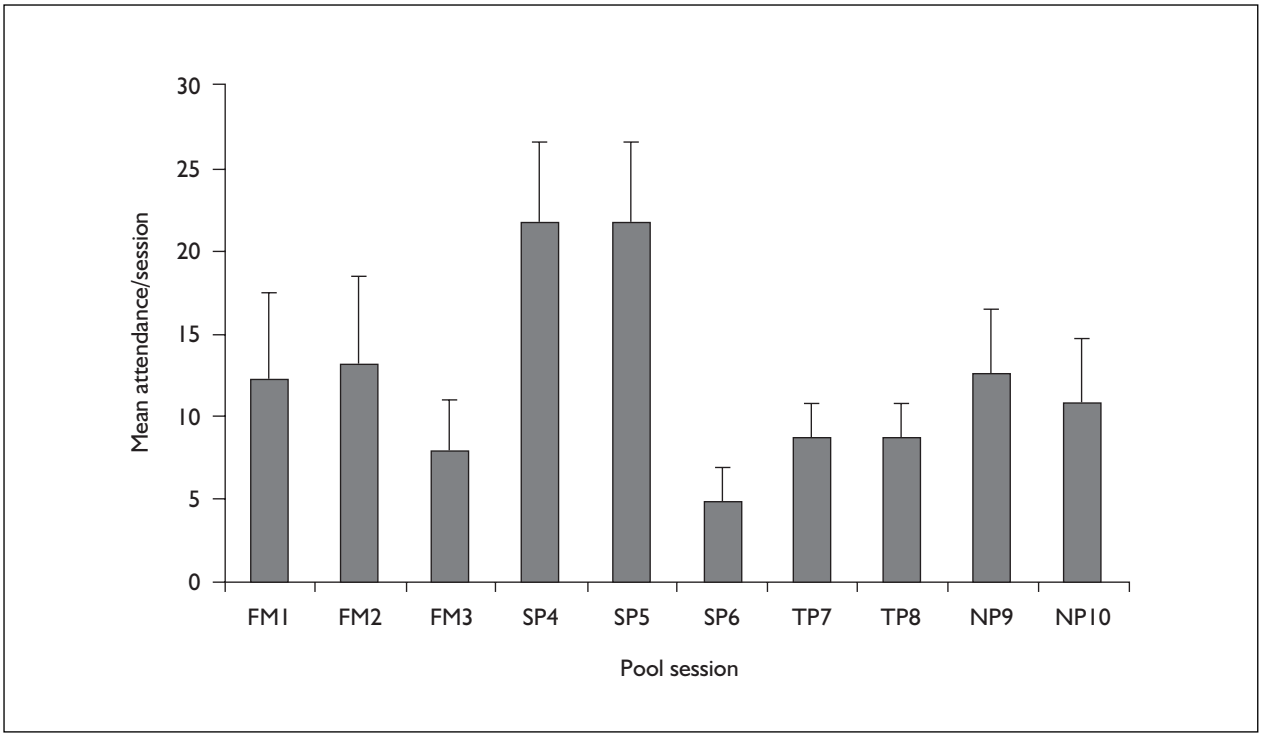

FIGURE 4 *Mean attendance per session for the four venues and ten sessions used throughout the trial. FM, Fenton Manor; SP, Shelton; TP, Tunstall; NP, Newcastle under Lyme (error bars represent SD).*

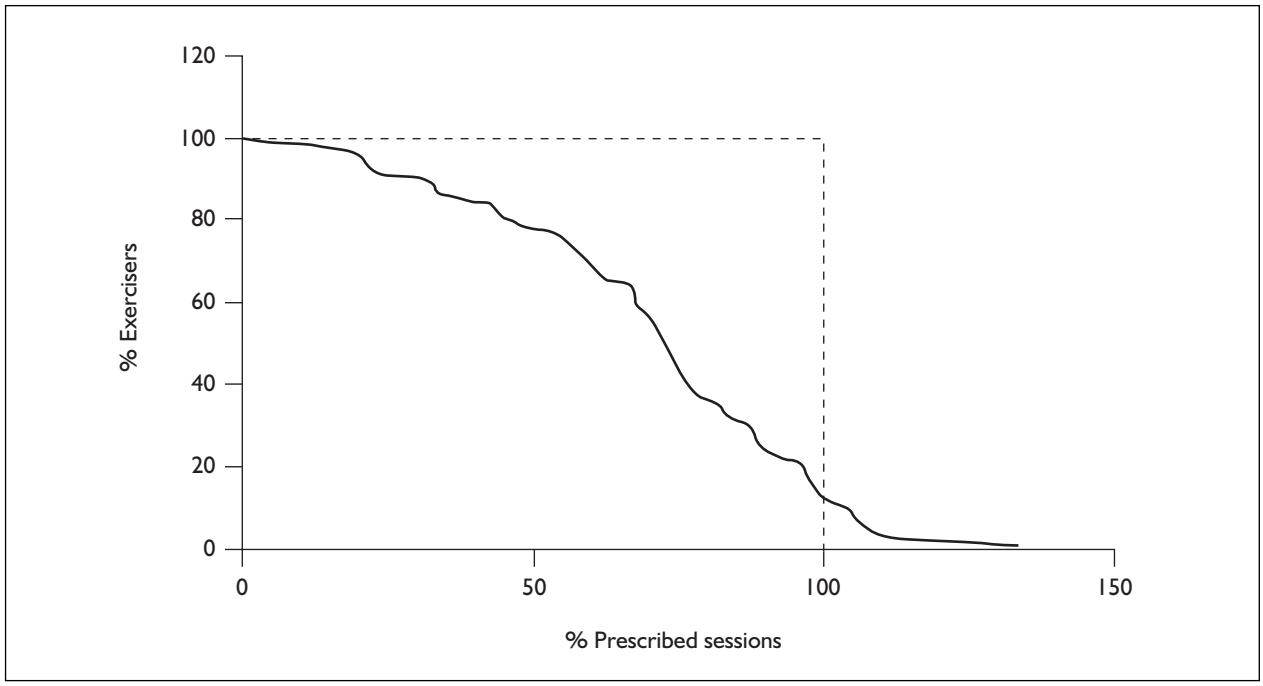

FIGURE 5 *Overall compliance with water exercise programme for those who attended at least one exercise session*

59% [area under the cumulative compliance distribution curve as a proportion of the area represented by the rectangular area (dotted lines)].

Data screening

Before analysis, relevant variables were screened to check for missing values, outliers and appropriateness for the proposed multivariate approach to be used.

For the main analyses, the number of missing items on any variable was small (<5%) apart from the WOMAC physical function score, which had 17 missing cases. There was no discernible pattern for the missing cases and no systematic relationship between missingness on the WOMAC physical function score and any of the other variables. Therefore, missing values at baseline were not replaced.

The physical function measures, 8-foot walk, stair ascent and stair descent contained relatively large numbers of values (25, 23 and 21, respectively) that were high outliers. These were related to patients who experienced great difficulty with walking. It was important to retain these cases but not to allow the recorded values to distort the analyses unduly. Thus, these extreme scores were set equal to the upper limit values (defined by Q3 + 1.5 IQR, where Q3 is the third quartile cut-off point and IQR is the interquartile range) for each of these variables, which were 5.5, 7.2 and 6.6 seconds, respectively.

There were no problems with multivariate outliers or multicollinearity.

Baseline data

Comparison of groups and main outcome measures

Baseline characteristics of the subjects recruited to the study are shown in *Tables 8* and *9*. Co-morbidity in the two groups is compared in *Table 10*. There were no significant differences between the groups at baseline on any of the study variables, although it was noted that the physical role limitations dimension of the SF-36 showed a trend towards better scores for the water exercise group ($p = 0.063$). It can be seen from *Table 10* that co-morbid conditions were common in both groups, with no significant disparity between the groups. Obesity (defined as a BMI > 30) occurred in almost 50% of the total sample. Cardiovascular, gastrointestinal and other musculoskeletal disorders and cancer also were noted frequently.

Distribution of joint disease

The distribution of the joints affected (hip and knee) for the whole sample and by group is shown in *Tables 11–15*. There were no statistically

TABLE 8 *Baseline data on self-report measures, by group*

	Control			Exercise		
	Mean	**SD**	***n***	**Mean**	**SD**	***n***
WOMAC pain score	9.10	3.14	154	8.72	3.62	152
WOMAC physical function score	31.05	11.24	149	30.06	13.13	146
WOMAC stiffness score	4.03	1.42	154	3.86	1.66	152
SF-36 pain	40.88	18.55	156	43.04	22.08	150
SF-36 physical function	50.53	20.82	150	50.61	24.01	148
SF-36 social function	64.73	27.37	155	63.11	29.90	150
SF-36 role physical	20.07	32.04	152	27.52	36.85	149
SF-36 role mental	44.37	44.78	154	46.94	45.46	147
SF-36 mental health	69.26	16.78	155	68.19	16.84	147
SF-36 vitality	44.22	19.21	154	42.53	21.31	148
SF-36 general health	51.69	19.40	153	50.34	19.77	146
EQ-VAS	61.67	17.05	154	60.00	19.01	148

TABLE 9 *Baseline data on physical measures, by group*

	Control			Exercise		
	Mean	**SD**	***n***	**Mean**	**SD**	***n***
Age (years)	69.63	6.26	158	69.86	6.82	153
BMI (kg m^{-2})	29.79	5.13	159	29.73	5.05	153
Left hamstrings strength (N), baseline	71.87	50.80	156	67.46	49.69	153
Left quadriceps strength (N), baseline	148.50	117.91	157	143.90	107.45	153
Right hamstrings strength (N), baseline	75.54	51.83	154	74.96	53.93	153
Right quadriceps strength (N), baseline	146.55	110.48	157	153.35	114.87	152
8-foot walk time (s), baseline	3.56	2.27	159	3.22	1.75	153
Timed stair ascent (s), baseline	3.91	3.18	156	3.67	2.95	152
Timed stair descent (s), baseline	4.29	3.15	156	3.94	3.11	151
Gender (female/male)		99/60			97/56	

TABLE 10 *Comparison of groups, by co-morbidity*[a]

Co-morbidity	**Control**	**Exercise**	**Total**
Obesity	73	74	147
Cardiovascular	22	28	50
Gastrointestinal	16	19	35
Other musculoskeletal	9	17	26
Cancer	18	6	24
Eye	7	7	14
OGU	7	7	14
Endocrine	8	4	12
ENT	2	7	9
Skin	6	1	7
Respiratory	2	4	6
Nutrition and blood	1	2	3

[a] Some patients had more than one additional condition.
OGU, obstetrics, gynaecology and urinary tract.

TABLE 11 *Cross-tabulation: number of joints affected, by group*

No. of joints affected	**Control**	**Exercise**	**Total**
1	45	42	87
2	76	78	154
3	14	13	27
4	24	20	44
Total	159	153	312

TABLE 12 *Cross-tabulation: side affected, by group*

Side affected	**Control**	**Exercise**	**Total**
Left	21	28	49
Right	30	31	61
Both	108	94	202
Total	159	153	312

TABLE 13 *Cross-tabulation: knee(s) affected, by group*

OA code: knee	Control	Exercise	Total
None	31	25	56
Left	20	28	48
Right	29	31	60
Both	79	69	148
Total	159	153	312

TABLE 14 *Cross-tabulation: hip(s) affected, by group*

OA code: hip	Control	Exercise	Total
None	76	75	151
Left	17	16	33
Right	21	20	41
Both	45	42	87
Total	159	153	312

TABLE 15 *Cross-tabulation: joints affected, by group*

Joints affected	Control	Exercise	Total
Left hip	8	5	13
Right hip	7	4	11
Both hips	16	16	32
Left knee	11	17	28
Left knee, left hip	2	6	8
Left knee, right hip	5	0	5
Left knee, both hips	2	5	7
Right knee	19	16	35
Right knee, left hip	3	3	6
Right knee, right hip	4	11	15
Right knee, both hips	3	1	4
Both knees	46	42	88
Both knees, left hip	4	2	6
Both knees, right hip	5	5	10
Both knees, both hips	24	20	44
Total	159	153	312

significant differences between the groups on any of these distributions.

Outcomes and estimation of effects

Comparison of self-report outcomes

Basic data on the self-report outcomes by group at the 6-month, 1-year and 18-month time-points are shown in *Table 16*. In most instances, reported individual p-values did not achieve the conservative target of 0.01. The interpretations were based on analysis of the profiles for each outcome measure, coupled with a more liberal threshold p-value than the original target, the latter adjustment being necessary because the design assumptions with respect to effect size (on an ITT basis) and treatment compliance (over 12 and 18 months) were underestimated.

WOMAC pain comparison at baseline, 6, 12 and 18 months

The WOMAC pain indices for the two groups for each of the four assessment points (baseline, 6 months, 1 year and 18 months) are compared in *Figure 6*. The control group profile demonstrated a general worsening of the WOMAC pain score over the 1-year intervention period, whereas the exercise group profile demonstrated a general improvement. The lines connecting to the 18-month mean scores are shown dotted to indicate that these data relate to the follow-up period, during which the water exercise intervention was no longer supported. In essence, the treatment was no longer controlled during this period. The mean difference between the groups on the WOMAC pain score at the end of the intervention period (1 year) was 0.89 units and the pooled standard deviation was 3.64 units. This difference was significant at $p = 0.031$ (independent samples t-test at the 1-year time-point).

The data in *Figure 6* are the unadjusted group mean scores for the WOMAC pain index at the four measurement points. *Figure 7* shows the comparison (over the intervention period only) of WOMAC pain scores, adjusted for baseline differences in WOMAC pain score. Interpretation of the group differences in this scenario was complicated by the fact that the repeated measures general linear model analysis, including baseline pain score as a covariate, revealed both a main effect for time ($p < 0.001$) and a time by baseline pain interaction ($p < 0.001$). The latter implies a divergence with time on the basis of baseline pain in the two groups (control group scores increased, intervention group scores decreased). Thus, the inclusion of baseline pain in the analysis masks some of the effect of treatment. In this case, the group difference at 1 year was not significant ($p = 0.052$).

Estimated effect sizes: self-report outcome measures

Effect sizes for the differences in group mean WOMAC indices, SF-36 dimensions and EQ-VAS scores are shown in *Table 17*. The primary interest was in the group differences at the end of the intervention period. Small but significant ($p < 0.05$) beneficial effects were observed for the

TABLE 16 *Comparison of self-report outcome measures by group at 6 months, 1 year and 18 months*

	Control			Exercise		
	Mean	**SD**	***n***	**Mean**	**SD**	***n***
6 months						
WOMAC pain score	9.34	3.78	158	8.59	3.68	152
WOMAC physical function score	32.57	13.20	155	28.84	14.23	148
WOMAC stiffness score	4.06	1.57	157	3.86	1.61	152
SF-36 pain	39.69	20.86	159	45.76	22.69	152
SF-36 physical function	47.61	22.46	157	53.20	23.24	150
SF-36 social function	62.38	28.03	158	65.42	30.00	152
SF-36 role physical	18.95	30.14	157	37.75	42.02	151
SF-36 role mental	44.94	45.14	158	55.48	45.62	149
SF-36 mental health	68.50	16.66	159	70.88	18.39	150
SF-36-vitality	42.26	18.83	159	46.95	20.81	151
SF-36-general health	48.68	19.85	158	52.64	20.87	151
EQ-VAS	59.37	19.23	156	63.16	17.90	150
1 year						
WOMAC pain score	9.35	3.54	158	8.46	3.74	152
WOMAC physical function score	32.42	13.25	156	29.26	14.48	149
WOMAC stiffness score	4.15	1.48	158	3.88	1.67	152
SF-36 pain	40.74	20.49	159	46.64	22.38	152
SF-36 physical function	49.03	22.48	159	49.97	24.05	151
SF-36 social function	63.94	28.08	159	63.96	30.07	152
SF-36 role physical	24.21	33.32	158	33.22	40.46	152
SF-36 role mental	44.51	45.24	158	51.23	46.10	149
SF-36 mental health	68.50	17.29	159	69.17	18.57	150
SF-36 vitality	43.40	18.84	159	45.43	21.13	151
SF-36 general health	49.66	19.35	159	51.14	20.40	151
EQ-VAS	60.68	17.39	157	62.55	18.61	150
18 months						
WOMAC pain score	8.88	3.45	158	8.49	3.94	152
WOMAC physical function score	31.15	12.73	156	29.73	14.62	150
WOMAC stiffness score	3.98	1.50	158	3.77	1.62	152
SF-36 pain	41.58	20.28	159	45.47	23.49	152
SF-36 physical function	48.62	22.31	159	49.97	23.65	151
SF-36 social function	63.45	28.24	159	64.25	28.90	152
SF-36 role physical	23.42	32.26	158	30.92	38.89	152
SF-36 role mental	46.84	45.62	158	50.34	45.46	149
SF-36 mental health	68.43	17.69	159	69.36	18.59	150
SF-36 vitality	42.64	19.25	159	45.53	20.06	151
SF-36 general health	49.74	19.71	159	52.56	20.72	151
EQ-VAS	60	19	157	62	19	150

WOMAC pain and physical function scores and the SF-36 pain and physical role dimensions.

The SF-36 questionnaire also incorporates a single question relating to the change in health compared to 1 year ago. The distributions of the raw scores on this index between the two groups at the self-report measurement points are summarised in *Table 18*. The distributions of ratings on this index of change in health over 1 year demonstrated a trend towards improved health in the water exercise group at the 6-month, 1-year and 18-month measurement points.

Effect sizes: physical function measures

Physical function measures at 1 year and 18 months are compared in *Table 19*. Mean differences in physical function measures and the corresponding effect sizes are shown in *Table 20*. Small beneficial effects were observed at the 1-year time-point for the stair ascent and descent times.

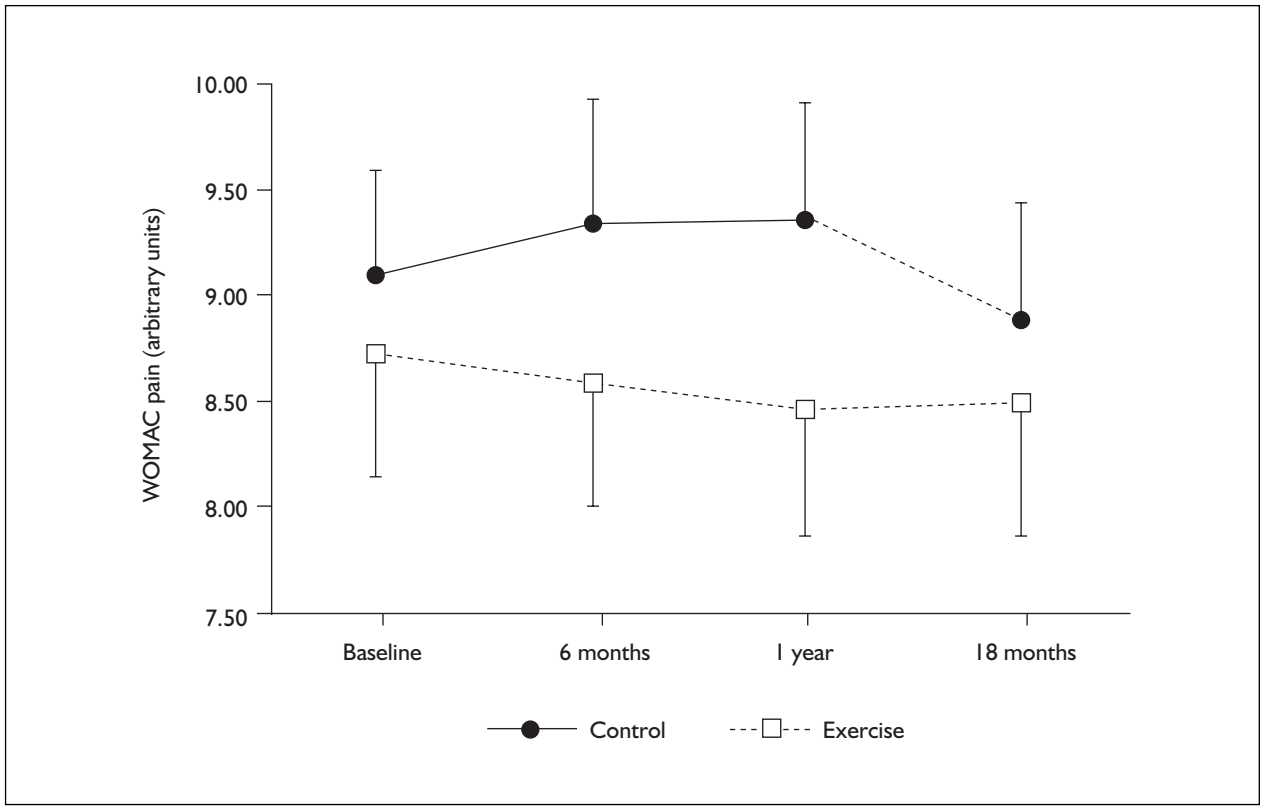

FIGURE 6 *Comparison of WOMAC pain scores by group (vertical bars represent semi-95% CIs)*

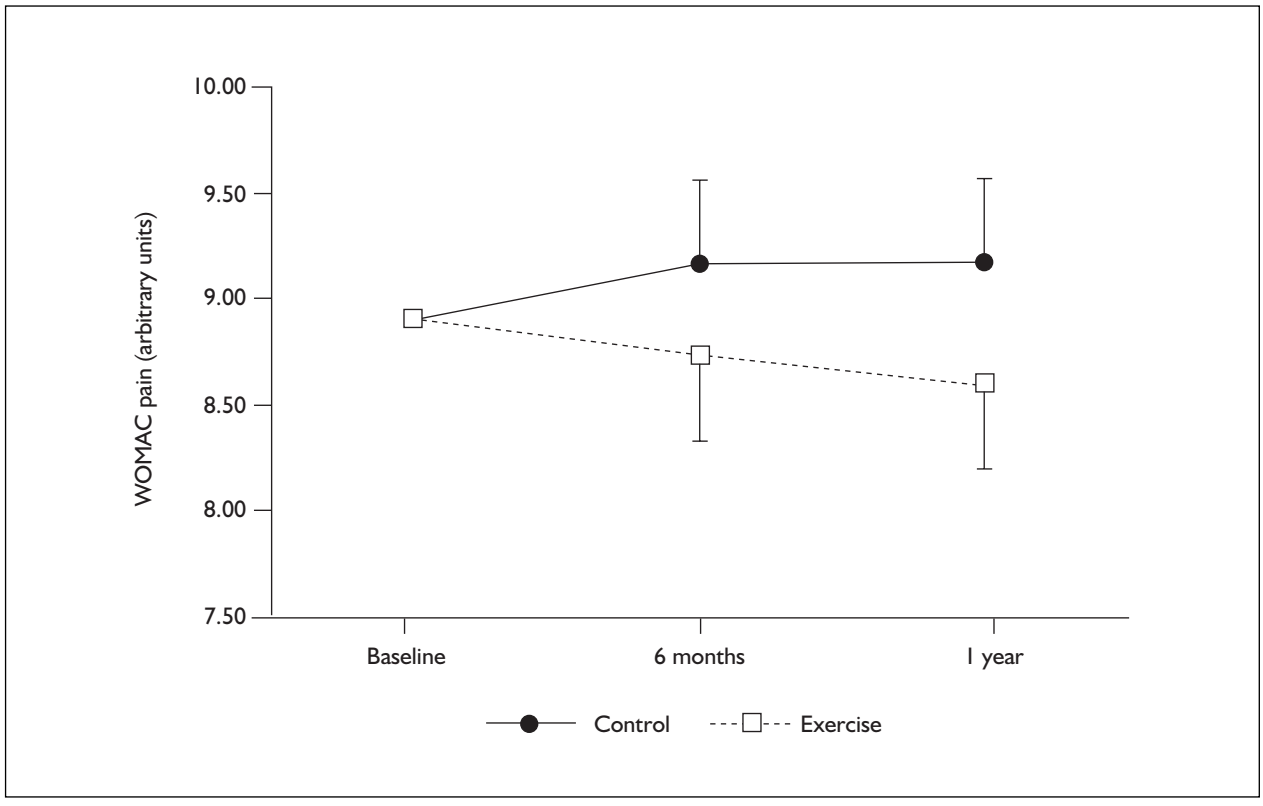

FIGURE 7 *Comparison of WOMAC pain scores by group, adjusted for baseline scores (vertical bars represent semi-95% CIs)*

TABLE 17 *Effect sizes on self-report measures at 6 months, 1 year and 18 months*

Measure	6 months			1 year			18 months		
	Mean difference[a]	ES[b]	95% CI for ES	Mean difference	ES	95% CI for ES	Mean difference	ES	95% CI for ES
WOMAC pain	0.75	0.2	–0.02 to 0.42	0.89	0.25*	0.02 to 0.47	0.39	0.10	–0.12 to 0.33
WOMAC physical function	3.73	0.27*	0.04 to 0.50	3.16	0.23*	0.00 to 0.45	1.42	0.10	–0.12 to 0.33
WOMAC stiffness	0.21	0.13	–0.09 to 0.35	0.27	0.17	–0.05 to 0.39	0.21	0.13	–0.09 to 0.36
SF-36 pain	6.07	0.28*	0.05 to 0.50	5.90	0.27*	0.05 to 0.50	3.89	0.18	–0.05 to 0.40
SF-36 physical function	5.59	0.24*	0.02 to 0.47	0.94	0.04	–0.18 to 0.26	1.35	0.06	–0.16 to 0.28
SF-36 social function	3.05	0.11	–0.12 to 0.33	0.02	0.00	–0.22 to 0.22	0.80	0.03	–0.19 to 0.25
SF-36 role physical	18.80	0.50*	0.29 to 0.74	9.01	0.24	0.02 to 0.47	7.50	0.21	–0.01 to 0.43
SF-36 role mental	10.54	0.23*	0.01 to 0.46	6.72	0.15	–0.08 to 0.37	3.50	0.08	–0.15 to 0.30
SF-36 mental health	2.38	0.14	–0.09 to 0.36	0.66	0.04	–0.19 to 0.26	0.93	0.05	–0.17 to 0.27
SF-36 vitality	4.69	0.24*	0.01 to 0.46	2.03	0.10	–0.12 to 0.32	2.89	0.15	–0.08 to 0.37
SF-36 general health	3.96	0.19	–0.03 to 0.42	1.48	0.07	–0.15 to 0.30	2.82	0.14	–0.08 to 0.36
EQ-VAS	3.79	0.2	–0.02 to 0.43	1.87	0.10	–0.12 to 0.33	1.48	0.08	–0.15 to 0.3

[a] Mean differences are expressed as positive where this demonstrates a beneficial change in this outcome measure in the water exercise group.
[b] Effect size: a positive value represents a beneficial difference in the water exercise group.
* $p < 0.05$.

TABLE 18 *Distribution of scores on the SF-36 question relating to health compared with 1 year ago at baseline, 6 months, 1 year and 18 months*

	Control	Exercise	*p*-value (χ^2), Cramer's *V*
Baseline			
Much worse	5	7	0.733, ns
Somewhat worse	63	66	
About the same	65	64	
Somewhat better	15	12	
Much better	5	2	
6 months			
Much worse	7	4	<0.001, 0.335
Somewhat worse	67	37	
About the same	76	69	
Somewhat better	5	32	
Much better	2	10	
1 year			
Much worse	10	6	<0.001, 0.286
Somewhat worse	60	36	
About the same	76	67	
Somewhat better	8	33	
Much better	4	10	
18 month			
Much worse	9	4	0.012, 0.204
Somewhat worse	59	38	
About the same	74	76	
Somewhat better	12	26	
Much better	4	8	

TABLE 19 *Comparison of physical function measures by group at 1 year and 18 months*

	Control			Exercise		
	Mean	**SD**	***n***	**Mean**	**SD**	***n***
1 year						
8-foot walk time (s)	3.43	1.78	159	3.10	1.27	153
Timed stair ascent (s)	3.78	2.72	157	3.24	1.93	152
Timed stair descent (s)	4.09	2.66	157	3.42	1.99	151
Left hamstrings strength (N)	78.15	51.41	157	81.85	55.88	153
Left quadriceps strength (N)	140.49	96.89	157	160.21	110.25	153
Right hamstrings strength (N)	83.96	52.70	157	90.33	59.24	153
Right quadriceps strength (N)	145.92	99.82	158	166.02	108.92	152
18 months						
8-foot walk time (s)	3.35	1.72	159	3.02	1.06	153
Timed stair ascent (s)	3.55	2.62	157	3.21	1.86	153
Timed stair descent (s)	3.89	2.52	157	3.49	1.94	152
Left hamstrings strength (N)	79.57	49.18	157	85.62	56.36	153
Left quadriceps strength (N)	134.05	89.02	157	149.33	96.55	153
Right hamstrings strength (N)	87.85	56.95	157	93.23	60.26	153
Right quadriceps strength (N)	135.47	92.65	158	152.22	100.47	152

TABLE 20 *Mean differences and effect sizes (and their 95% CIs) for group differences in physical function measures at 1 year and 18 months*

	Mean difference[a]	ES[b] 1 year	95% CI for ES	Mean difference	ES 18 month	95% CI for ES
8-foot walk (s)	0.33	0.22	–0.01 to 0.44	0.33	0.23*	0.00 to 0.45
Stair ascent (s)	0.54	0.23*	0.01 to 0.45	0.35	0.15	–0.07 to 0.38
Stair descent (s)	0.67	0.28*	0.06 to 0.51	0.40	0.18	–0.05 to 0.4
Left hamstrings strength (N)	3.70	0.07	–0.15 to 0.29	6.05	0.11	–0.11 to 0.34
Left quadriceps strength (N)	19.72	0.19	–0.03 to 0.41	15.28	0.16	–0.06 to 0.39
Right hamstrings strength (N)	6.37	0.11	–0.11 to 0.34	5.38	0.09	–0.13 to 0.31
Right quadriceps strength (N)	20.10	0.19	–0.03 to 0.42	16.76	0.17	–0.05 to 0.4

[a] Mean differences are expressed as positive where this demonstrates a beneficial change in this outcome measure in the water exercise group.
[b] Effect size: a positive value represents a beneficial difference in the water exercise group.
* $p < 0.05$.

Ancillary analyses

Effect of treatment: CACE

The main analysis above was performed on an ITT basis to determine whether the treatment approach is effective for the population of older patients with lower limb OA. Since relatively large numbers of patients in the water exercise groups did not take any, or took only limited, part in their prescribed exercise programmes, the apparent effects of treatment will be diluted by the inclusion of patients who received no 'dose' of treatment. Two questions, therefore, are of interest. First, can an estimate of effect size be obtained for those patients who do comply with their treatment? Second, is there a subset of the population for which the treatment is effective and are criteria available to enable an appropriate selection to be made? These questions cannot be wholly answered from the data obtained in the present research. However, some useful pointers may be obtained from further analysis on the basis of those who adhered to the treatment and those who did not.

To calculate an estimate of the effect of treatment on those treated, the data on adherence for those in the exercise group were dichotomised into compliers and non-compliers. Compliers were defined as those who attended at least 50% of their prescribed exercise sessions over the 1-year treatment period. Participants were thus classified into three groups: control, compliers and non-compliers, and CACE estimates for the various outcome measures were calculated using equation (1). CACE estimates at the 1-year and 18-month time-points are summarised in *Table 21*.

In view of the exploratory nature of this analysis and the limiting assumptions that have been made in deriving CACE estimates, 95% confidence intervals were not calculated for all of the study outcome measures. However, further analysis of a few key variables is instructive. *Table 22* reports mean values for the CACE estimates and 95% confidence intervals derived from 1000 resamples from the data sets for control, compliers and non-compliers at the 1-year time-point.

The data in *Tables 21* and *22* illustrate the importance of compliance with treatment. Small effect sizes reported in *Tables 17* and *20*, when considered on the basis of ITT, could actually be moderate if treatment compliance was improved and could even be larger if the upward trend in controls and the downward trend in the intervention group (*Figure 6*) were to continue with extension of treatment beyond the 1 year used in this study.

From the data presented in *Table 22*, one can be confident at the 95% level that a participant in the water exercise treatment would see a beneficial reduction in WOMAC pain of between 0.13 and 3.17 units (with implications for future quality of life and healthcare costs) and an improvement in the time to descend four stairs of between 0.26 and 2.2 seconds (with implications for mobility and future maintenance of independence). Furthermore, these benefits were achieved at a mean cost saving of £214 (£493 if the costs of providing the water exercise intervention are excluded) (*Table 22*).

Two important findings uncovered by this research, and to the authors' knowledge not reported elsewhere, relate to the variability of the EQ-VAS (and EQ-5D) and the treatment costs across the treatment groups. Both EQ measures

TABLE 21 *CACE analysis at 1 year and 18 months*

Outcome measure	Control	Complier	Non-complier	Nc	Nnc	Pc	CACE	ACE
1 year								
WOMAC pain	9.35	7.63	9.43	82	70	0.54	–1.65	–0.89
WOMAC physical function	32.42	27	32.01	82	67	0.55	–5.76	–3.17
WOMAC stiffness	4.15	3.71	4.07	82	70	0.54	–0.51	–0.28
SF-36 pain	40.74	50.83	41.75	82	70	0.54	10.95	5.91
SF-36 physical function	49.03	53.78	45.43	82	69	0.54	1.68	0.91
SF-36 social function	63.94	70.33	56.51	82	70	0.54	0.06	0.03
SF-36 role physical	24.21	42.38	22.5	82	70	0.54	16.71	9.02
SF-36 role mental	44.51	61.79	38.31	82	67	0.55	12.21	6.72
SF-36 mental health	68.5	72.24	65.46	82	68	0.55	1.25	0.69
SF-36 vitality	43.4	50.61	39.28	82	69	0.54	3.7	2
SF-36 general health	49.66	55.52	45.93	82	69	0.54	2.68	1.45
EQ-VAS	60.68	66.18	58.16	82	68	0.55	3.44	1.89
8-foot walk (s)	3.43	3.02	3.18	82	71	0.54	–0.62	–0.33
Stair ascent (s)	3.78	2.97	3.54	81	71	0.53	–1.02	–0.54
Stair descent (s)	4.09	3.23	3.65	81	70	0.54	–1.23	–0.66
Left hamstrings (N)	78.15	88.45	74.23	82	71	0.54	6.96	3.76
Left quadriceps (N)	140.49	159.29	161.27	82	71	0.54	36.5	19.71
Right hamstrings (N)	83.96	94.3	85.75	82	71	0.54	11.86	6.4
Right quadriceps (N)	145.92	157.6	175.89	82	70	0.54	37.21	20.09
18 months								
WOMAC pain	8.88	7.59	9.10	61	91	0.40	–0.96	–0.39
WOMAC physical function	31.15	26.97	31.63	61	89	0.41	–3.49	–1.42
WOMAC stiffness	3.98	3.31	4.08	61	91	0.40	–0.53	–0.21
SF-36 pain	41.58	55.92	38.46	61	91	0.40	9.69	3.89
SF-36 physical function	48.62	56.39	45.61	61	90	0.40	3.34	1.35
SF-36 social function	63.45	72.31	58.85	61	91	0.40	2.00	0.80
SF-36 role physical	23.42	39.34	25.27	61	91	0.40	18.70	7.50
SF-36 role mental	46.84	65.03	40.15	61	88	0.41	8.55	3.50
SF-36 mental health	68.43	75.15	65.39	61	89	0.41	2.29	0.93
SF-36 vitality	42.64	53.03	40.44	61	90	0.40	7.15	2.89
SF-36 general health	49.74	62.11	46.08	61	90	0.40	6.98	2.82
EQ-VAS	60.10	67.85	57.28	61	89	0.41	3.65	1.48
8-foot walk (s)	3.35	2.89	3.11	61	92	0.40	–0.82	–0.33
Stair ascent (s)	3.55	2.90	3.41	61	92	0.40	–0.87	–0.35
Stair descent (s)	3.89	3.15	3.71	61	91	0.40	–0.99	–0.40
Left hamstrings (N)	79.57	97.77	77.57	61	92	0.40	15.18	6.05
Left quadriceps (N)	134.05	149.75	149.04	61	92	0.40	38.31	15.28
Right hamstrings (N)	87.85	100.69	88.28	61	92	0.40	13.48	5.38
Right quadriceps (N)	135.47	152.25	152.21	61	91	0.40	41.75	16.76

ACE, average causal effect; Nc, number of compliers; Nnc, number of non-compliers; Pc, proportion of compliers.

TABLE 22 *Mean CACE estimates and 95% CIs for group differences in key study outcome measures at 1 year*

Measure	Mean	95% CI
WOMAC pain	1.65	0.13 to 3.17
Stair descent (s)	1.23	0.26 to 2.20
EQ-VAS	3.62	–3.76 to 11.00
Mean cost difference (all costs) (£)	214.14	–183.15 to 611.43
Mean cost difference (excluding costs of intervention) (£)	493.53	80.05 to 907.01

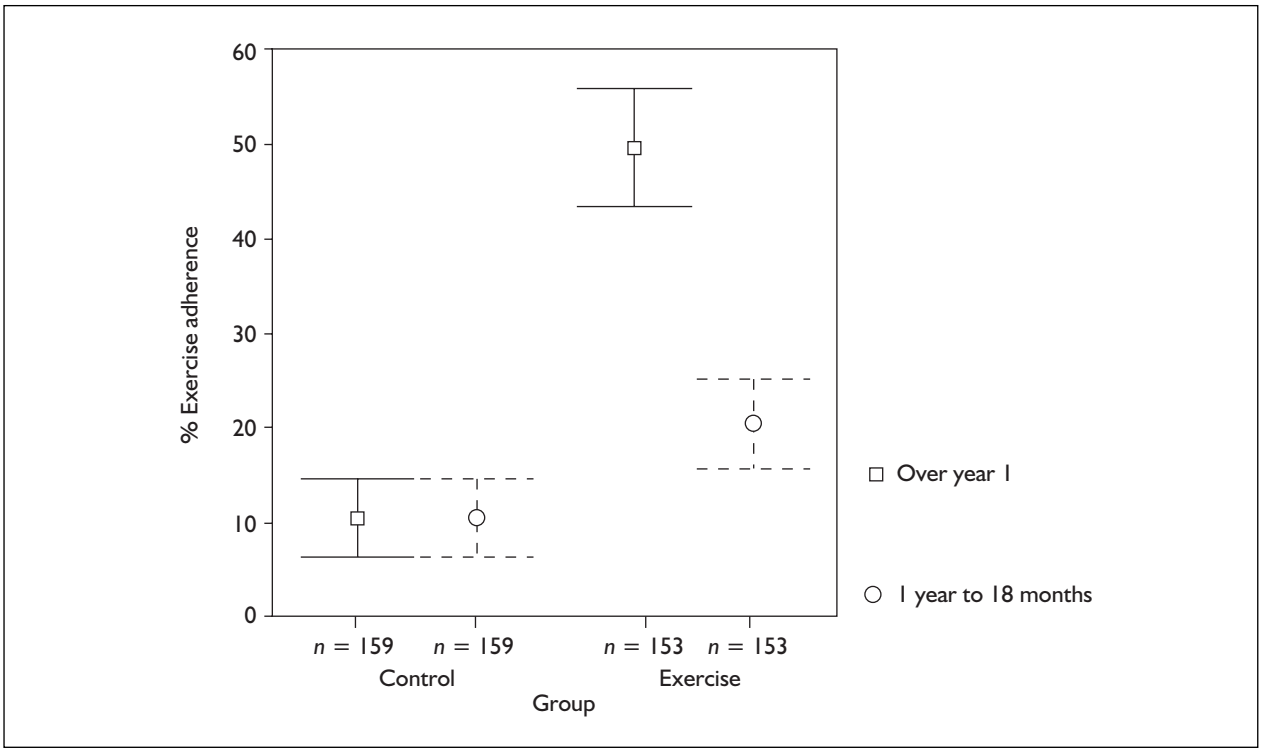

FIGURE 8 *Comparison of exercise dose in control and exercise groups over the 1-year intervention and 6-month postintervention periods (error bars represent the 95% CI for group mean)*

demonstrated wide variability across time. The factors influencing this variability are unknown, but may well be attributable to co-morbidity in this older patient population (*Table 10*). Mean cost estimates per participant were dominated by high-cost, low-frequency items, such as joint replacement or the purchase of an expensive mobility aid. Thus, the estimates for the treatment cost-effectiveness based on these measures did not achieve the 95% level of confidence in a net gain for the treatment group.

The above two observations have implications for health economic evaluations in such patient populations. First, with respect to effect estimates, either a measure that is more specific to OA is needed as the treatment comparator (on the basis of their experience the authors would propose the WOMAC pain scale) or the effects of co-morbidity need to be included in the analysis. Second, with respect to costs, either larger patient groups would need to be recruited to reduce confidence intervals of group mean cost estimates associated with low-frequency, high-cost items, or the treatment cohorts would need to be followed for longer. The authors would propose the latter as the preferred alternative because not only would this improve the stability of cost estimates, but it would also allow projections across time and longer term implications of treatment to be considered. Time to events such as hip or knee joint replacement could also be compared through appropriate survival analysis.

Reanalysis by those who exercised and those who did not

Quarterly telephone follow-up of control subjects indicated that a number of the control patients took up exercise either in response to advice from their GP or physiotherapist or of their own volition. Numbers of control subjects who took up exercise were small over the first 6-month period, but increased gradually throughout the study. At the end of 1 year of intervention, a number of control subjects opted to take up exercise (at least 31 were exercising regularly throughout the 6-month postintervention follow-up period), whereas a number of the water exercise group dropped out because sessions were no longer provided free of charge. The respective 'group' doses of physical activity over the 1-year intervention period and the 6-month postintervention period are summarised in *Figure 8*. It should be noted that the estimates for the activity patterns in control group subjects were taken from responses to questions in quarterly telephone follow-up interviews and in the programme evaluation questionnaire, and were

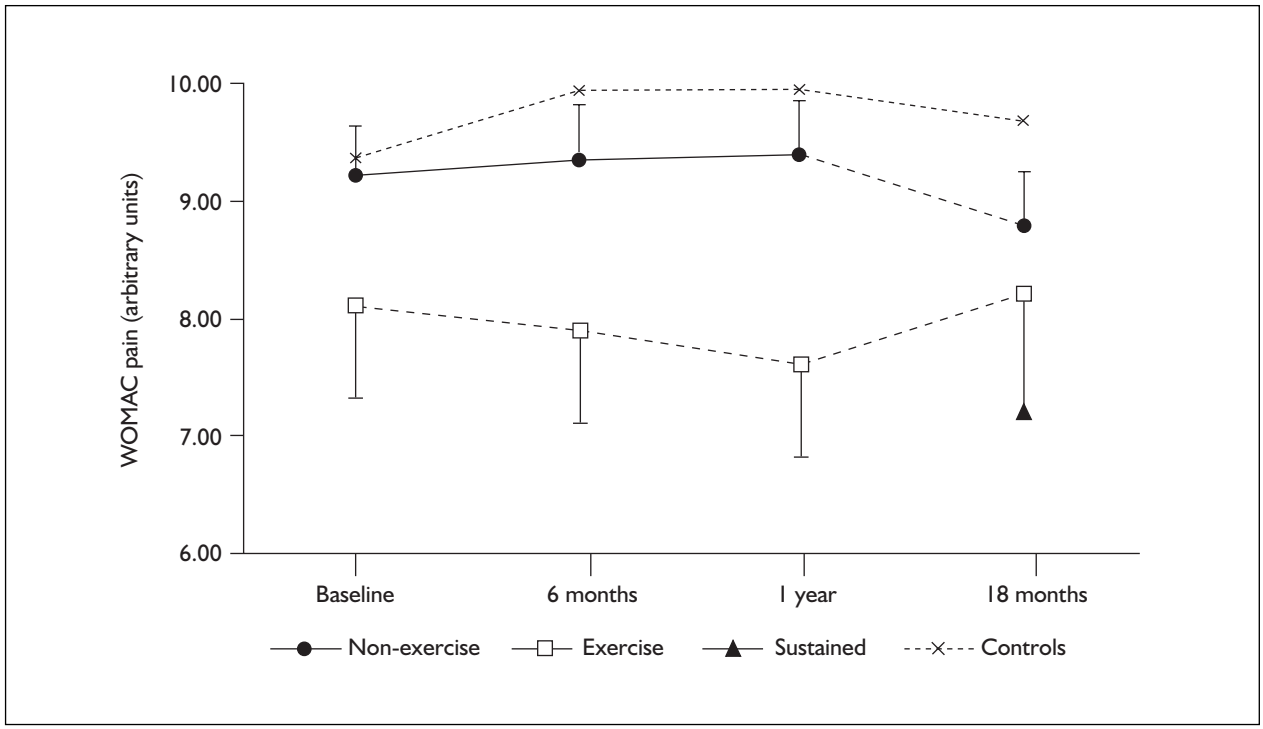

FIGURE 9 *Comparison of WOMAC pain scores by groups defined by those who exercised regularly and those who did not (vertical bars represent semi-95% CIs)*

not derived from direct observation as with the water exercise group.

The importance of compliance with treatment is further emphasised in *Figure 9*, where the WOMAC pain profiles are replotted by groups defined in terms of those who exercised regularly (irrespective of initial randomisation) and those who did not. Up to the 1-year time-point, those included in each group are the same, but at the 18-month measurement the data point for the non-exercisers includes those in the water exercise group who did not continue to exercise, and the data point for the exercisers includes those in the control group who took up and maintained regular exercise. The data point represented by the solid triangle is the WOMAC pain score for those in the exercise group who sustained their exercise programme beyond the 1-year intervention period. Also shown in *Figure 9* is the WOMAC pain profile (uppermost, dotted line) for those participants in the control group (n = 22) who reported exercising regularly (i.e. attended an exercise session on average at least once per week) over the 1-year to 18-month follow-up period.

The mean difference between the groups at the end of the intervention period was 1.74 units (95% CI 0.84 to 2.65) ($p < 0.001$, independent samples t-test) on the WOMAC pain scale. It is clear from this analysis that adherence to treatment is a crucial issue for this potential mode of management of patients with lower limb OA.

More detailed analysis of the effects of adherence and 'contamination' between groups is warranted, but is beyond the scope of the present report.

Factors influencing adherence

The pragmatic nature of the research undertaken in this trial meant that the participants included represented a broader range of lower limb OA distribution and broader range of severity than is often the case in other research in this area. It is pertinent to examine the factors influencing compliance with treatment to see whether selection criteria for recommending water exercise might be improved. In *Table 23*, baseline variables for the water exercise group are compared between adherers (those who attended at least 50% of their prescribed water exercise sessions) and non-adherers. Those who did not adhere to the exercise programme scored significantly worse than adherers on WOMAC pain index and SF-36 pain, social functioning and vitality dimensions. However, none of these factors, either alone or in combination, was able to provide a useful selection criterion on the basis of a useful logistic regression prediction model (data not shown).

TABLE 23 *Comparison of baseline characteristics of water exercise group by adherence category*

	Water exercise group						
	Non-adherer			Adherer			
	Mean	SD	*n*	Mean	SD	*n*	*p*-Value
Age (years)	70.01	7.51	71	69.72	6.21	82	0.79
BMI (kg m^{-2})	29.66	5.16	71	29.79	4.98	82	0.87
8-foot walk (s)	3.12	1.31	71	3.31	2.07	82	0.51
Right quadriceps (N)	165.49	117.33	70	142.99	112.41	82	0.23
Right hamstrings (N)	80.14	60.41	71	70.48	47.53	82	0.28
Left quadriceps (N)	153.75	115.44	71	135.37	99.94	82	0.29
Left hamstrings (N)	68.06	53.01	71	66.94	46.95	82	0.89
Stair ascent	3.44	2.38	71	3.87	3.38	81	0.38
Stair descent	3.58	2.31	70	4.25	3.65	81	0.19
WOMAC pain	9.46	3.58	70	8.10	3.56	82	0.02*
WOMAC stiffness	3.96	1.62	70	3.77	1.69	82	0.49
WOMAC physical function	31.48	13.35	66	28.89	12.91	80	0.24
SF-36 physical function	47.79	23.88	68	53.00	24.01	80	0.19
SF-36 social function	56.19	29.05	70	69.17	29.48	80	0.08*
SF-36 role physical	27.54	39.56	69	27.50	34.59	80	0.99
SF-36 role mental	43.78	46.13	67	49.58	45.00	80	0.44
SF-36 mental health	67.35	17.70	68	68.91	16.15	79	0.58
SF-36 vitality	38.70	19.32	69	45.89	22.49	79	0.04*
SF-36 pain	39.21	21.04	70	46.39	22.56	80	0.47*
SF-36 general health	47.10	19.05	69	53.25	20.07	77	0.6

* $p < 0.05$.

Discussion

Recruitment and sampling

The project had intended to recruit a representative random sample from the general practice population of North Staffordshire over the age of 60 years with OA of the hip or knee. At the outset, it had been assumed that this would be a relatively straightforward process, given that most practices are computerised and the condition is common. In the event, this proved not to be the case. Sixteen of the 67 practices contacted were willing to participate in the trial and, of these, only one was able to identify patients who had arthritis of the knee or hip from their computerised database. The other practices were not able to run disease-specific OA searches, or to identify patients who had been prescribed non-steroidal anti-inflammatory drugs (NSAIDs). Thus, the potential sampling population was restricted to approximately one-quarter of the target population and almost all patients over the age of 60 had to be contacted to identify those likely to have lower limb OA and who would be willing to participate in the research.

Similar studies conducted elsewhere have shown a higher uptake rate.[65,66] Several factors specific to this study may have affected GP recruitment rates. However, these are unknown as follow-up questionnaires asking for reasons for non-participation were not sent to individual practices. Other researchers have suggested reasons why practices may or may not be willing to participate in trials, such as time pressures of work and shortages of staff, involvement in other research studies, relevance of the research question, adequate support by researchers and no financial reimbursement.[67,68]

The placement of a newspaper article generated fewer participants, but was faster and less expensive at approximately £2.72 per patient compared with £27.66 for patients recruited through general practice. However, since the article was only placed on one day in one week, it is not possible to estimate how many people were exposed to it, so overall response rates cannot be determined. Nor is it possible to determine how many more volunteers could be recruited by repeat articles or a sustained media recruitment campaign. Other researchers have reported similar findings, where newspaper advertisements have been more efficient in recruiting older adults from the community.[66]

When comparing the main outcome measures at baseline, no statistically significant differences were found between the two methods of recruitment except in the gender balance of the respective samples, 59% women through general practice and 78% through the newspaper article.[64] This may be due in part to the fact that OA is twice as prevalent in women over 65 years of age as in their male counterparts.[69,70] The newspaper article appeared in the Health section. Older women are more likely to be interested in their health, in health issues and in socialising in group exercise compared with elderly men.[71]

There are some problems relying on GPs rather than researchers to recruit patients. There is a risk of introducing selection bias if potentially eligible subjects are selectively excluded by the practice that does not wish to participate (for whatever reason) in the trial; in this case 76% of GPs in the area. Thus, there are ethical dilemmas in relying on such 'gatekeepers' who may be denying patients potentially beneficial treatments. Lack of staff support and time has been identified as an important barrier to the recruitment of GPs in other studies. If lack of time and staff is the main problem, this augurs badly for those hoping to encourage more evidence-based practice in primary healthcare. The solution may lie in encouraging a research culture in general practice, with emphasis on opportunities for research training and academic attachments for GPs, practice nurses and health visitors, and for financial incentives for the development of networks for research in primary healthcare. Collaboration between researchers, practitioners and educators needs to be improved to support research and development similar to that undertaken in the research reported here.

Distribution of OA

It was not possible to obtain accurate, up-to-date local information on the distribution of hip and knee OA in the population of North Staffordshire. Thus, the characteristics of the sample recruited could not be compared with those of the whole population of OA patients. Based on the age distribution of the sample compared with that of the whole population of Stoke-on-Trent,[72] those in the 65–69-year-old age group were over-represented (32.4 versus 21.2) and those older than 80 years were under-represented in the sample (7.4 versus 18.9).

The gender split was 63% female and 37% male. This is consistent with a higher prevalence of hip and/or knee OA in women. However, the researchers were unable to confirm whether the distribution of lower limb OA is reflective of the prevalence in the older population of North Staffordshire as a whole.

Compliance and dropout

There are many challenges in delivering an effective community-based physical activity intervention to a disabled, elderly population. A subject's individual characteristics, health and personal circumstances all have a bearing on whether or not he or she is able to participate fully in the intervention. Factors related to the accessibility of the venue and the quality of the content and delivery of the programme are also important determinants of sustained participation, particularly over the longer term. Many previous studies have focused on individual-based determinants and not acknowledged the importance of environmental and societal factors.

The overall compliance of 59% (50% if those who did not attend any exercise session are included) in the present trial was lower than is commonly reported in shorter term trials of physical activity interventions.[73] That said, there is a paucity of research evidence of longer, larger scale interventions such as that undertaken here.[28] Most of the longer term research that has been carried out on exercise adherence suggests that compliance of greater than 50% is difficult to achieve.[74]

In their review of older adults' adherence to RCTs of exercise, Martin and Sinden[73] found an average dropout rate of 13.7% (SD = 6.2) and a range of 4–25% among 20 studies. However, they also noted a significant increase in dropout with the duration of the intervention or study. In contrast, Kovar and colleagues[51] reported a dropout of 25% in their RCT on fitness walking in OA patients after only 8 weeks.

Some of the difference in reported adherence between studies can be explained by differences in the measurement or calculation of adherence. In the research reported here, adherence with the exercise treatment was measured directly by recording individual attendances at all water exercise sessions provided.

Some studies that have been carried out on similar groups to that studied here report comparable adherence rates. Bradley[75] reported modest adherence rates ranging from 39 to 65% for the studies on home exercise in his review of adherence with treatment regimens among RA patients. In addition, he examined the compliance

with other types of treatment such as medication and concluded that across all different types of treatments, only 50% of RA patients reported adhering to their treatment. Thomas and colleagues[76] reported that 48.1% of their original exercise group of patients with knee pain completed their programme of home-based exercise over 2 years. Ettinger and colleagues[77] reported high adherence rates in the early part of their 18-month trial comparing aerobic and resistance exercise for OA patients, but this had declined to 50% at 18 months.

In the study reported here, 81 participants, roughly equally split between the two groups, dropped out at some point throughout the intervention period. There were no obvious differences in physical characteristics, WOMAC OA indices and disease distribution between those who dropped out during the intervention period and those who completed the study (*Table 5a*). The dominant reasons for dropout were not related to the treatment per se, but to illness or disability of the patients themselves or a close family member for whom they were the main carer. Twenty-three participants randomised to the exercise group were unable to attend any of the prescribed exercise sessions offered, again predominantly because they felt that they were too ill or had a spouse who was dependent on them for care. Further insight into the reasons for non-adherence may be gained from the follow-up analysis of those who adhered to the water exercise programme and those who dropped out (*Table 23*). Non-adherers in the water exercise group showed greater pain, poorer social function and vitality scores and a trend towards poorer health compared with 1 year ago than those who adhered. This suggests that this population of OA patients had a significant proportion of patients for whom attending an exercise class regularly was not a viable treatment option.

Many researchers have looked for determinants or predictors of adherence in their samples. This additional analysis is worthwhile as it may help to improve future selection of patients or design of interventions and inform practice at a community level. The compliance study by Rejeski and colleagues[78] reported that demographic, fitness and disability-related measures did not predict adherence, but that increased BMI, lower functional capacity, and increased disability and pain were found among the poorer compliers. They found that prior exercise behaviour had the strongest association with adherence (r = 0.5–0.8). Jette and colleagues[79] studied predictors of adherence in home-based resistance training in older adults and found that psychological variables such as positive attitude towards exercise were most important, although physical variables were important to general participation.

Efficacy and effectiveness of water exercise programme

Pain (WOMAC, SF-36)

The findings from the pilot study confirm a small to moderate effect of the water exercise on perceived pain related to hip or knee OA over the short term (12 weeks) (*Tables 2* and *3*). Over the longer term, the effect on pain was reduced but remained significant at the 1-year time-point on both the WOMAC pain index and the SF-36 pain dimension (*Table 17* and *Figure 6*). However, the difference in group mean scores was not maintained through to the 6-month postintervention time-point (18 months from baseline). The latter may be explained by the drop-off in attendance in the water exercise group and an uptake of activity in the control group at the end of the intervention period (before the end of the intervention period in the case of the latter) (*Figure 8*).

These results support the hypothesis that water exercise over 1 year is efficacious in reducing lower limb joint pain in older adults in a community setting. A mean reduction of 0.89 (95% CI 0.86 to 0.92) (*Table 17*) on the WOMAC pain index was found, representing about a 10% reduction relative to the control group. The improvement seen in self-reported pain was similar to that reported by Thomas and colleagues,[76] who examined the effects of home-based exercise on knee pain in patients over the age of 45, but is smaller than the improvements reported in some trials using other forms of exercise.[80,81] Comparison with other trials is difficult since the studies reported have differences in the outcome measures used, patient groups studied, settings, types of exercise intervention used and methods of analysis. Nonetheless, this study provides support for the potential value of water exercise in the management of lower limb OA.

Physical function and activities of daily living

Similar to the observations on pain outcomes, short-term moderate beneficial effects were found in the pilot study for the WOMAC physical function measures and the three activities of daily living: 8-foot walk, stair ascent and stair descent, (*Tables 2* and *3*). Again, over the longer period of the 1-year intervention, the effect size was reduced to small when using the ITT analysis (*Tables 17* and *20*). At 6 months postintervention, only the

difference in the 8-foot walk remained significant. Interpretation of the latter was again complicated by the cross-over in activity patterns postintervention (*Figure 8*).

Mean reductions attributable to the water exercise programme in 8-foot walk, stair ascent, stair descent and WOMAC physical function were 0.35, 0.55, 0.66 seconds and 3.65 units, respectively, improvements of 10–15% relative to the control group.

No significant differences were detected in any of the strength measures in either the pilot study or the main study, at any of the assessment points. This may reflect the conservative and gently progressive nature of the water exercise intervention provided, as well as the variability within the measurements themselves. Inspection of *Tables 19* and *20* demonstrates that there were, at least, trends towards a greater strength-improving effect in the water exercise group at the 1-year point. It is most likely that the present study was underpowered to detect these differences. The small changes in strength may be an indication that strength development could have been more progressive over the intervention period, although this consideration would need to be balanced against increased risk of adverse events in an older sedentary population and the threat to adherence that a more strenuous programme might face.

Psychosocial function

There was no strong evidence for a sustained effect of the water exercise programme on social well-being of participants. There were no significant differences in the SF-36 social function dimension at any of the assessment points (*Table 17*). Focus group evaluations and responses in the programme evaluation questionnaire were generally positive about this aspect of involvement in the study (see Chapter 6), but this did not manifest itself in detectable differences in the outcome measure used in this study.

General health and vitality

The changes in SF-36 vitality and SF-36 general health dimensions from baseline at the 6-month time-point were significant (independent *t*-test on the change in score from baseline, $p \leq 0.001$ in both cases). However, these early changes were not maintained at the later time points. Overall, there was no significant difference between the groups on either of these measures (*Table 17*).

Further evidence in support of an effect of the water exercise programme on general health perception is contained in *Table 18*, which shows the cross-tabulation of the distribution of scores on the SF-36 'change in health compared with 1 year ago' question, corresponding *p*-values from the χ^2 test for the difference between the distributions and Cramer's *V* for each table. Significantly more patients in the control group reported their health as being somewhat worse or much worse than 1 year ago, whereas significantly more patients in the water exercise group reported their health as being somewhat better or much better than 1 year ago. The small to moderate effect was strongest at 6 months (Cramer's $V = 0.335$) and declined progressively at the later time-points.

Comparison with other research

Physical activity

Systematic reviews of, mostly short-term, exercise programmes show variations in the reduction of pain and disability with effect sizes ranging from small to moderate.[82] More intensive short-term programmes report greater effect sizes[83–85] using a variety of delivery modes and settings. While these studies demonstrate what might be achieved using 'high-dose' exercise, the high resource costs of delivery and sustainability over time may limit the utility of these approaches on a population basis. The more pragmatic studies that have been performed, involving larger numbers of subjects over a longer term, including the findings reported here, have observed small effect sizes.[76] With the infrastructure that is available currently in the UK to support the delivery of exercise programmes, it is likely that achievable population effect sizes would be small. Nonetheless, such small gains may be enough to delay or even prevent the onset of severe musculoskeletal disability. Morbidity, then, could be reduced or compressed into a shorter period, leading to a reduced overall burden of the disease.[86]

Other interventions

Weight loss

Obesity is a risk factor for the development of OA and even modest reduction of weight has been shown to reduce the risk of developing knee OA in women.[87] Specific interventions[88,89] that have investigated weight loss in obese patients with knee OA have reported significant reduction of symptoms. However, these have involved small numbers of patients, and resource and deliverability issues have not been considered.

Education, self-help programmes

Studies evaluating education and self-help programmes[90–92] have demonstrated that patients

can have reduced symptoms, improved quality of life and reduced healthcare costs, although not in every case.[19] A recent meta-analysis of published trials of arthritis self-management education programmes supports the finding of a small but clinically significant reduction in pain and disability.[93]

Medication

- **NSAIDs and cyclooxygenase-2-specific inhibitors**
  The complexities of trials involving pharmacological interventions (including patient selection bias, dosage, treatment complications, trial duration and comparator treatment) make it difficult to draw comparisons with other interventions.[94–96] Well-designed RCTs that have been performed demonstrate small effect sizes,[97–99] but interpretation is complicated by morbidity, and possibly mortality,[100] associated with the treatment.
- **Complementary medicines**
  Suitable trial evidence from studies using complementary medicines is limited.
  McAlindon and colleagues[101] carried out a preliminary meta-analysis of small published trials which used glucosamine and/or chondroitin sulphate and concluded that these agents may have a small beneficial effect on the reduction of pain, similar to that found here for water exercise. These preliminary findings have been confirmed in mild to moderate OA in subsequent well-designed longer term studies,[102,103] but the benefit may not extend to patients with more severe disease or higher pain scores.[104]
- **Total joint replacement and arthroscopy**
  Total joint replacement has been shown to be a highly effective treatment for severe hip and knee OA,[105,106] but the use of arthroscopy remains equivocal.[107,108] Comparisons of such interventions with other forms of treatment are complicated because of the highly selective nature of the populations deemed suitable for joint replacement, mortality or morbidity associated with surgery, and the uncertainty related to the long-term effectiveness of the joint replacement and the possible need for further replacement.

Chapter 5

Cost and consequences comparison and cost-effectiveness analysis

Introduction

The pragmatic RCT described in Chapter 4 was undertaken to determine the effectiveness of water exercise therapy in the management of lower limb OA in an older population, under the circumstances pertaining to the primary care/community setting. In addition to establishing effectiveness (or otherwise) of a proposed treatment, it is pertinent to consider whether this treatment, if adopted, would prove cost-effective. Thus, an evaluation of the cost-effectiveness of water exercise in the management of lower limb OA was carried out alongside the primary RCT.

This evaluation had three objectives:

- To compare the cost (societal)-effectiveness (EuroQol-based utility) of adding water exercise therapy to usual care (treatment) with usual care only (control) for older patients receiving treatment for lower limb OA.
- To compare the cost (societal) benefit (WOMAC pain index) of these two alternatives.
- To provide a good quality set of cost and effect data relating to the management of lower limb OA in an older UK population.

Since the duration of the study was limited to the 1 year of intervention plus a further 6 months of follow-up, costs and consequences of OA under the two treatment arms were compared on a societal basis over the 1-year intervention period only.

Methods

Healthcare resource use and costing

Information on resource use over the intervention period was obtained through a combination of patient-completed questionnaire and interview at 1 year (Appendix 5) and review of patients' notes. Items included in the review were grouped under the following headings: impact on work, hip or knee replacement, medications, hospital usage, family health services, community services, services from professions allied to medicine, aids and adaptations to home or lifestyle, and personal, friends or family costs associated with OA. Medications were further subdivided into prescribed medications, over-the-counter medicines, complementary medicines or supplements, and other remedies.

Costs of medications were obtained from the most recently available information (British National Formulary online, March 2003). Hospital costs were taken from published reference costs for elective inpatient treatments [Healthcare Resource Group (HRG codes, 2002 tables]. Health and social care costs were obtained from data published by the Personal Social Services Research Unit at the University of Kent at Canterbury[109] using data for 2002. Costs of purchased or prescribed aids were obtained either directly from information provided by patients or from catalogues available from local suppliers. Additional items included in questionnaire responses were costed at local retail prices.

Unit costs of all items reported in the economic evaluation are included in Appendix 6.

Costs of delivering the water exercise programme

The total cost of providing exercise sessions (including cost of hiring exercise venues, training and hiring facilitators and hiring lifeguards) was divided by the number of participants in the water exercise group to give a mean cost per patient per year for this service. Travel costs to and from the exercise venues were taken directly from costs reported by the participants or estimated from distances travelled to the sessions, costed at £0.30 per mile. Estimated cost for attending an exercise session was multiplied by the total number of sessions attended to yield the estimated travel costs for each participant.

Health state preferences and benefits

Estimates of effectiveness were obtained from quality-adjusted life-years (QALYs) calculated from utility scores derived from the EQ-5D using weights developed by the time trade-off method.[110] The measure used to determine benefit was the score on the WOMAC pain index.

Missing value analysis and data imputation

Missing value analysis was performed using the SPSS MVA function. It was assumed that reasonable estimates of missing values on overall costs or effects could be obtained from available observations on subjects with similar characteristics, that is, the missing data were assumed to be missing at random (MAR). Thus, missing values for effects were estimated by multiple linear regression; missing cost data (medications and overall costs only) were imputed by random sampling from subgroups of subjects with similar characteristics.

Cost-effectiveness analysis model

The cost-effectiveness analysis was conducted prospectively alongside the clinical trial to compare the cost per QALY gained using water exercise therapy with that obtained using the control treatment. Cost-effectiveness was calculated as the ratio of the difference in costs between the water exercise group and the control group divided by the difference in QALYs gained between the two groups. The non-parametric bootstrap method (using 1000 replications) was used to derive confidence intervals for the incremental cost-effectiveness ratio (ICER) over 1 year of follow-up.[111] Cost-effectiveness acceptability curves (CEACs)[112] were constructed from these data to provide estimates of the probability that, for a given level of the cost per QALY gained – the 'ceiling' level – the water exercise treatment is more cost-effective than the control treatment.

Further similar cost–benefit analysis was conducted using the WOMAC pain score as the measure of benefit. Although not strictly a cost-effectiveness analysis, this approach provides an assessment of the cost–benefit of water exercise on pain, which is the major symptom with this condition.

Adjustments for timing of costs and benefits

As the study was of comparatively short duration and cost data were collected directly alongside the RCT, no adjustments were made for the timing of costs and benefits.

Results

Missing data

Six cases had missing data on WOMAC pain score, ten on EQ-VAS, 65 on EQ-5D and 22 on costs of medications. The large number of missing values on the EQ-5D occurred because this part of the questionnaire was only administered during the cost and consequences follow-up at 1 year, at which point a number of patients had dropped out of the study. Missing effect values for the EQ-VAS and WOMAC pain were imputed by regression based on age, gender and WOMAC pain. Missing values on the EQ-5D were imputed by regression based on age, gender and EQ-VAS. Missing costs were imputed by random sampling from groups of patients with similar characteristics of age, gender, WOMAC pain and type of OA.

Comparison of costs over the 1-year intervention period

The direct societal costs related to lower limb OA in the two groups over the 1-year intervention period are compared in *Table 24* and by broad resource type in *Figures 10* and *11*. Data shown are for costs with missing data imputed.

The distribution of costs by individual within the groups is shown in *Figure 12*. [Note that the cost data presented have been inverse transformed (transformed cost = 1000/cost)]. Both groups showed high positive skew and contained extreme values associated with relatively infrequent, but high-cost items, such as hip or knee replacement or the purchase of a motorised wheelchair. The distributions remained non-normal even after transformation. Mean costs in the two groups overall were £631 and £473 (£331 without costs of intervention) in the control and intervention groups respectively.

Non-parametric bootstrap estimates of the distribution of cost and effect differences

Cost population samples were generated with and without imputation of missing cost data and effect samples were generated from the EQ-5D, the EQ-VAS and WOMAC pain scores, again with and without imputation of missing effect data. Cost and effect differences were then generated using the non-parametric bootstrap approach (using 1000 sampled mean cost and effect estimates from the 159 individual control and 153 individual water exercise data sets) for each of the six basic data sets. An example of the distribution of cost and effect differences and ICER (based on the EQ-5D with imputation of missing data) is shown in *Figure 13*. The corresponding normal distributions are shown superimposed on these histograms.

Mean cost and effect differences and their 95% confidence intervals are summarised in *Table 25*.

TABLE 24 *Comparison of costs (£): resource category by group*

	Control (*n* = 159)			Exercise (*n* = 153)			
	Mean	**SD**	**F[a]**	**Mean**	**SD**	***F***	**Difference**
Total cost of healthcare	630.76	1320.70	159	473.02	556.15	153	157.7
Hip or knee replacements	233.70	1131.41	7	28.47	352.16	1	205.2
GP visits	122.42	63.89	152	80.80	48.32	149	41.6
Medications (total)	80.76	98.07	116	73.51	127.68	105	7.3
Cost of lost work	48.43	610.65	1	9.78	120.94	1	38.7
Outpatient visits	38.94	130.42	25	36.54	132.97	26	2.4
Physiotherapy	31.54	60.69	42	13.33	37.20	25	18.2
Prescribed aids	28.66	152.08	44	39.67	195.01	29	–11.0
Home adaptations	26.39	102.69	20	31.05	160.59	13	–4.7
Travel to exercise sessions	0.00	0.00	0	32.67	24.83	127	–32.7
Delivery of exercise sessions	0.00	0.00	0	109.80	0.00	153	–109.8
Complementary therapist	8.03	95.32	2	0.54	5.16	2	7.5
Other therapies	3.09	26.15	3	0.00	0.00	0	3.1
Treatment visits	2.38	12.16	14	2.08	9.00	14	0.3
Personal costs for therapies	1.86	3.57	42	0.78	2.19	25	1.1
Domestic helper	1.29	10.50	5	7.83	54.31	6	–6.5
Day patient	1.08	7.78	3	1.12	7.93	3	0.0
GP home visits	0.77	9.68	1	0.40	4.93	1	0.4
Day centre	0.68	8.56	1	1.62	19.98	1	–0.9
Home help	0.47	3.59	3	0.73	6.35	3	–0.3
Volunteer helper	0.16	2.06	1	0.17	2.10	1	0.0
District nurse	0.13	1.59	1	0.00	0.00	0	0.1
Practice nurse	0.00	0.00	0	1.96	24.25	1	–2.0
Nurse specialist	0.00	0.00	0	0.18	2.18	1	–0.2

[a] Frequency that resource-use item cited.

Cost-effectiveness

Two scenarios are presented, one based on cost per QALY derived from the EuroQol and one based on the pain index from the WOMAC questionnaire. The latter is provided, first, because the authors' experience with the EQ-VAS and EQ-5D with this patient group demonstrated these to be rather volatile measures (possibly reflecting the health and quality of life challenges in this older population) and, second, to enable direct comparison with other studies that have used pain on the WOMAC index as the primary measure of clinical effectiveness.

Sample estimates of cost and effect differences, based on the 1000 bootstrap estimates described above and plotted in the cost-effectiveness plane,[111,112] are shown in *Figures 14–16*. The origin on these plots represents the neutral position, that is, no cost and no effect differential. Data points below the horizontal axis demonstrate lower cost for the water exercise treatment. Data points to the right of the vertical axis demonstrate greater effect for the water exercise treatment. Sample estimates generated by the raw data (with adjustment of the denominator to account for missing values) are shown by solid circles and those with imputation for the missing data are shown by open circles. Corresponding CEACs are shown in *Figures 17* and *18*, and the ICER, their 95% confidence intervals (2.5 to 97.5 percentile as recommended by Briggs and Gray[111]) and ceiling valuations at both the 50th and 95th centiles are shown in *Table 26*.

Discussion

Cost-effectiveness

Costs by individual resource category are compared in *Table 24* and *Figures 10* and *11*. The mean cost per participant for the delivery of the exercise intervention was £142.47 per annum (*Table 24*), which equates to approximately £1.70 per session, assuming 84 sessions available per annum (allowing for holidays, etc.). This may seem high when compared with a standard prescription charge for medication of £7. However, mean costs in the water exercise group were £158 less than in the control group, even after including the marginal costs of delivering the exercise programme. Main sources of cost

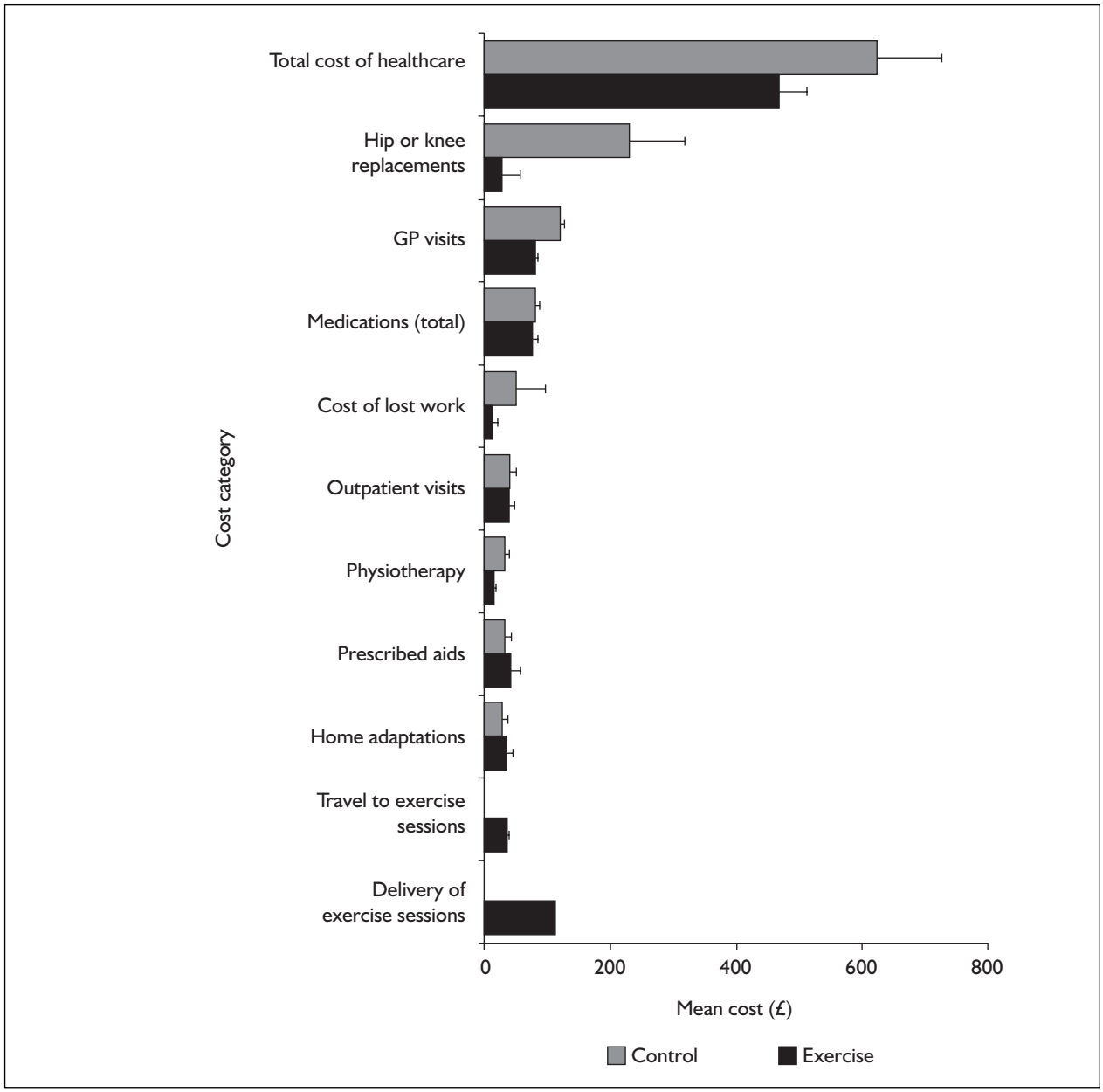

FIGURE 10 *Comparison of group costs by resource category: higher cost items (error bars represent standard error)*

difference between the two groups were those for hip or knee replacement, visits to the GP, loss of employment and physiotherapy (all greater in the control group), and travel and delivery of exercise sessions and prescribed aids (all greater in the water exercise group). Of these, hip or knee replacement, loss of employment and some of the prescribed aids were rare but high-cost events in this sample population. This complicates the interpretation of mean cost differences since one or two such events different in either group can make a big difference to the mean cost per individual.

Some of this difficulty can be overcome using the bootstrap sampling approach, whereby the actual sample is taken as an 'adequate' representation of the variation in costs across the population of interest and a sufficiently large number of random samples, with replacement, (typically 1000 replicates) is drawn from this to generate reasonable estimates of the probability distribution of the difference of interest. This approach has been used with the six data sets of costs and effects generated in the present study. *Figures 14–16* illustrate the uncertainty inherent in determining the cost-effectiveness of water exercise in patients

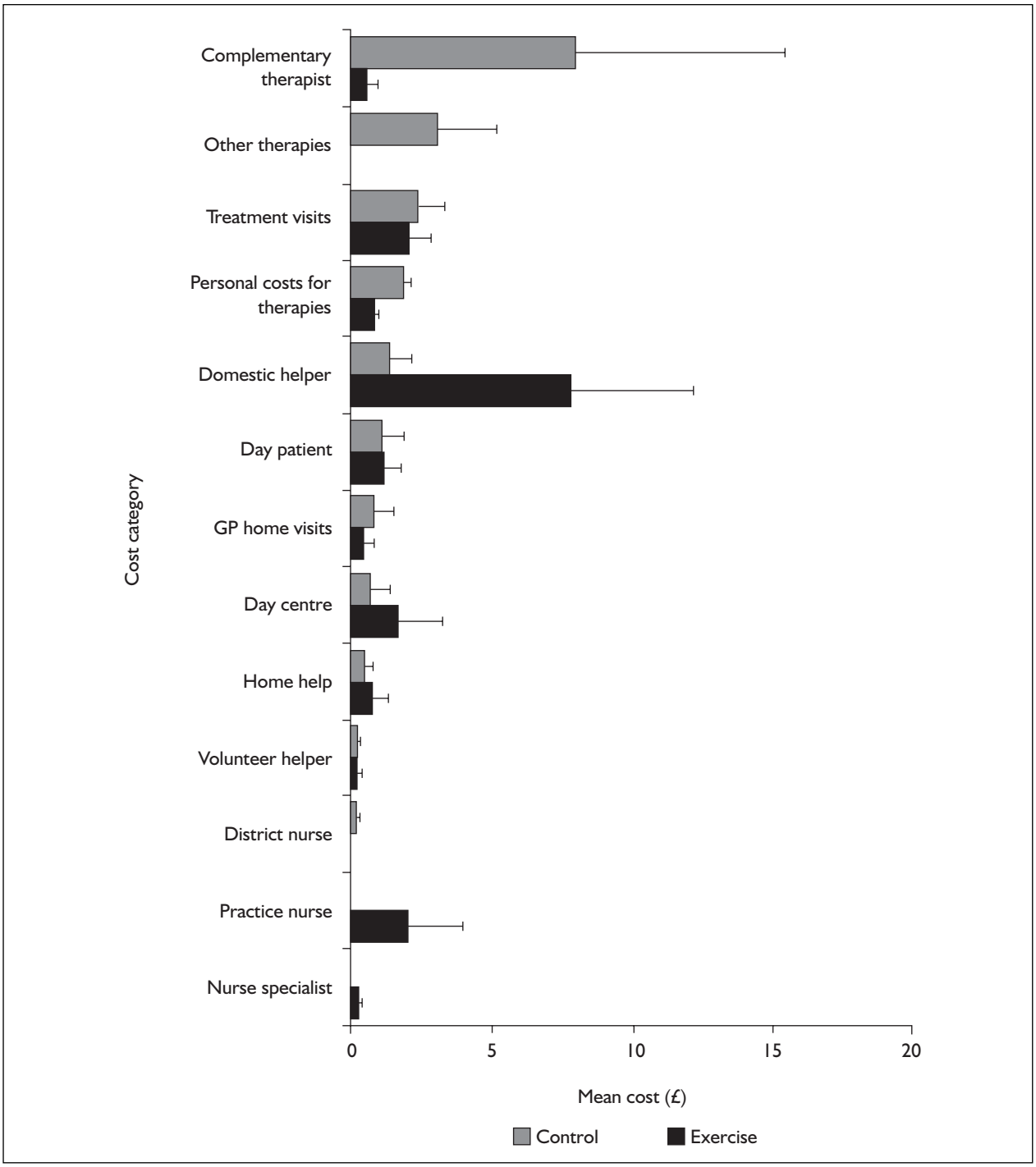

FIGURE 11 *Comparison of group costs by resource category: lower cost or infrequently cited items (error bars represent standard error)*

with lower limb OA. If all points were located in the lower right quadrant then there would be little doubt about whether the intervention was cost-effective. While the majority of points do lie in this quadrant in all of the analyses, significant numbers of points occupy the other three quadrants, creating uncertainty in the determination of cost-effectiveness.

This is reflected in the CEACs, (*Figures 17* and *18*) and the ICER confidence intervals (*Table 26*). Mean values for the latter all show a benefit of the water exercise treatment over the control comparator, at attractive estimates for the cost per QALY gain (EuroQol data) or unit of pain reduction (WOMAC index), but five out of the six ICER confidence intervals contain negative values

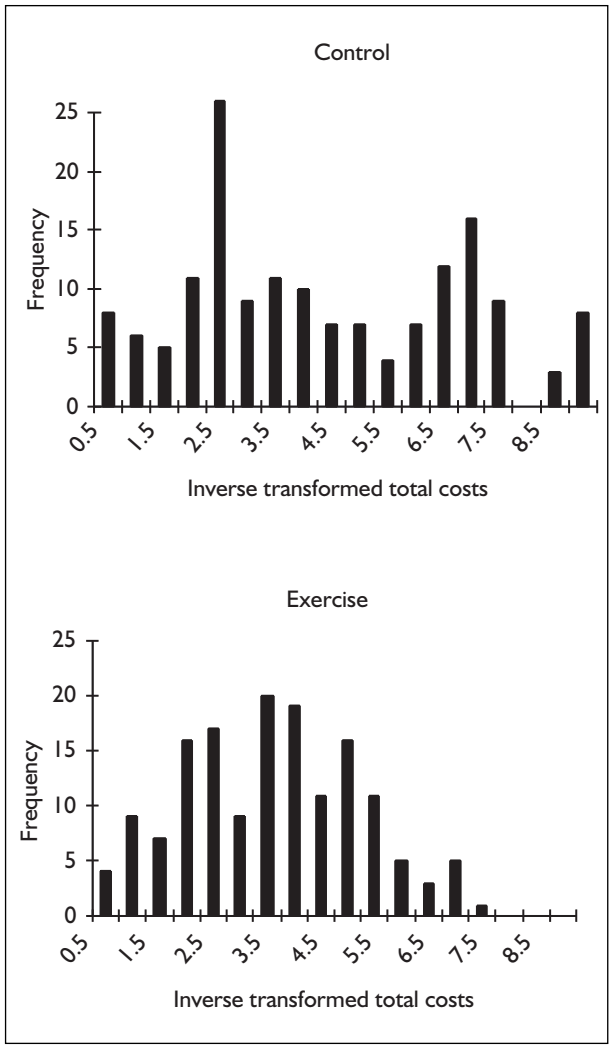

FIGURE 12 *Distribution of costs compared by group (data have been transformed using 1000/total cost)*

and all four CEACs for the EuroQol-based analyses fail to reach a conventional 95% level of confidence. Thus, despite the comparatively large sample groups and the longer period of the intervention used in this study, both the cost and the effect estimates show wide variation, as indicated by the large coefficients of variation in *Table 24*. As a consequence, it was not possible to derive 95% ceiling levels for the QALY-based analyses. Less conservative ceiling valuations (at the 50th centile) ranging from £4722 to £6857 suggest good value for this approach.

The situation is improved when considering the cost–benefit scenario represented by *Figure 18*, based on a reduction of one unit on the WOMAC pain scale. The 95% probability level is reached for a ceiling valuation of £580 and £740, respectively, for the analysis with imputation of

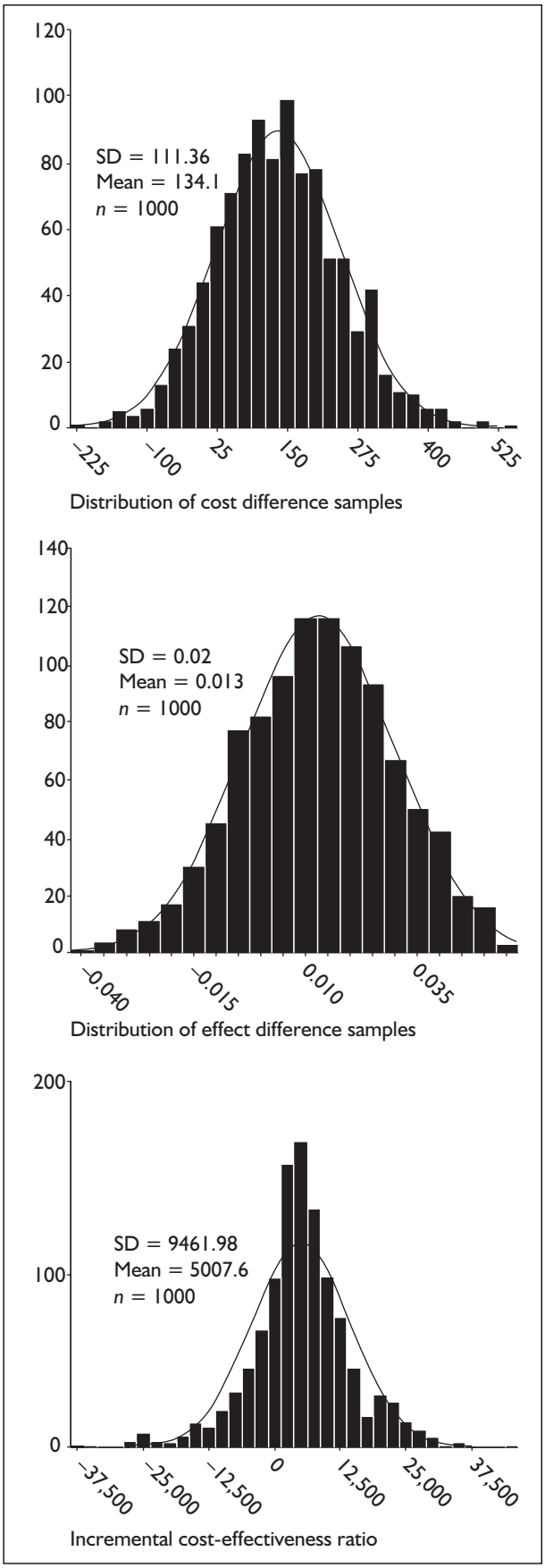

FIGURE 13 *Distribution of cost and effect samples (based on EQ-5D with imputation of missing data items)*

TABLE 25 *Summary of mean cost and effect differences from the six different cost-effectiveness analyses*

	Cost difference				Effect difference			
	Mean (£)	**SD**	**CV%**	**95% CI**	**Mean (£)**	**SD**	**CV%**	**95% CI**
EQ-5Di	134.1	111.4	83	127.2 to 141	0.013	0.02	134	0.0117 to 0.0138
EQ-5D	165.5	125.6	74	157.7 to 173.3	0.024	0.02	78	0.0228 to 0.0251
EQ-VASi	123	112.7	92	116 to 130	0.022	0.02	95	0.0205 to 0.0231
EQ-VAS	175.3	123.7	71	167.6 to 182.9	0.023	0.02	88	0.0217 to 0.0243
WOMACi	135.2	113.57	84	128.1 to 142.2	0.89	0.42	47	0.865 to 0.917
WOMAC	172.5	125.6	73	164.7 to 180.3	0.89	0.41	46	0.86 to 0.91

CV%, coefficient of variation (SD/mean) expressed as a percentage; i, with imputation of missing data.

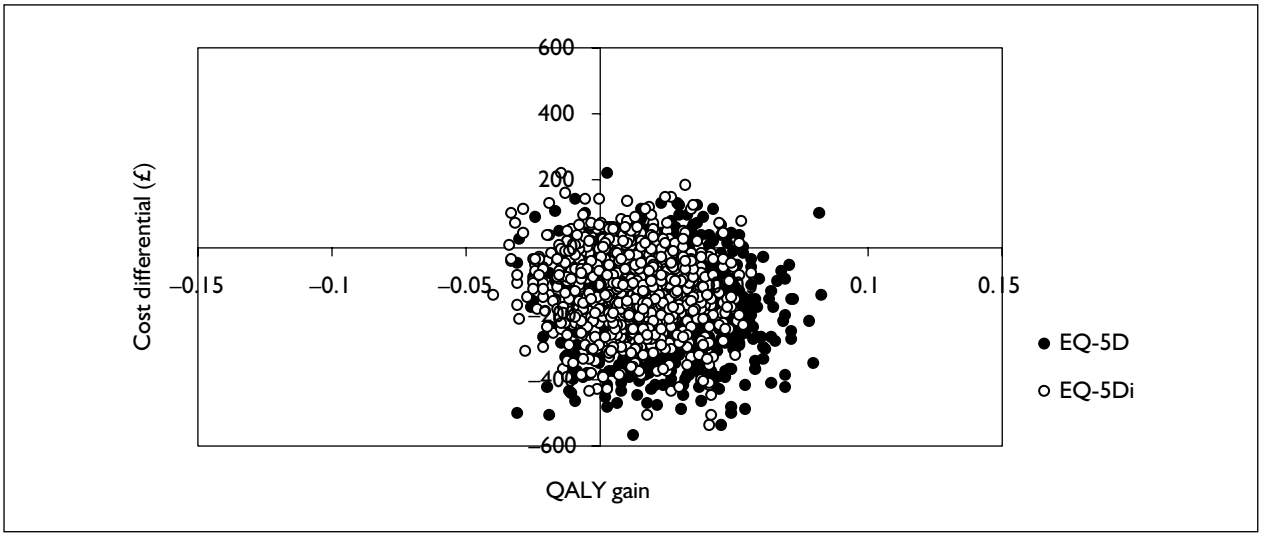

FIGURE 14 *Cost and effect samples (generated using the EQ-5D data sets) plotted on the cost-effectiveness plane (i denotes imputation of missing values)*

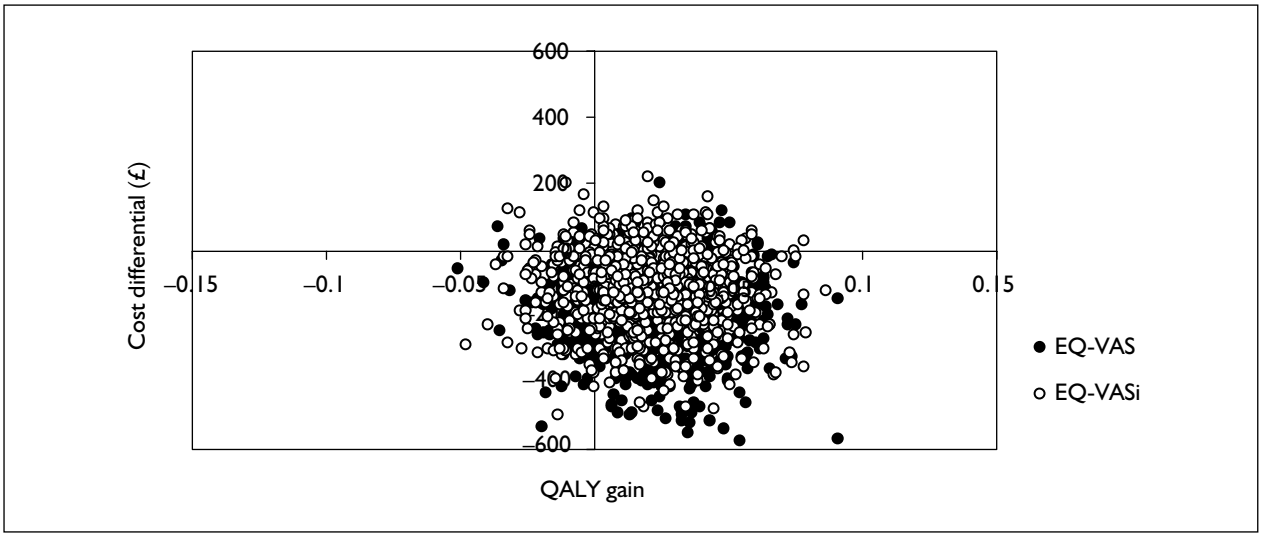

FIGURE 15 *Cost and effect samples (generated using the EQ-VAS data sets) plotted on the cost-effectiveness plane (i denotes imputation of missing values)*

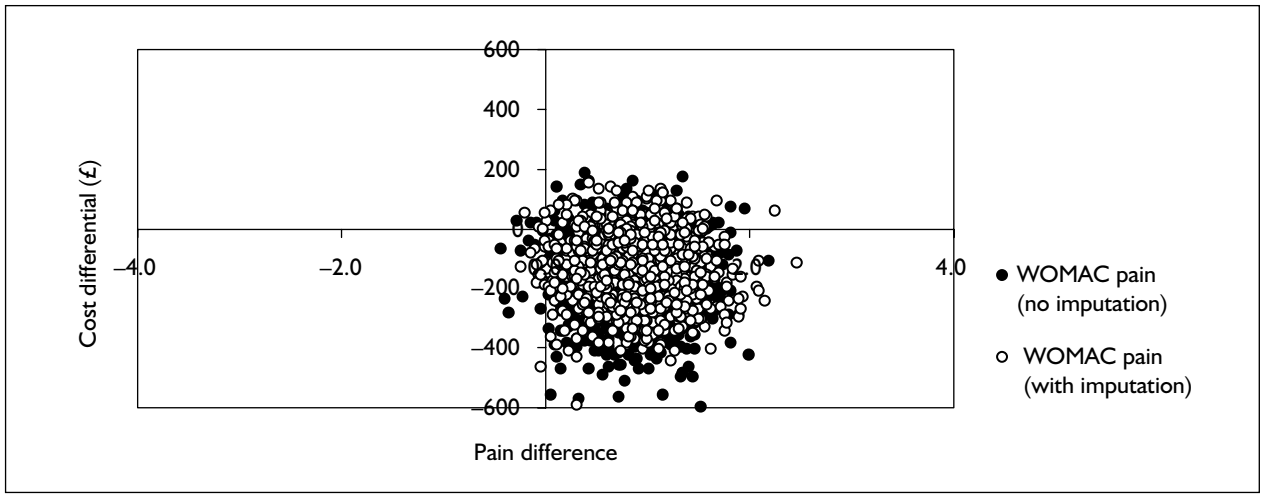

FIGURE 16 *Cost and effect samples (generated using the WOMAC pain data sets) plotted on the cost-effectiveness plane*

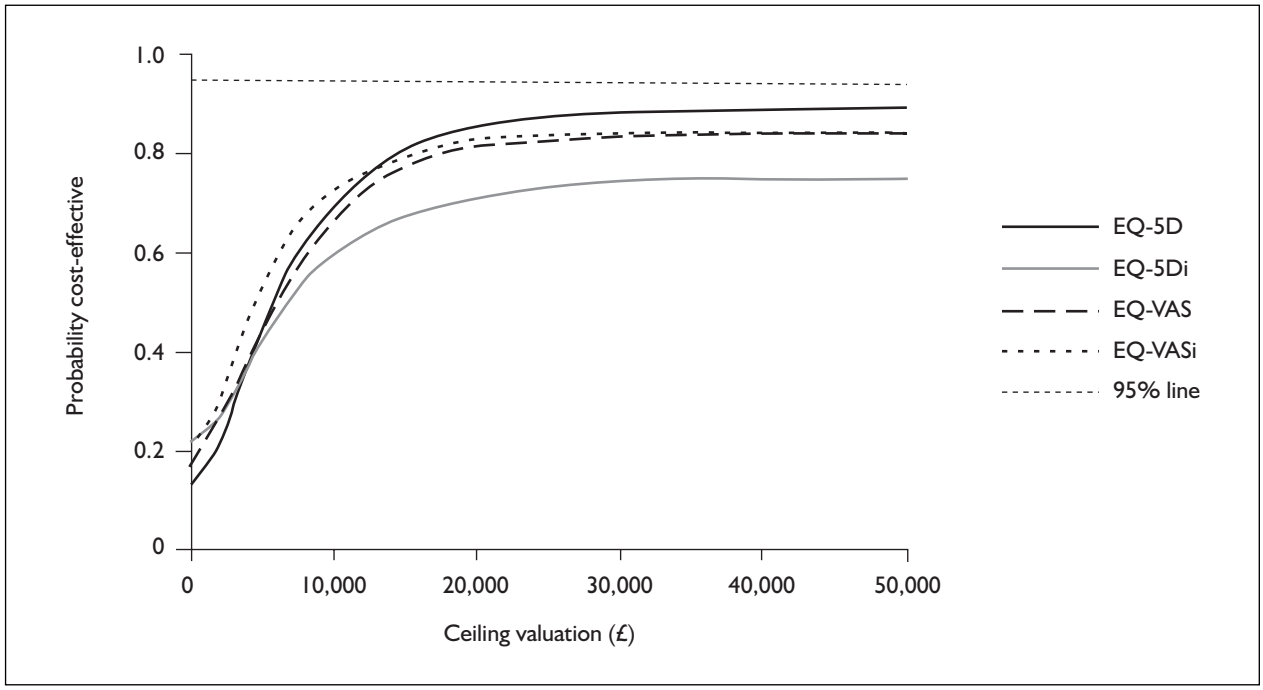

FIGURE 17 *CEACs based on the 1000 bootstrap samples generated using the EQ-5D and EQ-VAS data sets (i denotes imputation of missing values)*

missing data and without imputation of missing data. The improvement is most likely to be explained by the fact that the WOMAC index is a lower limb OA specific measure and is, therefore, more sensitive to change in this condition and less likely to be influenced by other factors. This is borne out by the lower coefficient of variation recorded in *Table 25*.

Effects of missing data and which scenario to use

The choice of which data set should command the most weight in the decision-making process is important. In most instances, a reasonably complete set of cost and effect data could be obtained (5% or fewer cases with missing values) and imputation had little effect on outcome. However, the sample of EQ-5D data had 65 missing values and the imputation used appears to have added to the uncertainty in the effect estimates derived from this data (see CV in *Table 25*). This is counter to what one would have expected. Thus, these data would rank as the least reliable for decision-making.

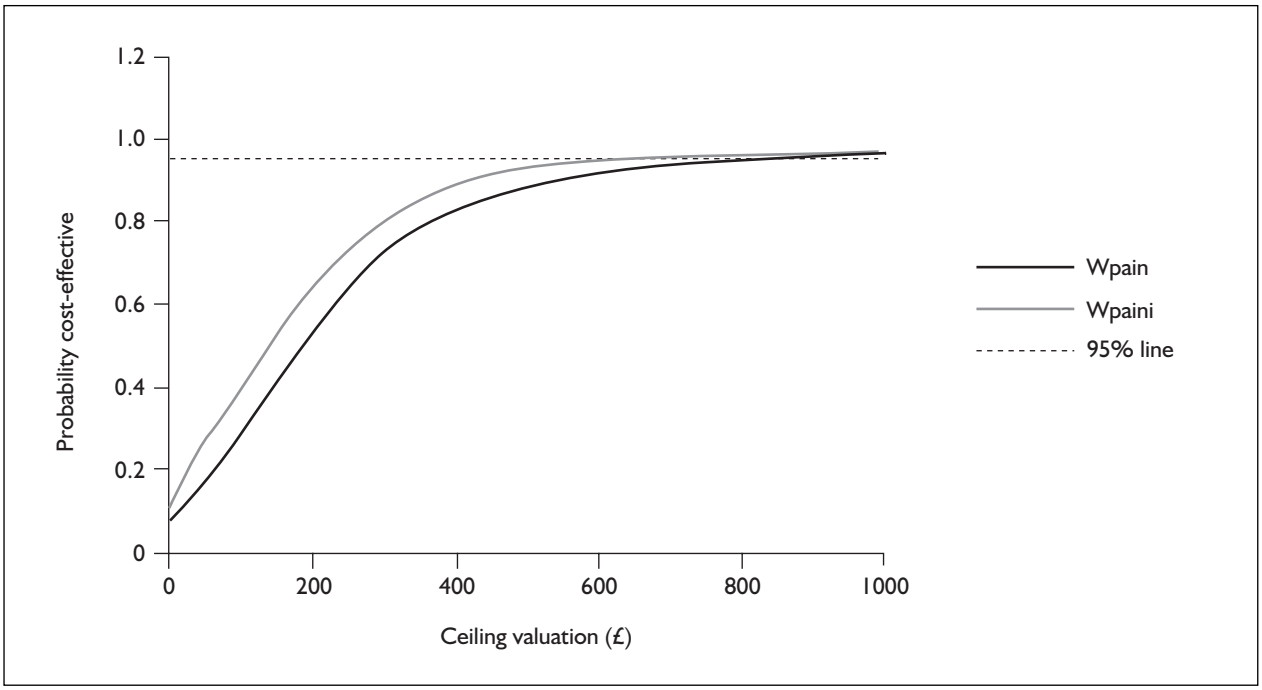

FIGURE 18 *CEACs based on the 1000 bootstrap samples generated using the WOMAC pain (Wpain) data sets (i denotes imputation of missing values)*

TABLE 26 *Mean ICERs, their 95% CIs and ceiling valuations (at 50th and 95th centiles) for the six different data sets used in the analysis*

	ICER		Ceiling valuation (£)	
	Mean (£)	95% CI[a] (£)	50th	95th
EQ-5Di	5008	–22,314 to 25,288	6857	–
EQ-5D	5738	–16,085 to 25,985	5833	–
EQ-VASi	3838	–23,699 to 25,569	4772	–
EQ-VAS	5951	–22,740 to 25,836	6667	–
WOMACi	170	–122 to 789	143	580
WOMAC	219	330 to 938	177	740

[a] 2.5 percentile to 97.5 percentile.

Both groups had significant co-morbidity. A large proportion of patients in both groups were receiving medication for health problems other than their arthritis (*Table 10*); 64 (control) and 74 (exercise) inpatient episodes in the 18 months before baseline and 98 (in 53 control patients) and 120 (in 54 exercise patients) inpatient episodes in the 18-month follow-up period were recorded. In addition, five deaths were recorded in the control group and one in the water exercise group. Consequently, it is not surprising that the measures based on the EuroQol show considerable variability throughout the trial period, even though the test–retest reliability using the VAS was good. It is likely that this inherent instability in the health status in this group of patients, coupled with a moderate effect, at best, and limited treatment compliance have combined to reduce the power of the economic evaluation to detect a difference using the EuroQol-derived data sets.

The WOMAC index appeared to perform better and to be more sensitive to changes in response to water exercise, to the extent that one can be 95% confident about there being a benefit in pain reduction from the water exercise programme.

Other cost-effectiveness studies

There is a shortage of well-designed studies on the cost-effectiveness of treatments for lower limb OA

under the conditions prevailing in clinical practice. This impedes the development of evidence-based management guidelines[113] and decisions with respect to the appropriate mix and allocation of healthcare resources.[20] At present, it is not possible to make a fair comparison of the various treatments for lower limb OA.

Notwithstanding this observation on the status quo, Segal and colleagues[20] present an interesting approach to combining available data from a number of published studies with disparate outcome measures to facilitate cost-effectiveness analysis. The various outcomes were converted to utility scores using a transfer to utility technique, whereby multiple regression conversion equations were developed by administering the commonly used OA outcome measure alongside the utility instrument in 303 patients representing a wide range of severity of OA. This approach enabled the authors to present a comparison of the cost-effectiveness of a number of different approaches to the management of OA. In their analysis, intensive clinic or outpatient-based exercise/strengthening, total hip replacement and total knee replacement were deemed to be highly cost-effective treatments, supported by strong evidence, and had cost per QALY estimates below Aus$ 15,000 (= £6200). The mean ICERs (*Table 26*) reported here compare favourably with these, despite the fact that mean effect sizes on the utility measures (*Table 25*) were only of the same order as those obtained for the basic home exercise programme.[47]

In terms of pain control, Kamath and colleagues[114] report that ibuprofen had an ICER approximately US$611 (=£345) based on a change in pain equal to the minimum perceptible clinical improvement and relative to the dominant therapy in their study (acetaminophen). For comparison, the ICERs observed here were £170 and £210 based on a change of one unit on the WOMAC pain index and relative to usual care.

Patrick and colleagues[38] carried out an economic evaluation of a similar water exercise programme to that considered here. Patients in this study were aged between 55 and 75 years, with physician-confirmed OA, and the study took place in Washington State, USA. Costs reported in this study were much higher than those found in the present UK study, possibly reflecting different costs for services in the respective countries, but also partly explained by differences in the resource items included in the respective costing analysis. In addition, the OA-related outcome measures were different, so that it was not possible to compare the two studies directly. One area of agreement, however, was that confidence intervals associated with cost-effectiveness estimates of water exercise in OA reflect the wide variability in both individual costs and effects observed in such populations.

Chapter 6

Process evaluation: implications for delivery and sustainability

Introduction

Pragmatic research of the type undertaken here is rare. Thus, those wishing to design and execute similar evaluations have limited published information on which to develop appropriate methods. To address this paucity of methodological detail, a wide-ranging process evaluation was embedded within the main trial. This had three strands: (1) to assess reliability and utility of the study outcome measures for use with older adults with hip and/or knee OA, (2) to establish the association between disease status and the various outcome measures, and (3) to identify key factors relating to the delivery and sustainability of group-based water exercise as a public health intervention for lower limb OA in an older population.

Although the instruments and measures used in this research had been used widely and validated in many studies involving populations similar in age to this study population, the reality was that it was impossible to tell at the outset that they would provide the reliability and sensitivity to detect group differences under the specific circumstances in which they would be used. It was important, therefore, to establish the reliability and utility of the outcome measures for this particular population. The next section reports short-term reliability (test–retest within 1 week) statistics for all the outcome measures. Incidence of floor and ceiling scores (i.e. scores at the bottom or top of the relevant subscale, and therefore having no capacity to detect change) were also recorded for the questionnaire-derived dimensions.

Reliability alone is not sufficient to ensure the utility of a given measure for use in an RCT. To be able to detect group differences, the measure must adequately characterise and be responsive to change in disease status. Associations between disease status and distribution, self-report measures and physical function measures at baseline were examined in some detail and are reported in the third section of this chapter.

No published information was found on comparable long-term trials of water exercise as a public health intervention in a UK setting. This meant that implementation of the water exercise programme was not developed from a strong evidence base and sustained delivery of such an intervention was a new experience for all those involved, including the participants. Short-term delivery and efficacy of the water exercises were established in the pilot project. However, it is likely that, to continue to derive benefit, the exercise would need to be maintained on a regular basis. For these reasons, an evaluation was undertaken of the factors contributing to the successful long-term delivery of water exercise on a population basis and those militating against it. Factors considered were those associated with the venue and programme content and delivery, those associated with individual participants and their circumstances, and wider issues such as public service partnership, local usage policy and funding of such programmes. The findings are presented and discussed in the final three sections of this chapter.

Reliability of outcome measures

Test–retest reliability statistics for self-report and physical function measures are summarised in *Tables 27* and *28*. Also shown in *Table 28* is the number of baseline questionnaires scored at either the ceiling score or the floor score for the given index. A high number of these scores at either end of the scale would indicate a lack of sensitivity to detect change, as was the case for SF-36 social function at the positive end of the scale and for SF-36 role physical and role mental at both ends of the scale.

Although all of the measures used here have been validated in other studies and are commonly used in research in this area, none can be considered an ideal measure. From a test–retest reliability study using a sample of 21 subjects, only the EQ-VAS score had a standard error of the measurement that was less than 10% of the group mean (SEM%, *Tables 27* and *28*). The role physical and role mental dimensions of the SF-36 had unacceptably high test–retest variability in this sample population. Thus, these measures must be

TABLE 27 *Test–retest reliability statistics for the self-report measures (n = 21) and ceiling and floor effects for the baseline scores*

Measure	Mean	SD	95% CI difference	*p*-Value	ICC	SEM	SEM%	C	F
WOMAC pain	0.10	1.89	–0.78 to 0.98	0.82	0.90	1.40	16.32	0	1
WOMAC physical function	1.30	5.59	–1.32 to 3.92	0.31	0.93	3.76	11.91	0	2
WOMAC stiffness	0.10	1.45	–0.56 to 0.75	0.77	0.77	0.94	23.82	3	5
SF-36 pain	–4.23	16.28	–11.64 to 3.18	0.25	0.78	9.88	21.97	2	6
SF-36 physical function	4.52	11.50	–0.71 to 9.76	0.09	0.85	7.67	16.78	2	0
SF-36 social function	0.00	17.21	–7.84 to 7.84	1.00	0.79	12.43	19.26	64	4
SF-36 role physical	–5.95	20.77	–15.41 to 3.50	0.20	0.84	14.24	66.45	36	173
SF-36 role mental	4.76	38.42	–12.73 to 22.25	0.58	0.65	25.38	49.96	109	130
SF-36 mental health	0.19	14.61	–6.46 to 6.84	0.95	0.69	9.10	12.98	8	0
SF-36 vitality	–2.86	11.68	–8.17 to 2.46	0.28	0.83	7.72	16.98	0	5
SF-36 general health	–0.95	10.07	–5.54 to 3.63	0.67	0.88	6.79	12.76	0	0
SF-36 change in health	2.38	15.62	–4.73 to 9.49	0.49	0.74	10.71	21.41	7	12
EQ-VAS	–1.95	8.46	–5.81 to 1.90	0.30	0.87	5.85	9.44	4	1

C, number of questionnaires scored at the ceiling value; F, number of questionnaires scored at the floor value; ICC, intraclass correlation coefficient; SEM%, standard error of the measurement as a percentage of the mean.

TABLE 28 *Test–retest reliability statistics for the physical function measures (n = 21)*

Measure	Mean difference	SD of difference	95% CI of the difference	*p*-Value	ICC	SEM	SEM%
8-foot walk	0.18	0.55	–0.07 to 0.43	0.14	0.88	0.45	13.62
RQ strength	–12.57	22.04	–22.60 to –2.54	0.02	0.96	17.25	17.12
RH strength	–3.62	27.31	–16.05 to 8.81	0.55	0.90	17.78	22.94
LQ strength	–9.90	27.99	–22.65 to 2.84	0.12	0.90	18.61	18.50
LH strength	–5.43	29.50	–18.86 to 8.00	0.41	0.86	19.54	26.22
Stair ascent	0.48	0.80	0.11 to 0.84	0.01	0.86	0.72	19.13
Stair descent	0.51	0.78	0.16 to 0.87	0.01	0.86	0.70	17.43

regarded as unreliable in the context of this research. The 8-foot walk, quadriceps strength measures, stair ascent and descent, WOMAC pain and physical function indices and SF-36 physical function, social function, mental health, vitality and general health dimensions had SEM% values in the range 10–20 and were regarded as reliable. The reliability of the remaining measures must be regarded as questionable. The modest test–retest reliability of the best available measures imposes a limit on the sensitivity to detect small, but potentially important, changes in health-related outcomes in the type of conservative, longitudinal study undertaken here. At the same time it drives up the cost and complexity of this type of research.

Associations between outcome measures and disease status and distribution

OA is a condition that is associated with pain and loss of physical function. Thus, it was anticipated that the outcome measures used in the study would be associated with disease status and disease distribution. These associations are reported below.

Physical function and disease

Figure 19 shows the variation in strength measures with number of joints affected.

Quadriceps strength asymmetry, defined as (RQ-LQ)/(RQ+LQ), is plotted against number of joints affected and side of reported pain (left, right or bilateral) in *Figures 20–22*. These figures demonstrate the strength asymmetry associated with unilateral disease, whereby the contralateral limb is dominant. The strength deficit on the affected side is most likely to be caused by functional inhibition due to pain associated with the OA. However, a contribution of strength asymmetry to the development of OA cannot be discounted.

WOMAC indices and disease

Associations between the WOMAC indices and the number of joints affected are illustrated in

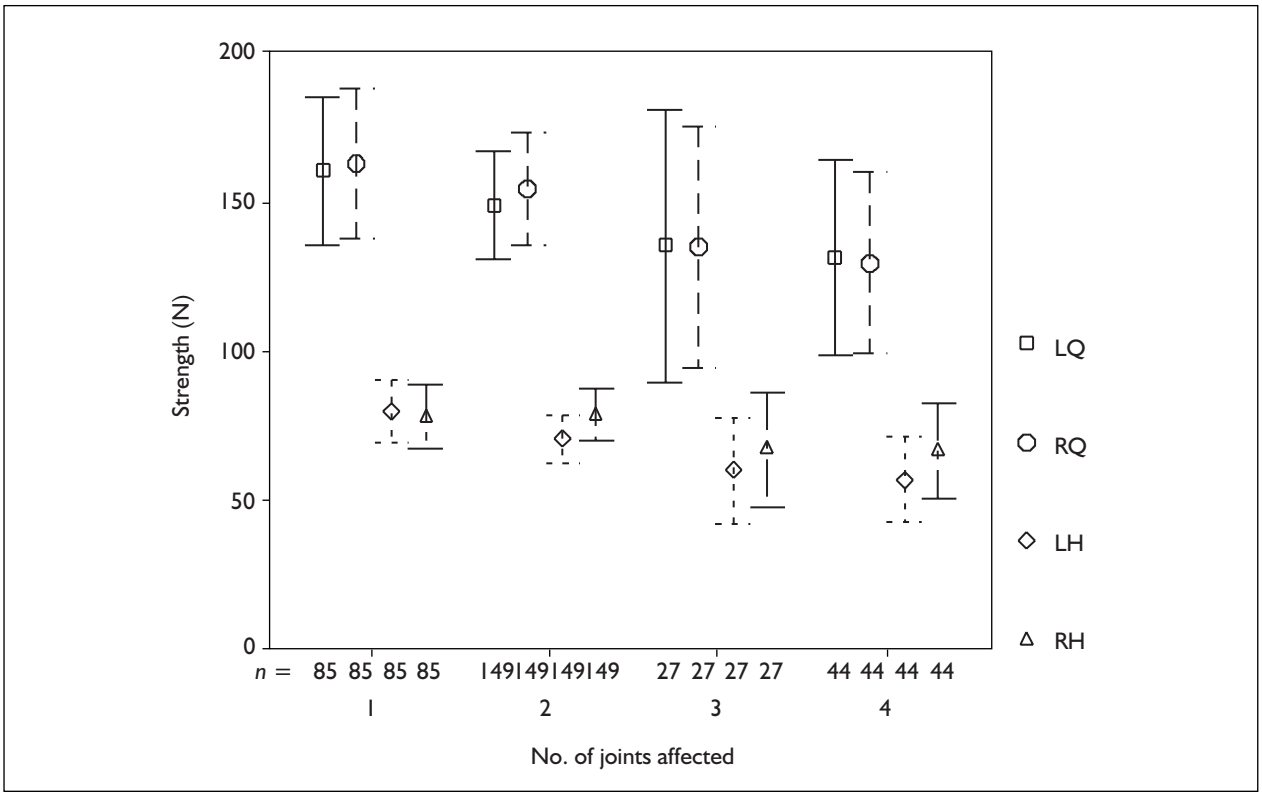

FIGURE 19 *Lower limb isometric strength measures plotted against number of joints affected. LQ, left quadriceps; RQ, right quadriceps; LH, left hamstrings; RH, right hamstrings) (error bars represent subgroup 95% CIs about the mean).*

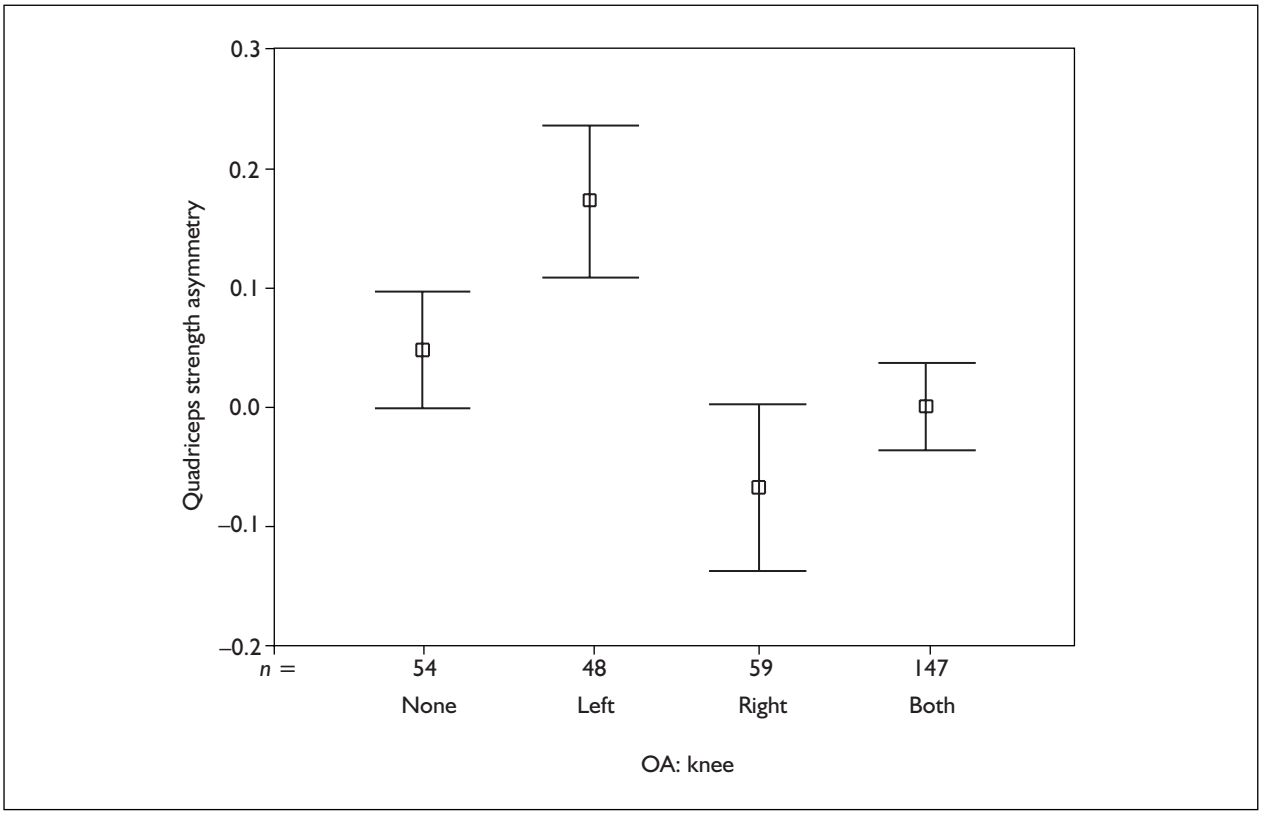

FIGURE 20 *Quadriceps strength asymmetry plotted against knee OA (error bars represent subgroup 95% CIs about the mean)*

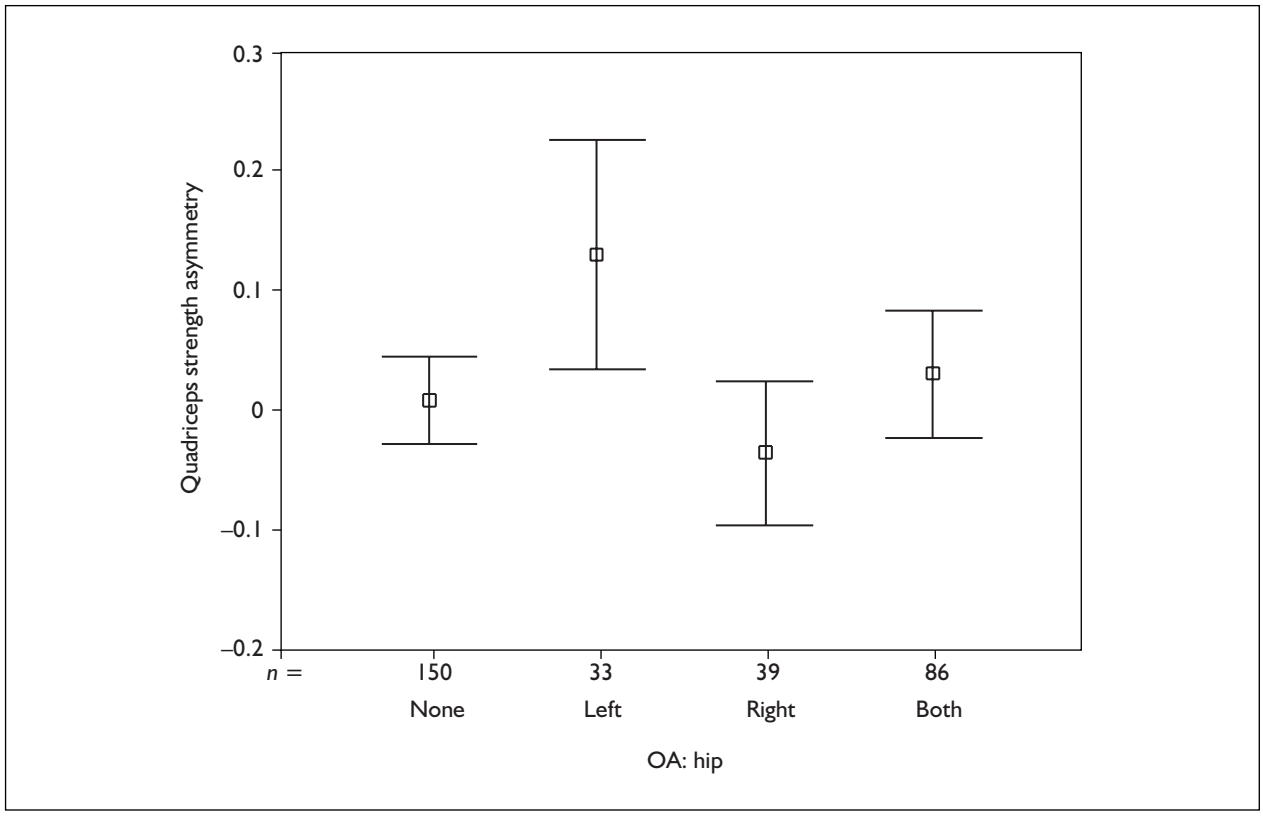

FIGURE 21 *Quadriceps strength asymmetry plotted against hip OA (error bars represent subgroup 95% CIs about the mean)*

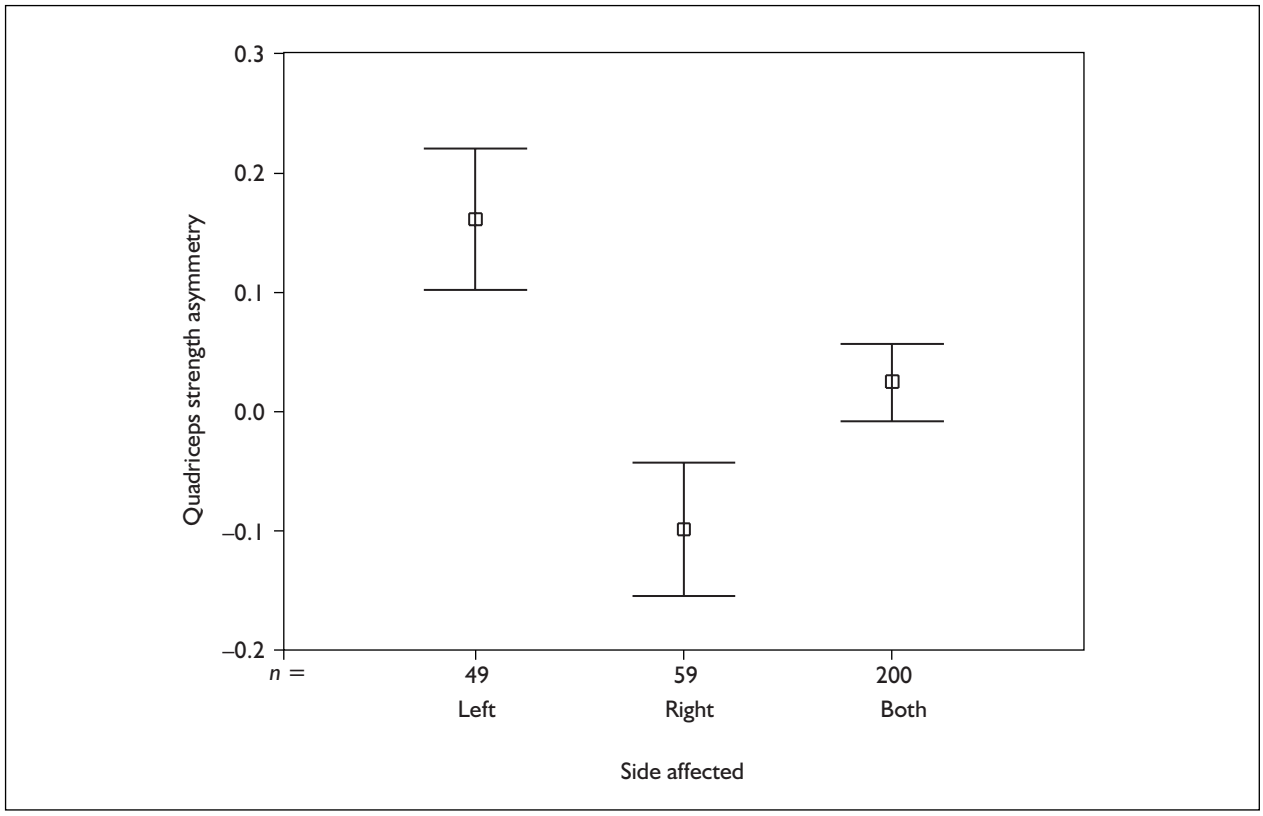

FIGURE 22 *Quadriceps strength asymmetry plotted against side affected by OA (error bars represent subgroup 95% CIs about the mean)*

Figure 23 and between the WOMAC indices and the side of pain in *Figure 24*. For ease of presentation, these scores have been normalised by the number of questions making up the composite score. These show the trend towards higher WOMAC scores with increasing number of joints affected and the side affected (left-sided < right-sided < bilateral).

Physical measures and WOMAC

Significant associations between the physical measures at baseline and the WOMAC indices are summarised in *Tables 29* and *30*.

Most of these associations were as expected. Strength decline was associated with poorer performance on the three walking measures, as was increasing age. Both hamstring strength measures declined with age but, interestingly, not the quadriceps measures. The time taken to descend four stairs was longer than the time taken to ascend, which is counter to what might be expected. It can be noted from *Table 29* that the time to descend the stairs increased with increasing BMI and from *Table 30* that the association with pain was slightly stronger for descending than for ascending the stairs. Both of these observations would support the hypothesis that greater impact forces experienced in descending may contribute to the greater loss of function in descending relative to ascending the stairs.

Increasing pain and poorer physical function WOMAC scores were associated with poorer function on all three walking measures and also with decline in strength. The WOMAC physical function score also increased with increasing age and BMI, although these associations were weak.

SF-36 dimensions and disease

Associations between SF-36 dimensions and number of joints affected are illustrated in *Figure 25* and between the SF-36 dimensions and the side of pain in *Figure 26*.

SF-36 dimensions and physical function

Significant associations between the SF-36 dimensions and the physical function measures at baseline are summarised in *Table 31*.

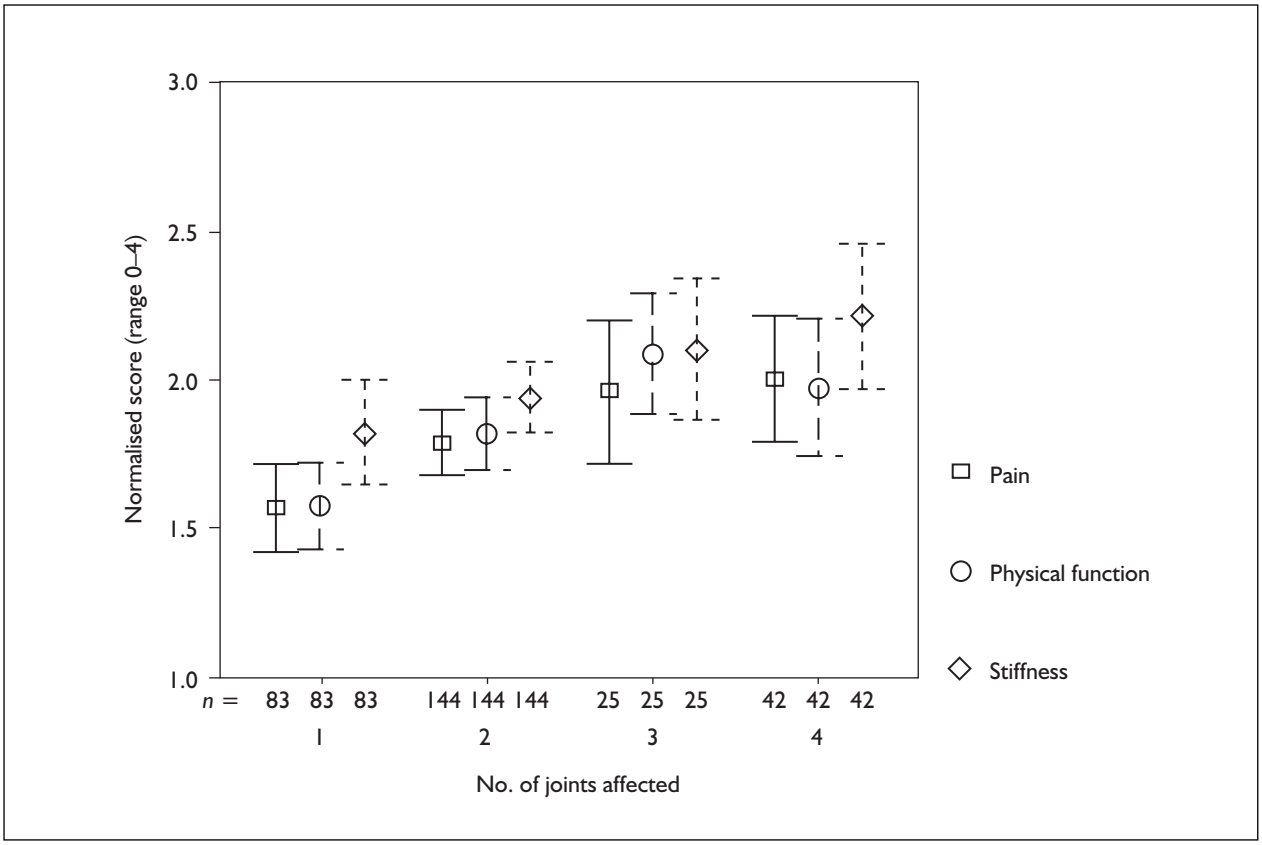

FIGURE 23 *WOMAC indices (normalised by the number of questions making up the composite score) plotted against number of joints affected (error bars represent subgroup 95% CIs about the mean)*

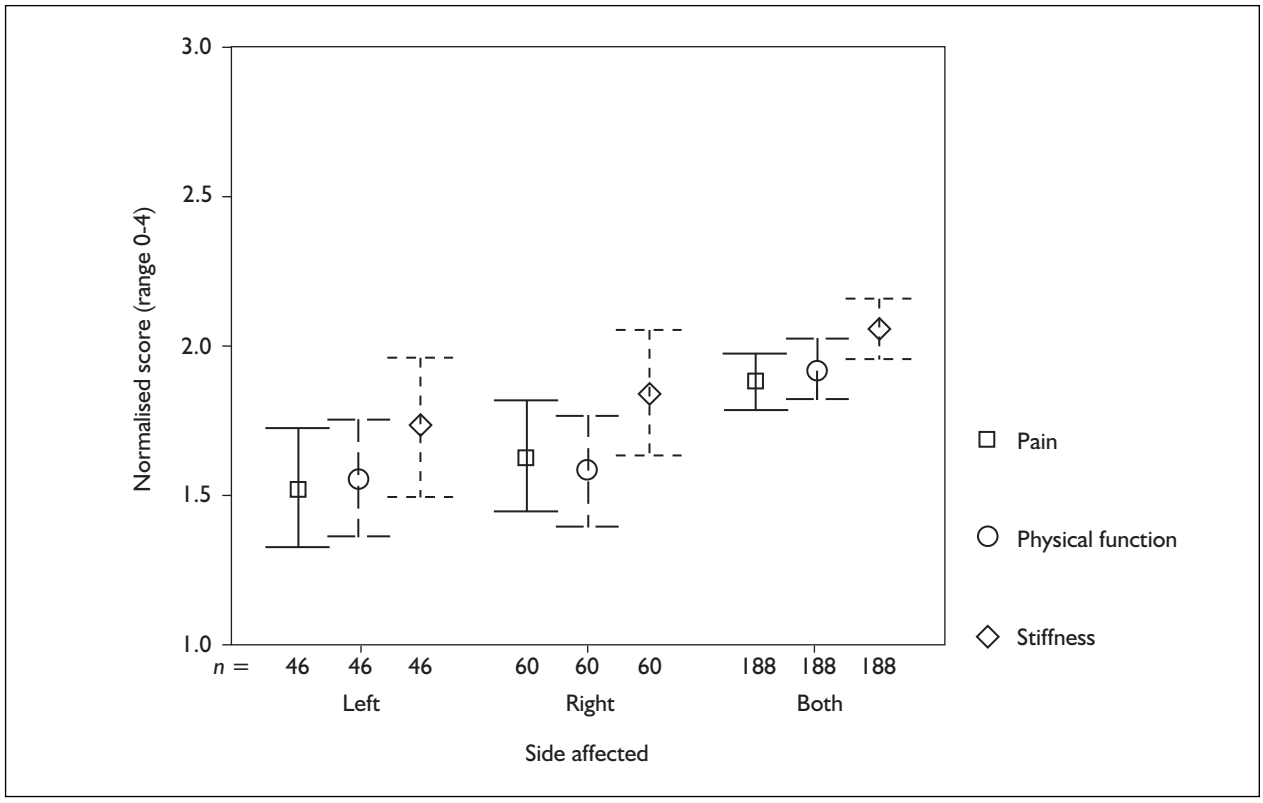

FIGURE 24 *WOMAC indices (normalised by the number of questions making up the composite score) plotted against side affected by OA (error bars represent subgroup 95% CIs about the mean)*

TABLE 29 *Significant associations between physical measures*

	8-foot walk	Stair ascent	Stair descent	LH	LQ	RH	RQ	Age	Weight
Stair ascent	0.792** 308								
Stair descent	0.777** 307	0.943** 307							
LH	–0.313** 309	–0.284** 307	–0.306** 306						
LQ	–0.262** 310	–0.257** 307	–0.270** 306	0.770** 308					
RH	–0.248** 307	–0.306** 304	–0.298** 303	0.793** 306	0.705** 307				
RQ	–0.253** 309	–0.275** 306	–0.282** 305	0.662** 307	0.865** 308	0.760** 306			
Age	0.138* 311	0.205** 307	0.249** 306	–0.133* 308		–0.137* 306			
Weight				0.253** 309	0.275** 310	0.273** 307	0.245** 309	–0.245** 311	
BMI			0.123* 307					–0.140* 311	0.802** 312

Significant correlations: ** $p < 0.01$ (two-tailed), * $p < 0.05$ (two-tailed).

TABLE 30 *Significant associations between WOMAC indices and physical measures at baseline*

	Pain	Physical function	Stiffness	8-foot walk	BMI	Age	LH	LQ	RH	RQ	Stair ascent	Stair descent
Pain		0.786** 294	0.676** 305	0.351** 306			–0.213** 303	–0.167** 304	–0.156** 301	–0.173** 303	0.319** 302	0.344** 301
Physical function	0.786** 294		0.745** 295	0.445** 295	0.126* 295	0.139* 294	–0.269** 292	–0.188** 293	–0.200** 290	–0.199** 292	0.430** 291	0.457** 290
Stiffness	0.676** 305	0.745** 295		0.343** 306	0.128* 306		–0.185** 303	–0.179** 304		–0.168** 303	0.311** 302	0.347** 301

** $p < 0.01$, * $p < 0.05$.

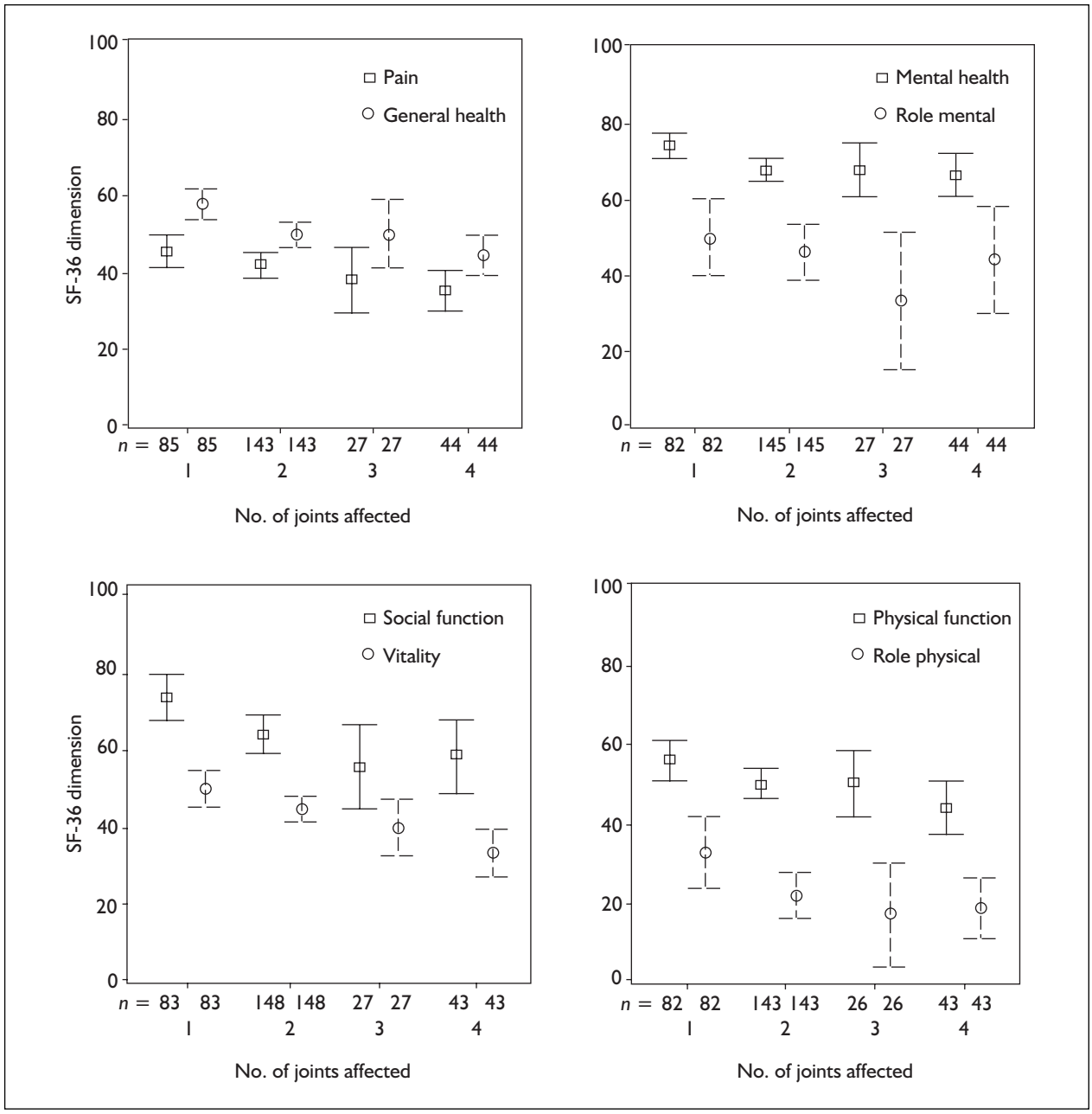

FIGURE 25 *SF-36 dimensions at baseline, by number of joints affected (error bars represent subgroup 95% CIs about the mean)*

Not unexpectedly, the strength measures were positively associated and with all SF-36 dimensions. Similarly, longer times on the three walking measures were negatively associated with all SF-36 dimensions. Increasing BMI had a negative impact on the physical function, role-physical and vitality dimensions of the SF-36, and increasing age was negatively associated with social function.

WOMAC indices and SF-36 dimensions

Baseline associations between WOMAC and SF-36 dimensions are shown in *Table 32*. These associations confirm the importance of pain, loss of physical function and joint stiffness in the quality of life of the participants in this study. Moderate correlations between the respective WOMAC and SF-36 pain and physical function scores indicate that these measures share some common variance, but that the 'pain' and 'physical function' measured by each is different.

Gender and main outcome measures

Comparison of the main outcome measures by gender is summarised in *Figures 27–29*. There were no significant differences by gender group on any of these measures.

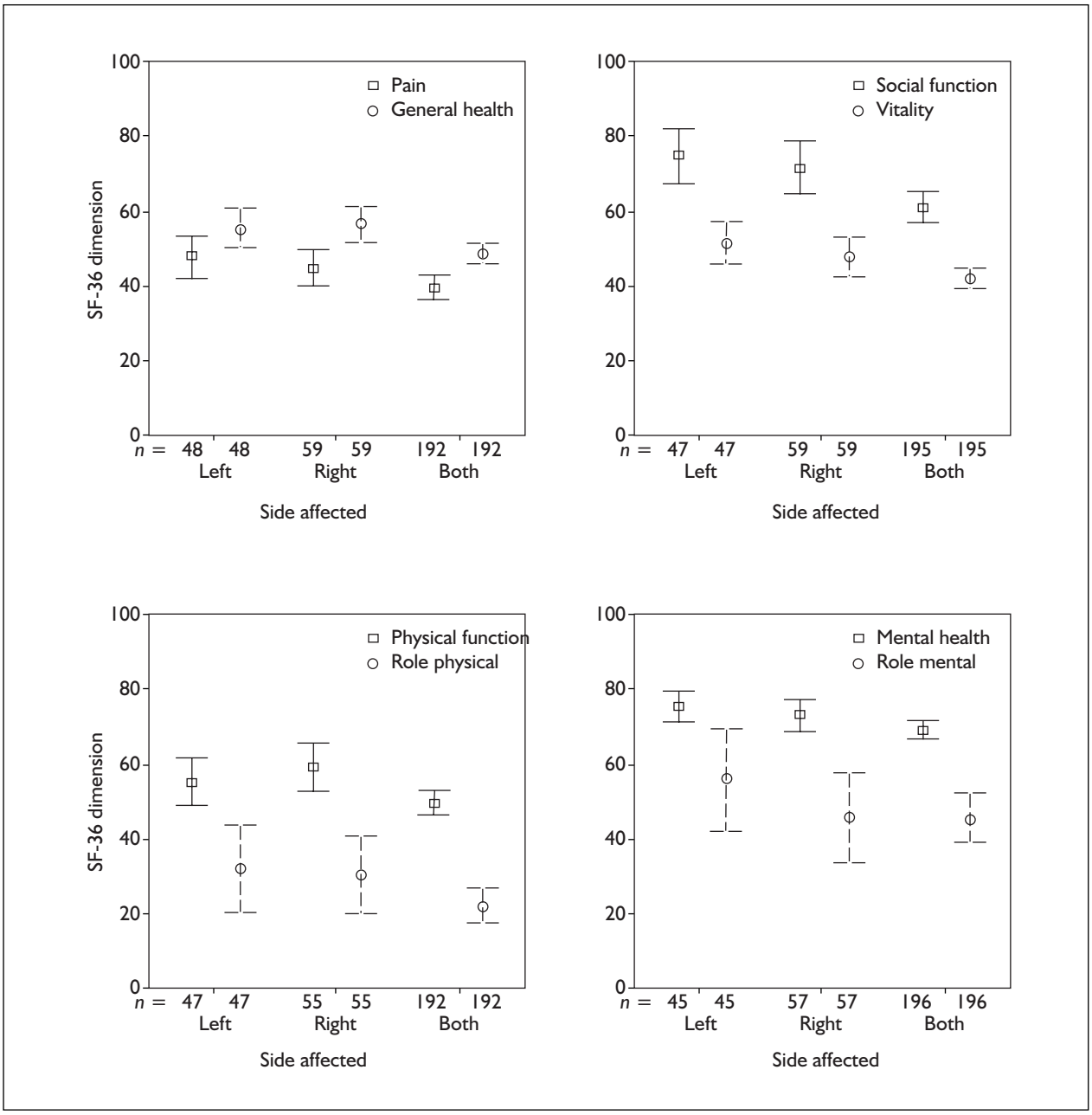

FIGURE 26 *SF-36 dimensions at baseline, by side affected by OA (error bars represent subgroup 95% CIs about the mean)*

Gender and physical function measures

Physical function measures by gender group are compared in *Figures 30* and *31*. Men were significantly faster on all the timed measures and stronger on the strength measures, compared with women.

EuroQol and disease

Associations between the EQ-VAS and the number of joints affected are illustrated in *Figure 32* and between the EQ-VAS and the side of pain in *Figure 33*. Similarly to the WOMAC pain index, the EQ-VAS showed a trend towards poorer scores with increasing number of joints affected and the side affected (left-sided < right-sided < bilateral).

EuroQol and physical function

Correlations between the EQ-VAS and the physical function measures are summarised in *Table 33*. The significant associations here merely confirm the importance of maintaining lower limb strength to sustain health-related quality of life and mobility.

TABLE 31 *Significant associations between SF-36 dimensions and physical measures*

	SF-36 dimension							
	Pain	**Physical function**	**Social function**	**Role physical**	**Role mental**	**Mental health**	**Vitality**	**General health**
Pain		0.551** 298	0.639** 305	0.458** 300	0.338** 301	0.339** 302	0.518** 302	0.520** 299
Physical function	0.551** 298		0.596** 297	0.504** 294	0.269** 294	0.188** 294	0.441** 295	0.492** 293
Social function	0.639** 305	0.596** 297		0.468** 299	0.505** 300	0.433** 301	0.611** 301	0.521** 298
Role physical	0.458** 300	0.504** 294	0.468** 299		0.459** 297	0.149** 297	0.341** 296	0.337** 294
Role mental	0.338** 301	0.269** 294	0.505** 300	0.459** 297		0.423** 298	0.394** 298	0.397** 296
Mental health	0.339** 302	0.188** 294	0.433** 301	0.149** 297	0.423** 298		0.564** 299	0.444** 296
Vitality	0.518** 302	0.441** 295	0.611** 301	0.341** 296	0.394** 298	0.564** 299		0.630** 296
General health	0.520** 299	0.492** 293	0.521** 298	0.337** 294	0.397** 296	0.444** 296	0.630** 296	
8-foot walk	–0.299** 306	–0.419** 298	–0.400** 305	–0.206** 301	–0.242** 301	–0.173** 302	–0.232** 302	–0.274** 299
BMI		–0.224** 298		–0.181** 301			–0.131* 302	
Age			–0.117* 304					
LH	0.213** 303	0.153** 295	0.236** 302	0.178** 298	0.220** 298	0.152** 299	0.220** 299	0.169** 296
LQ	0.184** 304	0.155** 296	0.163** 303	0.147* 299	0.210** 299	0.198** 300	0.198** 300	0.145* 297
RH	0.154** 301	0.141* 293	0.169** 300	0.173** 296	0.222** 296	0.147* 297	0.188** 297	0.148* 294
RQ	0.154** 303	0.143* 295	0.144* 302	0.145* 298	0.176** 298	0.166** 299	0.202** 299	0.132* 296
Stair ascent	–0.343** 302	–0.398** 294	–0.388** 301	–0.167** 297	–0.205** 297	–0.149* 298	–0.254** 298	–0.287** 295
Stair descent	–0.349** 301	–0.429** 293	–0.401** 300	–0.207** 296	–0.189** 296	–0.130* 297	–0.251** 297	–0.277** 294
Weight		–0.137* 298		–0.114* 301				

** $p < 0.01$, * $p < 0.05$.

TABLE 32 *Significant associations between WOMAC and SF-36 dimensions at baseline*

WOMAC	SF-36 dimension							
	Pain	**Physical function**	**Social function**	**Role physical**	**Role mental**	**Mental health**	**Vitality**	**General health**
Pain	–0.676** 304	–0.558** 297	–0.482** 303	–0.357** 300	–0.276** 300	–0.216** 300	–0.403** 301	–0.356** 297
Physical function	–0.704** 293	–0.690** 288	–0.624** 292	–0.468** 290	–0.315** 289	–0.226** 289	–0.447** 289	–0.431** 287
Stiffness	–0.534** 304	–0.486** 297	–0.413** 303	–0.332** 301	–0.177** 300	–0.193** 300	–0.337** 300	–0.234** 297

** $p < 0.01$.

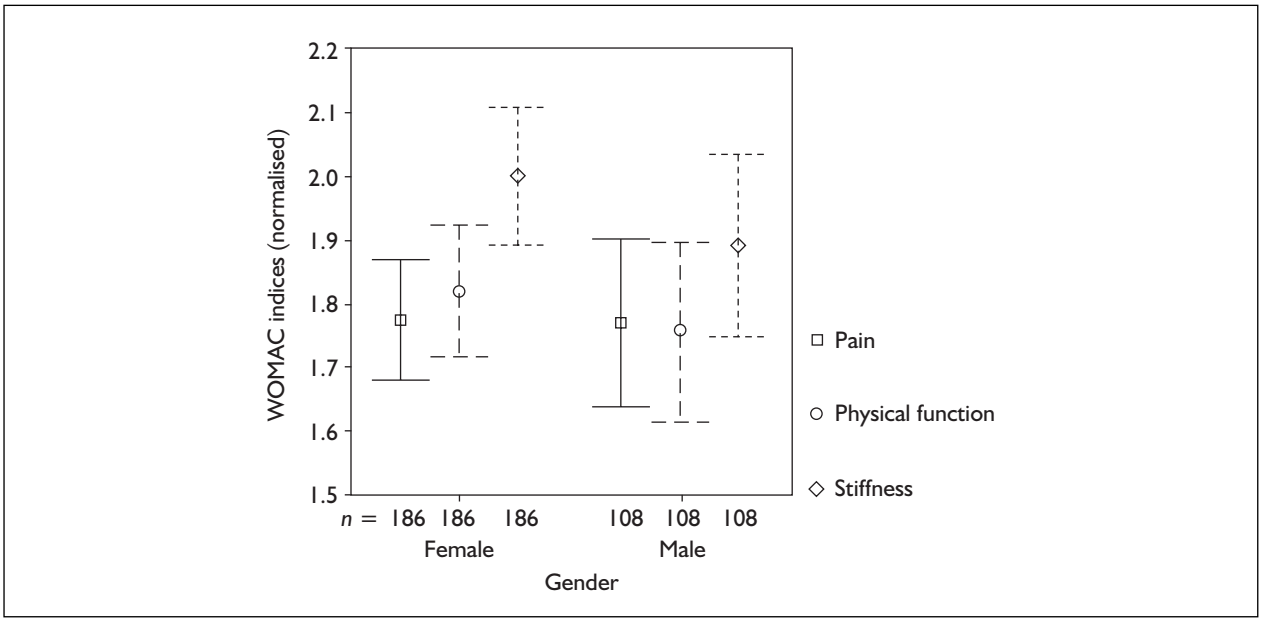

FIGURE 27 *WOMAC indices at baseline (normalised by number of questions making up the composite score), by gender (error bars represent subgroup 95% CIs about the mean)*

EuroQol and other study outcome measures

Baseline associations between the EQ-VAS, WOMAC and SF-36 measures are summarised in *Table 34*.

Delivery of sessions

Initially, seven instructors were recruited to lead the exercise sessions. This was felt to be adequate for the requirements of ten weekly sessions over the 1 year of intervention (actually 18 months of delivery, given the staggered recruitment period). In practice, the sustained delivery of the weekly exercise programme proved much more of a challenge than was originally envisaged. Two additional facilitator recruitment and training phases were undertaken during the intervention period to maintain the supply of facilitators. In all, 19 instructors participated in the programme, only one of whom remained for the whole intervention period.

The quality of the sessions and programmes offered at the four venues used in the study was evaluated in separate focus group sessions. Ratings on a scale of 1–3 (where 1 = poor or unsuitable, 2 = suitable to good and 3 = ideal or excellent) were given on ten key factors identified by

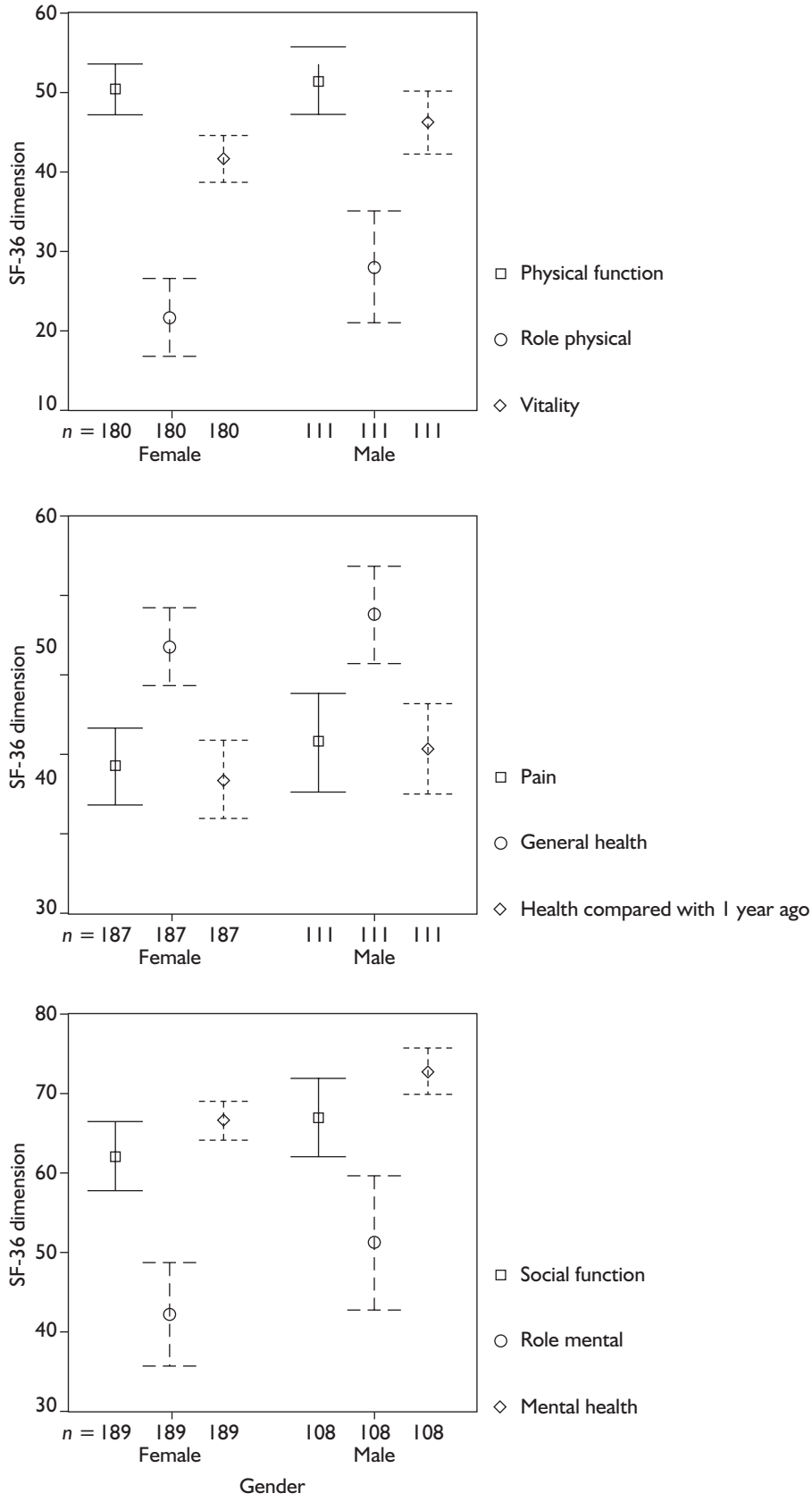

FIGURE 28 *SF-36 dimensions at baseline, by gender (error bars represent 95% CI)*

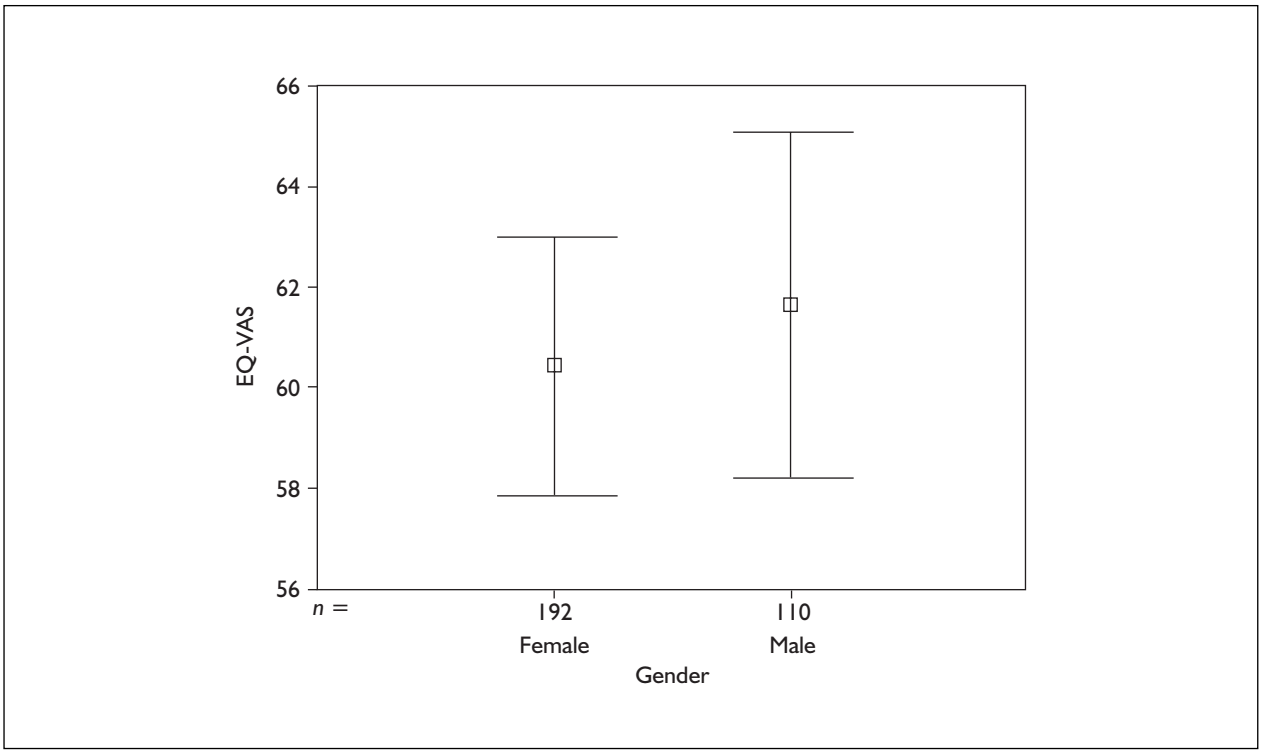

FIGURE 29 *EQ-VAS at baseline, by gender (error bars represent 95% CI)*

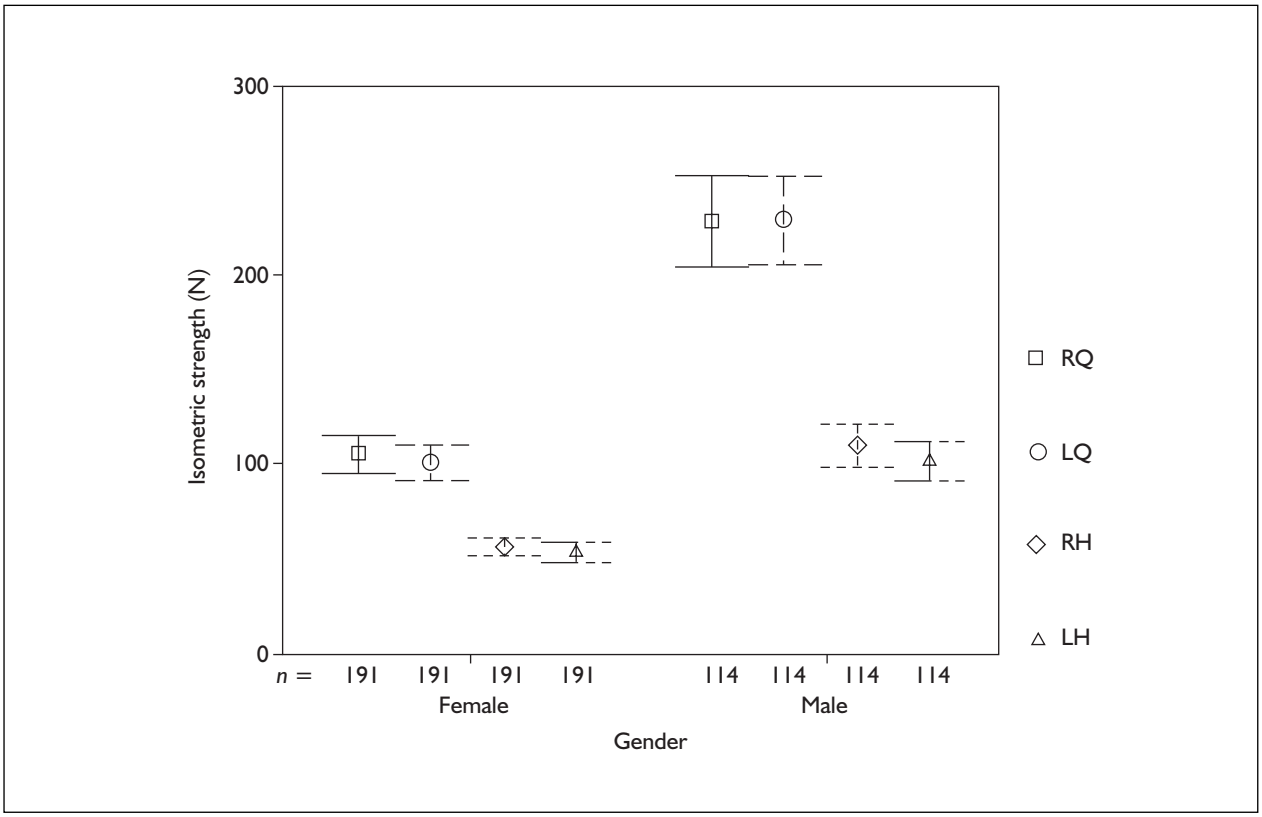

FIGURE 30 *Isometric strength measures at baseline, by gender (error bars represent 95% CI)*

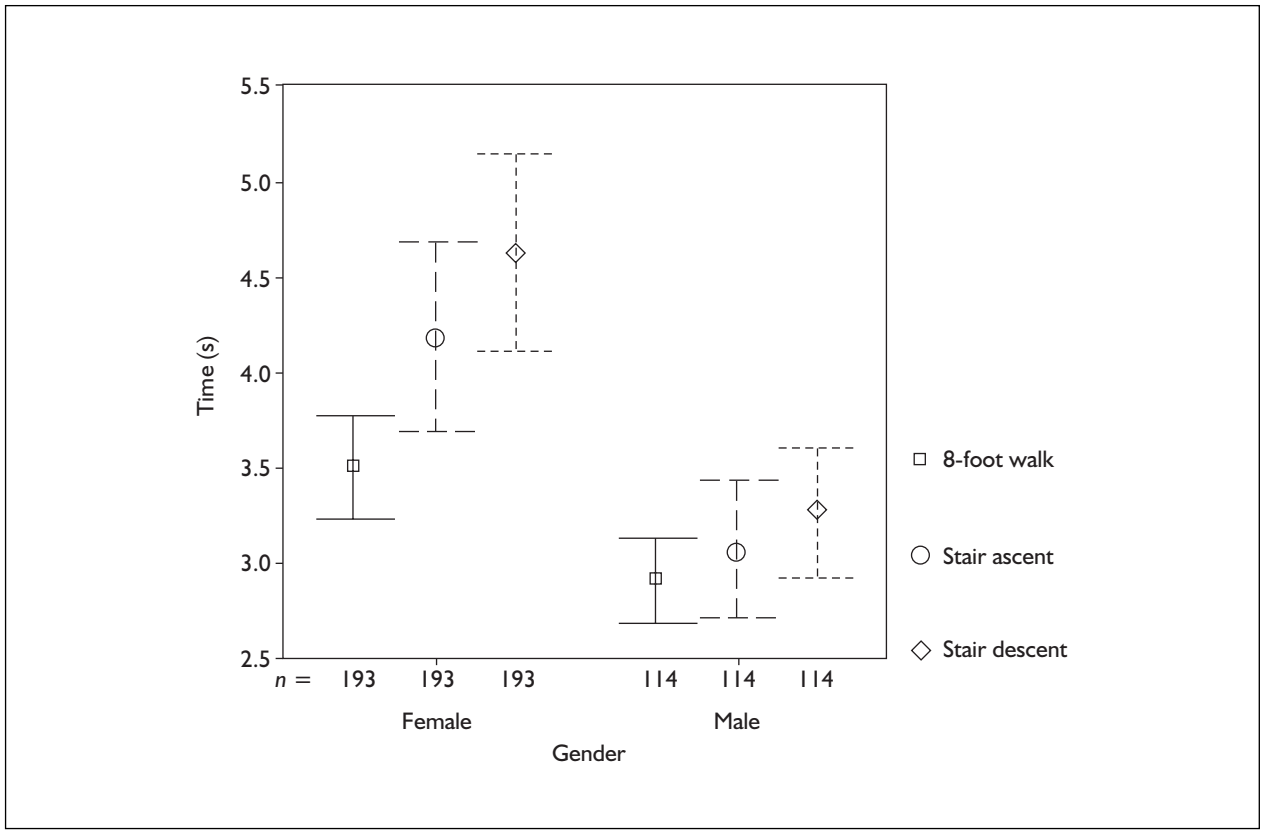

FIGURE 31 *Times on 8-foot walk, stair ascent and stair descent at baseline, by gender (error bars represent 95% CI)*

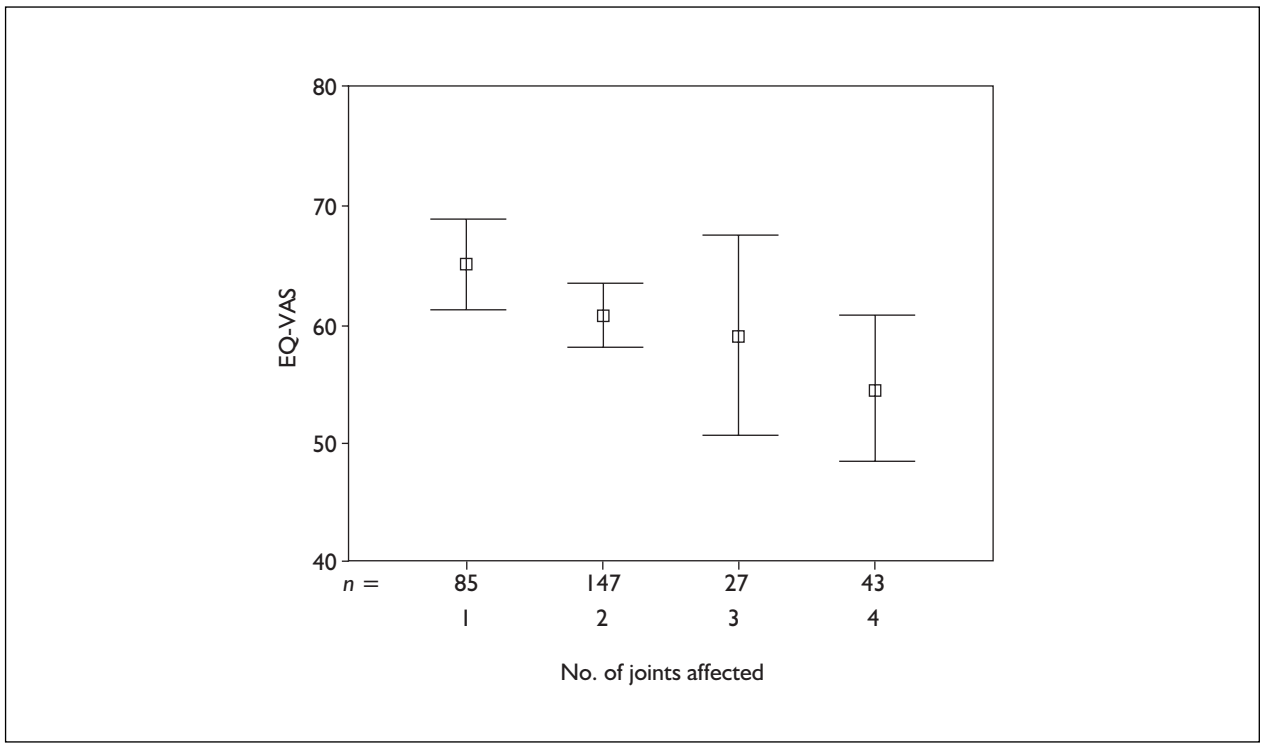

FIGURE 32 *EQ-VAS at baseline, by number of joints affected (error bars represent 95% CI)*

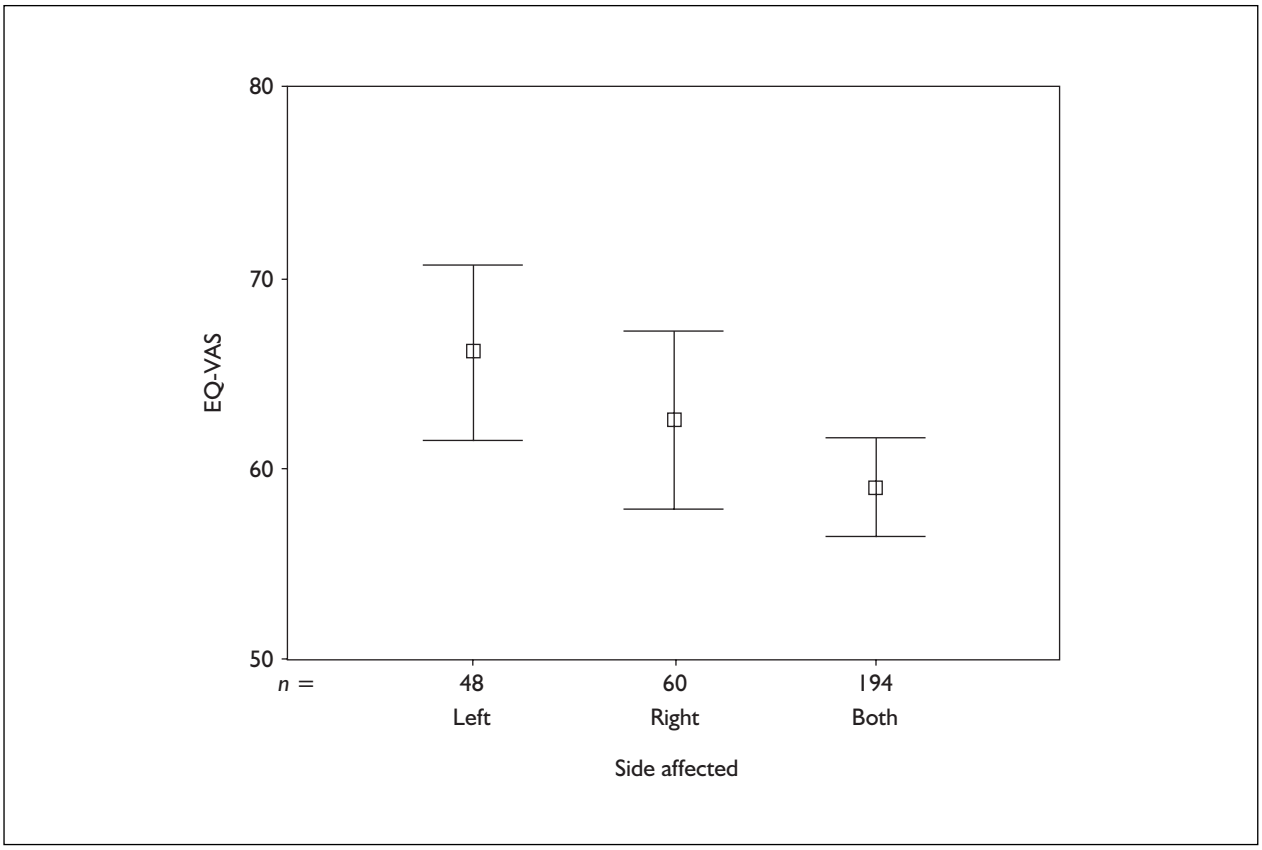

FIGURE 33 *EQ-VAS at baseline, by side affected by OA (error bars represent 95% CI)*

TABLE 33 *Significant associations between EQ-VAS and physical measures at baseline*

	8-foot walk	LH	LQ	RH	RQ	Stair ascent	Stair descent
EQ-VAS	–0.309** 302	0.235** 299	0.204** 300	0.210** 297	0.205** 299	–0.294** 299	–0.296** 298
** $p < 0.01$.							

TABLE 34 *Significant associations between EQ-VAS and other self-report outcome measures at baseline*

	WOMAC			SF-36							
	Pain	Physical	Stiffness	Pain	Physical function	Social function	Role physical	Role mental	Mental health	Vitality	General health
EQ-VAS	–0.394** 301	–0.481** 290	–0.278** 301	0.596** 301	0.520** 293	0.554** 300	0.369** 296	0.370** 297	0.340** 297	0.567** 297	0.661** 294
** $p < 0.01$											

TABLE 35 *Quality of venues and programmes*

Key factor	Venue[a]			
	FM	SP	TP	NP
Water temperature (i.e. ≥31°C)	1	3	2	2
Within 3 miles from home	2	3	2	2
Little traffic to and from class	2	1	2	3
Ramp/easy access to pool	1	3	3	1
Ramp/easy access to building	1	3	1	2
Changing facilities	3	1	1	2
Quality of instruction	2	3	3	2
Enjoyable class atmosphere	2	3	2	2
Public transport available	1	2	2	2
Sufficient, free parking nearby	3	2	2	2
Total (out of 30)	18	24	20	20

[a] Venues: FM, Fenton Manor; SP, Shelton; TP, Tunstall; NP, Newcastle under Lyme.

participants as being important in water exercise programmes for older people. The results are summarised in *Table 35*.

This table shows that none of the four venues was satisfactory on all of these key factors. This may have had an influence on adherence to the programme. The Shelton pool was the venue that had the most suitable environment for the participants. Two of its three sessions were the best attended throughout the intervention (*Figure 4*), although the third session at this venue was poorly attended because of its timing. The majority of unsatisfactory ratings (six of nine) that were identified related to problems of access to the venue or to the pool (i.e. traffic, transport and parking).

This study also evaluated each venue to examine the potential influence on adherence (*Table 35*). The higher score for the Shelton pool (SP) was reflected in the higher attendance at this pool (SP4 and SP5, *Figure 4*) and also in the higher number of adherers from the sessions that took place there. Note, however, that timing is also critically important, as demonstrated by the low attendance at the Shelton pool session (SP6, *Figure 4*), which took place on a Sunday over lunchtime. In general, mid-morning or early afternoon on a weekday seemed to be the best times to suit older adults. In all, ten factors that might be termed environmental or psychosocial were identified as being important determinants of adherence in this community-based water exercise programme. On the basis of data recorded here, the average number of patients per session could be as many as 22 or as few as five depending only on choice of venue and timing of the session.

Not many other specific OA studies have looked at these environmental or programme factors. Estabrooks and Carron[115] studied group cohesion in an older adults exercise setting. They found that the team-building group had higher adherence and was more likely to return to classes after a break than the control and placebo conditions, and concluded that this is an important factor in exercise classes for the elderly. This may help to explain the high adherence seen at SP as it was the class that had the most sociable atmosphere and instructors who promoted a 'team' feeling. In their review, Robison and Rogers[116] agreed, stating that having the social support of fellow participants is associated with increased adherence.

Another programme-related factor that may help to explain the higher adherence at SP was the water temperature, which was approximately 5°C warmer than in the other pools. Bunning and Masterson[117] observed that compliance with water exercise for OA patients increased when the temperature was above 29°C because patients found the higher temperature better for stiff joints.

Exit questionnaire analysis

Programme evaluation questionnaires were returned by 110 (69%) of the control group participants and 95 (62%) of the exercise group participants. A summary of the main findings is given in *Table 36*.

TABLE 36 *Summary comparison of responses to programme evaluation questionnaire by group [n = 95 (62%) water exercise, n = 110 (69%) control]*

	Control	Exercise
Reasons for participating in research		
Relieve pain	53	48
Benefit research	21	5
GP recommended	11	10
Personal interest in exercise	2	6
Improve mobility	3	9
None given	21	17
Reasons why older people would not participate		
Too old to benefit	48	15
No transport	75	59
Too embarrassed	39	23
Afraid to go alone	45	31
Venues not suitable	24	14
Times inconvenient	14	30
Too ill	38	23
Too disabled	54	32
Do not want to socialise	26	16
Bad weather	8	6
Too many other commitments	36	26
Do not believe in benefits of exercise	41	8
Apathy	15	5
Form filling	3	
Fear of condition worsening	1	3
Lack of awareness	11	5
Cost	1	7
Group allocation	1	
Fear of water/unable to swim		3
Water temperature		2
Things to encourage more participation		
Awareness/publicity	39	18
More/nearer venues	2	2
Better transport	8	5
More suitable times	3	3
GP commitment	3	3
Lower cost	2	3
New activities taken up		
Yes	19	10
Would you like to continue current programme?		
Yes	68	65
Additional comments		
Positive	37	50
Adverse	1	3

Participants in the water exercise group were asked additional questions relating to their participation in the exercise programme. The responses are summarised in *Table 37*.

Walking, bowling, swimming and dancing were strongly supported as additional modes of exercise suitable for older people. Golf, yoga, home exercise and t'ai chi were also mentioned, but only on one or two occasions.

Delivery of water exercise on a population basis

One issue that emerged as central in the process

TABLE 37 *Participants' responses related to the water exercise programme [n = 95 (62%)]*

	n	
Difficulties in getting to sessions		
Transport	11	
Illness	5	
Family commitments	2	
Times available	3	
Mode of getting to class		
Car	75	
Bus	14	
Taxi	3	
Walk	2	
Rating of water exercise activities (range 0 = least to 5 = most)	Mean	SD
Exercises with floats, etc.	4.3	1.16
Strength, range of motion exercises	4.47	0.82
Group activities	4.01	1.27
Relaxation	4.33	0.91
Social aspects	4.28	0.95
Most important attribute of session leader		
Voice/confidence	11	
Empathy/patience	21	
Knowledge/skill/organisation	7	
Friendly/outgoing/sense of humour	19	
Perceived benefits		
None noticeable	33	
Increased mobility	23	
Decreased pain	13	
Increased fitness	5	
Improved social life	9	
Improved general health or well-being	12	
Perceived deterioration		
Increased pain in affected joint(s)	4	

evaluation carried out alongside this clinical trial was the ability of a society or community to set up, deliver and sustain a conservative management programme, such as that evaluated here.

Changing societal norms: becoming fully engaged with health

The Wanless Report[118] illustrated the considerable variation in expected cost of achieving better health for the whole population, depending on how well health services become more productive and how well people become fully engaged with their own health. The follow-up report[119] focused on prevention and the wider determinants of health in England, concentrating particularly on the frameworks and processes that are likely to foster sustained action to improve public health. There is little remaining doubt not only that social norms need to be shifted if improvement in public health is to be achieved at reasonable cost, but also that the challenges that this implies will not be easily overcome. Several illustrations of such challenges were encountered in the course of this research.

First of all, there was the question of whether water exercise programmes are appropriate for older, disabled people, both from the perspective of patients themselves and from that of healthcare providers. Taking a pill is certainly easier than getting to and from a swimming venue and exercising for an hour or more. Also, the offer of exercise to those who have not exercised for some considerable time, who are obese and suffering from poor health and poor economic circumstances (as was the case for many of the participants), was a daunting prospect that may have proved too much for some people. Having made this point, the feedback from participants was predominantly positive about their experience of the water exercise programme (*Table 37*).

A second issue arose as to who should have priority access to public venues and services. The water exercise programme developed here had to compete for pool time with swimming programmes for local schools and also, to some extent, with sports clubs and private paying customers. This meant that it was not always possible to offer the water exercise at the best times for older people. This may have been an additional factor in reducing adherence.

In England, although water exercise is commonly taken by those who have joint problems, the specific use of group sessions for older people with lower limb OA was novel and there was clearly some tension around who should be the 'gatekeepers' to healthcare provision and who should be the providers. Although recent policy and activity have been directed at strengthening partnership for the delivery of public health improvement, difficulties remain with respect to capacity, coping with organisational change and alignment of priorities from national strategy between contributing partners.

Sustainable delivery

There were also challenges related to sustainable delivery of water exercise on a population basis. Delivering a physical activity programme is not as simple as taking medication, either for the provider or for the recipient. The latter must commit considerable time and effort, and probably expense under present circumstances, to taking their 'treatment'. Similarly, the provider must commit resource and effort to sustain the service against the backdrop of competition for those services from elsewhere. It became clear during this research that accessing the venues was a major issue for programme participants. Seven out of ten key factors important to sustainable delivery were related to access (*Table 35*). A significant number of participants in the water exercise group either did not take part in the prescribed programme or dropped out after attending some sessions only, citing their inability to reach a suitable venue as their reason for non-adherence (*Tables 36* and *37*).

The other main cause of non-adherence or dropout was poor health, either of the participant or a close family member. With hindsight, it may have been that the inclusion criteria were too broad and more stringent exclusion criteria should have been incorporated, such as severity of the disease or coexistent conditions or criteria related to accessibility to the water exercise venues. However, such restrictions would have been at the expense of interpretation and generalisation of the findings.

Other key factors identified related to the quality of the delivery of the programme at each venue or session. Water temperature was mentioned commonly, particularly when perceived to be too cold over the winter months or in the earlier morning starts. It appears from the data in *Figure 4* that environmental factors, including the psychosocial environment of the group, can account for a lot of the success, or otherwise, of the programme (a four-fold difference in mean attendance was recorded between the least well-attended and the most well-attended session). This area merits greater attention in future research.

The most important characteristics of those leading the water exercise sessions were related more to being able to communicate and empathise with older people and being friendly than to the actual programme content (*Table 37*). Feedback relating to the exercises was good. The skills and training required to become an exercise leader are not difficult to acquire and are probably less than those required to become a swimming teacher. However, reliability and the ability to develop and maintain a group dynamic among older people appear to be key attributes.

In the programme delivered here, it was difficult to maintain a consistent quality of delivery due to high turnover of facilitators. Two of the research team with responsibility for overseeing the intervention (SME and RD) provided support on several occasions when a member of the pool of facilitators was unavailable at short notice. Notwithstanding this support, 15 sessions (3.6%) (out of 420 delivered during the programme) had to be cancelled without prior notice because no-one was available to deliver the session.

Local usage policy and funding gap?

The intervention was supported by the research team and free of charge to participants up to the end of the intervention period. Thereafter, support funding and most of the support of the research team was removed. (The control group was offered the water exercise programme free of charge for 12 weeks after the 18-month point and were free to take up exercise of their own volition after the 1-year point.) This feature of the research design was incorporated to assess whether there is a need for such programmes to be supported and to observe any carry-over effects from the intervention over the follow-up period.

The leisure services teams in both Stoke-on-Trent and Newcastle under Lyme expressed an interest in maintaining the programmes that had been established, but had no option but to introduce charges at the 'leisure card' rate then in operation, £1.50 per individual per session. This led to an immediate drop of about 50% in the number of participants continuing in the water exercise group and an almost immediate closure of half of the sessions because they were deemed as not viable because of low numbers attending. At the same time, a number of control group participants took up exercise (*Figure 8*). This had the result that actual exercise 'dose' over the 1-year to 18-month follow-up period in the two groups may not have been very different. The latter observation provides a plausible explanation for the beneficial changes seen in many of the 'control' group outcome measures and the failure to detect differences between the groups at the 18-month time-point.

The fact that the introduction of charging appeared to have a detrimental effect on participation may have implications for the funding of such public health programmes. A charge of £1.50 per session plus travel and parking costs, as well as the effort in sustaining the exercise was too much for the majority of potential participants, such that, at the end of the 18-month follow-up period, only about one-fifth of the eligible population in the study was still exercising. Therefore, it is unlikely under current societal norms and health and leisure policy settings that these programmes will be self-financing. The individual does not see the societal cost or the potential saving, since it is the health service that pays or reaps the benefit. The leisure service provider has a service to provide within an available budget and must strive to cover at least marginal costs from every participant using the service.

This implicit funding gap needs to be bridged if physical activity programmes, such as the water exercise programme evaluated here, are to become established. Perhaps better public service partnerships, as set out in the Wanless Report,[119] or even public–private partnerships, or both, are ways to move beyond the impasse.

Chapter 7

Summary of main findings, limitations and implications

Conclusions with respect to research objectives

Efficacy

The short-term efficacy of water exercise in the management of lower limb OA was confirmed. Effect sizes ranged from 0.44 (95% CI 0.03 to 0.85) on the WOMAC pain index to 0.76 (95% CI 0.33 to 1.17) on the WOMAC physical function index. This beneficial effect on pain was comparable to, if not better than, that obtained with NSAIDs over the short-term.[120] The lower limb functional activities, 8-foot walk, stair climbing and descending demonstrated modest beneficial effect sizes, but changes in isometric strength of the hamstrings and quadriceps muscles and ROM at the hip and knee were small.

Effectiveness

Water exercise remained effective (0.89 unit reduction in WOMAC pain, ES=0.25, 95% CI 0.02 to 0.47), $p = 0.031$) over the longer term and under the more pragmatic conditions of the main study, although effect sizes, where significant, were small. To continue to derive the benefit, it is important to maintain the treatment. There is evidence from this research that the latter is difficult to achieve. Approximately half of the patients in the original water exercise group remained active at the 1-year follow-up point. After researcher and financial support for the intervention had been removed, less than one-quarter of this cohort remained active (at the 18-month follow-up). Group-based exercise in water over 1 year can produce significant reduction in pain and improvement in physical function in older adults with lower limb OA and may be a useful adjunct in the management of OA of the hip and/or the knee.

The smallest detectable difference and minimum clinically important difference (MCID)[121] are important considerations. The former depends on the design of the RCT (treatment effects, response variability, including that in the measurement process, levels of uncertainty to be accepted in the analysis and number of subjects). The study was designed to detect a difference of 1.33 pain units with the expectation that the standard deviation of scores would be 3 units and assuming a false-positive error probability of 0.01 and statistical power of 0.9. In the event, the mean group difference in pain scores was 0.89 units and the standard deviation in pain score was 3.64 units. This resulted in a lower confidence level ($p = 0.031$, independent samples t-test) in the effect of treatment on WOMAC pain score (*Table 16*). Whether this is a clinically important difference has yet to be established.

The MCID concept as used by Angst and colleagues[121] is interesting, but the methodology is not yet sufficiently robust for application in all contexts.[122] The MCID has been shown to vary depending on baseline score, the approach used to calculate it, the context in which it is measured and the perspective from which it is measured. Furthermore, the confidence limits for any given MCID, although rarely quoted, are likely to be broad, given the variability in individual interpretation and responsiveness. The perspective in the Angst study[121] is rather different from that of the present research, although the same instruments are used, and it would be unwise to apply the same MCID. Notwithstanding this latter point, it is notable that the effect sizes achieved in this research are similar to those reported by Angst and colleagues (*Table 1* thereof) despite being analysed on an ITT basis and using a less resource-intensive mode of rehabilitation over 1 year with a further 6 months of follow-up.

The effect size of the intervention on self-reported pain was small and the water exercise intervention was not well maintained in the 6-month follow-up period. Therefore, the question of whether the effort is worth the return remains if the exercise treatment cannot be maintained. At the level of the individual, the majority answer to this question appears to be 'no', given the 18-month treatment compliance. However, the difference between the compliance at the 1-year (when acceptable levels of compliance were found) and 18-month time-points, the difference between the effect sizes at these time-points and the variation in compliance across the different venues, pose the question as to

whether this would remain the case if water exercise was better supported such that it was an established treatment norm and that it was easier for patients to take their prescribed treatment.

Ancillary analysis on the basis of those who complied with treatment yielded an estimate of 1.65 (95% CI 0.13 to 3.17) units of reduction in WOMAC pain (18.5% reduction from baseline) and 1.23 seconds (95% CI 0.26 to 2.2) reduction in time to descend four stairs (30% reduction from baseline).

Cost-effectiveness

Wide variation in both the individual costs and the utility measures, combined with small effect sizes, has limited the power of the project to detect a difference between the groups on the QALY-based analyses. The non-parametric bootstrap sampling approach yielded mean cost difference estimates showing a saving in the water exercise group of between £123 and £175 per patient per annum and ICERs ranging from £3838 to £5951. However, uncertainty inherent in the data meant that the latter had wide 95% confidence intervals such that it was not possible to determine a ceiling valuation (with 95% confidence) for comparison with competing approaches.

One can be more confident with respect to the analysis of cost–benefit. A net reduction in pain (judged as one unit on the WOMAC pain index) was achieved at a favourably low ceiling valuation (at the 95% level) of between £580 and £740. A group mean reduction in pain of 0.89 units was estimated with a net saving of between £135 and £175 per patient per annum, even after allowing for the marginal costs of providing the water exercise programme.

Ancillary analysis on the basis of those who complied with their treatment estimated a mean cost saving (excluding marginal costs of delivering the water exercise programme) of £493 (95% CI £80 to £907) per patient per annum for the treatment group.

Delivery of water exercise on a population basis

Public swimming pools provide an appropriate venue with the capacity to deliver 'exercise on prescription' on a population basis to older patients with lower limb OA. In general, exercising in water was beneficial in reducing the pain of weight-bearing activity and allowing greater ease of movement about the major lower limb joints. The activities were well tolerated and the water exercise programme did not appear to expose patients to much risk. Thus, from the perspectives of acceptability and tolerability, water exercise is a viable treatment alternative.

In contrast, treatment accessibility, in terms of transport to and from the venue, getting into and out of the building, getting into and out of the pool and costs, collectively, was far from optimal. In addition, there were other environmental factors militating against compliance, chief of these being the water temperature. Further research is needed to develop ways to enhance access and the exercise environment for older people.

Ability to access the water exercise sessions was not included in the inclusion criteria. The water exercise was designed to be delivered in community swimming pools and each participant was allocated to their preferred venue and time from those available in the trial (in most cases this was the venue nearest to their home). Community transport was used by some participants, although most drove or were driven to their exercise sessions and only a small proportion walked (*Table 37*). Once groups had formed, some participants were able to make arrangements to travel to sessions in one car. Inability to access the water exercise sessions may in part have contributed to the loss of participants that occurred between initial expression of interest in participation and baseline testing (the point at which randomisation took place), although at this stage participants did not know to which group they would be allocated.

Present understanding of the mechanobiology of synovial joints and the part that dynamic exercise plays in initiating or mitigating the effects of OA is not adequate to allow water exercise programmes to be prescribed based on sound evidence. More detailed research on the specific effects of dynamic exercise on the major synovial joints of the lower limb is warranted to allow better selection criteria to be devised and exercise to be prescribed tailored to patient need.

Sustainable treatment requires sustainable delivery. The research reported here questions whether present levels of support and training are adequate to meet this need. There is a perceived funding gap, whereby neither the potential service provider nor the patients were willing, or able, to meet the marginal cost of providing this service. The high turnover of facilitators also indicated that there may be issues relating to workforce

development and career progression for suitable exercise leaders.

Those who did not comply with their exercise treatment had poorer scores on WOMAC pain and SF-36 pain, social function and vitality dimensions, but it was not possible to develop a useful linear regression selection model on the basis of the baseline data recorded in this project.

Implications for healthcare

Judged on the basis of a reduction in pain over 1 year of intervention, water exercise is an appropriate and effective form of treatment for lower limb OA. Similar benefits were found in this relatively long-term intervention as have been reported for pharmacological interventions, including NSAIDs and glucosamine/chondroitin, without the complicating side-effects of the former. There was no evidence either in favour of or against exercise in water compared with other forms of physical activity or strengthening programmes for lower limb OA. Effect sizes were small but, since the intervention can be delivered, at least potentially, on a population basis, the benefit to the health service could be valuable. Furthermore, such conservative management could forestall the need for joint replacement or the loss of independence, although this has not been tested in a prospective trial.

Limitations of the research

Complex, pragmatic research such as that undertaken here inevitably has its limitations. This section reports some of the limitations, self-inflicted or otherwise, encountered in the course of this research, so that others may benefit from this experience and judge the findings fairly in the knowledge of these limitations.

Population and sampling

Significant problems arose in obtaining a truly representative sample of the population of interest. The main difficulty was that only 16 of 67 general practices contacted felt able to support the research. This restricted the researchers to a pool representing only about 24% of the target population. As a result, recruitment was more challenging and limited than it otherwise might have been. To reach target numbers of suitable patients, an additional group of patients had to be recruited through an article in the local newspaper. Thus, the possibility of a selection bias in the research sample cannot be ruled out. Notwithstanding this limitation, the recruitment target was achieved and the randomisation provided two groups well matched on demographic variables, outcome measures and disease distribution.

Co-morbidity, disease status and access to treatment

Owing to the pragmatic nature of the research, inclusion criteria were kept deliberately broad. With the benefit of hindsight, several patients (~15%) were included in the water exercise group for whom this mode of treatment was not a viable option. Co-morbidity in this age group may limit accessibility of group-based water exercise. Approximately 50% of those who dropped out of the study (41 out of 83) did so either because of significant other illness, either personal or of a family member who they had to look after, or because they did not have transport. Sustained compliance with treatment because of illness was a significant problem for many of the exercise group. Overall, only 38% of the water exercise group achieved a compliance of 70% or greater (i.e. attended 59 or more of the 84 'prescribed' sessions in the one year of the intervention).

It is also possible that a number of those included with more severe disease may gain little from water exercise, or any other form of exercise, because the condition of the joint had deteriorated too much. Similarly, those who have had a joint replaced may not derive further benefit from an exercise programme.

Site of disease

The rationale for the benefit of exercise applies equally well to both the knee and the hip joints. However, the development and distribution of the disease within the joint differ markedly. Mixing of both hip and knee disease, those with previous joint replacement and those without, male and female, and different types of disease adds to the heterogeneity of the sample and, therefore, reduces the power to detect a difference between groups.

Delivery of the exercise programme

The generic nature of the sample dictated the generic nature of the activity programme that could be prescribed. Given a gender and morbidity mix and an age range of 60–90 years, it was not feasible to tailor the delivery down to the specific needs of each individual and to progress everyone at the optimum level for their ability to respond. To a certain extent, each individual was

able to adapt their effort to suit their needs, but within limits. Overall, this would have limited the population 'dose' of water exercise. The lack of significant improvement in all four strength measures may be an indication that the water exercise programme could have been more progressive.

Facilitator turnover was another factor that limited delivery. There is little doubt that the group dynamic is important in the type of intervention evaluated here. This is threatened by the constant changing of the group leader. The sustained delivery of such an intervention, while attractive from a public health perspective, poses significant challenges. On the basis of the experience and the data collected during this research, the most important challenges are the quality of and access to the water exercise venue, training and rewarding of suitable water exercise leaders, and funding.

Maintenance of physical activity and contamination

Physical activity is a very difficult treatment to control in an RCT. Although the authors are confident about the precision of the measurements of treatment compliance in the water exercise group, since this was measured directly, they cannot be confident about the physical activity undertaken by the control group. Telephone interviews, focus group feedback and evaluation questionnaires showed that 'contamination' was a problem, in this respect. The reverse contamination was also a problem in that a large proportion of the water exercise group either did not take any exercise or dropped out after only a few sessions.

Background information on prevalence

Surprising as it may seem to include as a limitation, it was not possible to obtain reliable local statistics on the prevalence of OA, despite its undoubted high burden on the NHS. This limited the researchers' ability to draw inferences about the representation of the sample or to generalise about the implications for the wider population.

Cost-effectiveness

Costs varied widely among individuals. Similarly, the outcome measures, particularly the unidimensional quality of life measures, showed wide variability across time with this population sample. This limited the inferences that could be drawn from the health economic evaluation. The main sources of difference were related to healthcare costs associated with joint replacement or visits to the GP, costs associated with lost work and costs associated with delivering the water exercise intervention. Joint replacement and loss of work were rare but high-cost events. Thus, cost outcome, and hence cost-effectiveness, would be highly sensitive to the numbers of these 'events' included in the respective population samples.

Full economic evaluation would involve projecting costs and benefits beyond the intervention period, with appropriate discounting to derive estimates of lifetime cost and effect differences. This analysis could not be performed here, for two reasons. First, no trends could be established from the baseline, 6-month, 12-month and 18-month data sets collected here. Second, any benefit would be contingent on sustaining the treatment beyond the specific intervention period. The drop-off in adherence observed between 12 and 18 months would appear to negate this assumption. Long-term data on costs and disease-specific outcomes in this patient population are needed.

Recommendations for research

Research on the nature of the work carried out here resolves some questions and researchers can gain a greater insight into hitherto under-researched problems that could guide future research. On the basis of this experience, six areas were identified where research would be valuable. These are presented in priority order below.

Promoting wider and more effective collaboration

Although the present study achieved a reasonably large sample and maintained the intervention over the 1-year period, the control and monitoring of such a large cohort in a single health region presented a challenge. This challenge arose, not because the research per se was under-resourced (although resourcing is an underlying issue), but because of the pragmatic nature of the research. Evaluation was conducted in circumstances as they existed in general practice and the treatment took place in community settings. More research of this nature is required, but it would be better if this could be multicentre and across multiple regions. A good example of such a trial is the Diabetes Prevention Program conducted in the USA.[123] This study involved 27 centres, recruited 3234 participants and had a mean follow-up period of 2.8 years. The main advantages of multiple centres are that delivery is shared across many sites, but the individual research burden on any one community

and primary care setting is reduced, and that the participants are selected from a larger, potentially more representative, pool and delivery is balanced across the different centres, making recruitment easier and generalisation of the findings more reliable. The downside is that coordination and quality-control issues become more complex. Research in this area could be improved if the commissioning process stipulated and facilitated such collaboration, for example, by using a two-stage process; first, to assemble the expert group and potential collaborating centres, and then to design and deliver the trial.

Recruitment of patients and practices

Recruitment of both patients and supporting practices in this study was challenging and costly, yet it is clear that if research is to develop the best evidence on how to change and maintain behaviour to promote or preserve better health, researchers must be able to obtain representative samples of participants of adequate size from the communities in which they live. Pre-emptive healthcare, ideally, should occur before serious health problems arise. This means that many of those who would benefit from behaviour change are not yet in receipt of treatment, which may pose a problem for recruitment. However, almost all residents of the UK are registered with a GP. This means, in principle, that the general practice database has a direct connection to almost everyone in the whole population. This, and the primary responsibility of general practice for healthcare, would seem to indicate recruitment through general practice as the obvious choice for access to suitable population samples.

The research undertaken here adopted this approach and found it wanting. Thus, better and more cost-effective mechanisms need to be developed to obtain representative samples for public health interventions. The research question (and, presumably, resource issue) that needs to be addressed is how best can general practice be supported to facilitate access to participants for research trials in healthcare? One option is to develop regional networks of GPs appropriately resourced to provide this administrative support. Sixteen out of 67 practices contacted in this project were able to support the research to varying degrees. A further question arises, therefore, as to how practices in the network should be selected. Care would need to be taken to ensure that networks were constituted in such a way as to be representative both of general practice and of the population(s) of interest. Facilitating access to such population samples has the added advantage that it might foster greater public involvement in the evolution of healthcare provision. This access must, however, also be cognisant of the threat to public health research through the difficulty of obtaining data because of the need to protect individual identity and the right to privacy.

Capacity: infrastructure and workforce development

The more proactive approach to health maintenance embodied in a funded programme of physical activity, as with any other healthcare programme, requires resources to deliver. These include infrastructure and a skilled, motivated workforce. Research should be commissioned to assess these capacities and the potential extent to which healthcare may be supported in this way. This should probably be extended to cover other forms of physical activity. At the same time, this research should consider how to strengthen links, coordination of strategy and collaboration between academia, public health deliverers and other potential providers.

Selection criteria and specificity of exercise

Patients with higher scores at baseline appeared, as a subgroup, to derive greater benefit from regular participation in water exercise. Paradoxically, some patients with higher pain scores derived no benefit or got worse. This implies that the selection criteria for suitable patients and/or the specificity of exercise prescription were not optimal. The biomechanical factors (in addition to increased weight or BMI, which increase mechanical loading) that are important in the progression of OA are:

- joint injury or deformity or asymmetry
- habitual activity, current or historical (e.g. certain sports or occupations)
- muscle weakness.

Alteration in the mechanical environment of the joint brought about by injury, deformity or asymmetry, which may involve laxity, malalignment, limb length difference or alterations in proprioception, often results in adverse changes to joint load distribution that can cause disease. In turn, the load distribution may be altered by the development of pain as disease progresses. Activities that place high, repetitious strain on joints, especially in situations where the supporting structures (muscles, tendons and ligaments) are also fatigued, are known to increase the risk of developing OA in those joints.

Quadriceps muscle weakness is common in patients with knee OA and increase in quadriceps strength has been predicted to result in a reduced risk of developing OA.[18] It was not feasible to consider all of these factors and to prescribe a tailored, progressive exercise programme for each individual in the research reported here. Indeed, the state of understanding of the specificity of exercise for the different subtypes of knee and hip joint disease is poor. Despite this limitation, a significant number of participants in the water exercise group benefited from their treatment and, overall, perceived pain was reduced. This should encourage further research aimed at developing a better understanding of the types of exercise that will work for the different biomechanical subtypes of knee and hip OA. It is also possible that this research would indicate certain disorders where exercise would be contraindicated, thus improving selection criteria.

Recent promising research has shown that dynamic mechanical loading can induce beneficial changes in chondrocyte cellular matrices *in vitro*.[124] To date, little attempt has been made to translate these mechanical loads into loads that might produce similar beneficial physiological changes to cartilage *in vivo*. It is plausible to suggest that this might be a fruitful avenue for research, particularly in the early stages of the development of OA, but probably not in the later stages, when the structural integrity of the cartilage has been destroyed.

Sustainability

Taking one's exercise medicine requires a lifetime commitment. Access and environmental issues were identified as being at least as important as programme content in this research. More research needs to be done to understand these issues from both a provider and a participant perspective. This analysis should probably include the marginal costs of delivery and willingness to pay for exercise.

Cost-effectiveness

The information base on cost-effectiveness of management approaches for lower limb OA identified in this research was poor. This made it difficult to compare the cost-effectiveness of water exercise treatment with other treatments, even those for the same condition. If evidence is to drive decisions then more longitudinal data are needed on the societal costs of the different approaches to the management of OA and longer term trends in outcome measures (costs and effects). The body of evidence relating to conservative or public health interventions such as that evaluated here is particularly sparse. In order to allocate funding in the most cost-effective manner between public health interventions and other forms of healthcare it is vital that comparative analytical studies are performed. Cost comparisons are complicated by the mix of high-frequency, low-cost items and restricted frequency, high-cost items in the treatment mix. More consideration needs to be given to future designs to ensure that research evaluations will have the statistical power to detect expected cost differences, and more good quality cost data on the various treatments are required.

Effect comparisons are complicated by the lack of a unifying comparator across all treatments. At the same time, there is an opportunity to generate evidence directly from public health practice if evaluation became an explicit part of delivery. Such an opportunity can only be realised if improvements can be made to the design and implementation of primary care data systems and the extraction and dissemination of relevant information for research and evaluation purposes. Data records, as well as recording information on patient demographics and treatments, would need to compile evidence on effectiveness. It is likely that the latter would need to be disease specific and would require consensus on concise but reliable measures of effect. With respect to lower limb OA, the WOMAC index appears to offer a tool with adequate reliability and sensitivity to form the basis of an evaluation tool for this group of disorders and treatments. Suitable tools for other areas could be developed through action research involving groups assembled from relevant experts and patients, starting with the highest priority areas for the health service.

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Contribution of authors

All authors were involved in the design of the study and contributed to the writing of the report. S Matthes Edwards (Lecturer, Health Related Physical Activity) was responsible for recruitment, overseeing the delivery of the exercise intervention and monitoring adherence. R Davey (Reader, Physical Activity and Public Health) developed the water exercise intervention, trained the exercise facilitators and negotiated the venues. T Cochrane (Professor, Sport and Exercise Science) was responsible for randomisation, screening of all data, statistical analysis and interpretation of the data and drafted the main body of the final report. T Cochrane will act as guarantor for the study.

Other contributors

A McConnell and A Bloomer (Technicians, Sport Science Support) were responsible for the physical function assessments. S Lomas (Research administrator) administered the questionnaires, including the semi-structured telephone interviews with the control subjects, and oversaw the maintenance of the study database.

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Appendix 1

Patient information sheet and consent form

PATIENT INFORMATION SHEET

Clinical trial for patients with lower limb arthritis

What is the purpose of this study?
Arthritis of the knee(s) and/or hip(s) is common in older people and often causes joint pain and stiffness. This may restrict activities such as walking and shopping. Our study aims to find out whether regular participation in exercise in water can help reduce joint pain and stiffness and improve quality of life.

What will be involved if I agree to take part in the study?
If you agree to participate in this study, you will be randomly allocated to one of two groups. Patients in one group will be asked to take part in a 12 month, community-based, water exercise programme. The exercise programme will be run by specialist instructors and exercise will be tailored to each individual. Exercise classes will consist of a gentle warm-up (10 to 15 minutes), muscle and joint conditioning (30 to 40 minutes) and flexibility exercises (10 to 15 minutes). Classes will last for about one hour and will take place twice a week.

Patients in the other group will not participate in the water-exercise but will have their arthritis and health monitored over the same period. They will also be contacted by telephone every 3 months to find out how they have been affected by their arthritis and whether there have been any changes in their circumstances. Those who have no access to a telephone will be visited by a researcher to find out how they have been affected by their arthritis and whether there have been any changes in their circumstances.

How will I know which group I am in?
It is an important aspect of the study that patients will not be able to pre-select which group they are in. Allocation to groups will be done randomly by an independent researcher. If you agree to participate in the study you will also agree to the group allocation that you are given.

What other information will be collected in the study?
Patients in both groups will carry out a number of simple tests at the start of the study and again at 12 and 18 months. These tests will include walking a short distance of 8 feet, going up and down a set of four stairs and measuring the strength of your legs. This will take about 30 minutes on each occasion. In addition, you will be asked to complete a health questionnaire at the start of the study and at 6, 12 and 18 months.

What information will the study yield?
At the end of the study we will compare the patients in both groups to find out whether water exercise has made a difference in terms of pain, flexibility and general function.

Where will the study take place?
The testing will be done in the Exercise Physiology Laboratory, Sport, Health & Exercise, Brindley Building, Leek Road Campus, Staffordshire University, at the beginning of the study, and at 12 and 18 months as described above.

The water exercise programme will take place at a local swimming pool and sessions will be free of charge to you. Transport will be arranged for those who are unable to get there by car or public transport. Patients will be reimbursed their travel costs if they come by public transport or use their own motor cars.

Can I withdraw from the study at any time?
You are under no obligation to take part in this study and you may withdraw at any time.

Will the information obtained in the study be confidential?
All experimental data and information will be confidential and will be used only for the purpose of this study. No names will be mentioned in any reports and care will be taken so that individuals cannot be identified from details in reports of the study.

Can I ask further questions about the study?
Yes. This information sheet is intended to give you information about why this study is being done and what commitment will be asked of you. If you have any further questions then please ask the researchers who will answer any queries you have. Alternatively, you can call the Help Line telephone number: 01782 295986.

What if I wish to complain about the way in which this study has been conducted?
If you have any cause to complain about any aspect of the way in which you have been approached or treated during the course of this study, please contact the project co-ordinator:

Dr Rachel Davey,
Sport, Health & Exercise,
Staffordshire University,
Leek Road,
Stoke-On-Trent, ST4 2DF
Tel: (01782) 295986

RESEARCH CONSENT FORM	
TITLE OF PROJECT: Clinical trial for patients with lower limb arthritis	
The patient should complete the whole of this sheet himself/herself	**Please circle either Yes or No**
Have you read the Patient Information Sheet?	YES/NO
Have you had an opportunity to ask questions and discuss the study?	YES/NO
Have you received satisfactory answers to all of your questions?	YES/NO
Have you received enough information about the study?	YES/NO
Do you agree that appropriately qualified members of the NHS staff may confidentially review your medical records?	YES/NO
Do you understand that you are free to withdraw from the study: • at any time • without having to give a reason for withdrawing • and without affecting your future medical care?	YES/NO
Do you agree to take part in this study?	YES/NO
Signed ..... Date ..... (NAME IN CAPITALS)	
Signature of Witness ..... (NAME IN CAPITALS)	

Appendix 2

Initial participant screening questionnaire

OSTEOARTHRITIS QUESTIONNAIRE

— — — — — —

Please tick the appropriate box, please give an answer to every question. Your name and address do not appear on this questionnaire, all information is confidential.

	YES	NO
1. Has your doctor ever told you that you have osteoarthritis of the knee and (or) hip?	☐	☐
2. Do you have pain around the knee joint on most days of the month?	☐	☐
3. Is your knee joint stiff first thing in the morning or after a period of sitting?	☐	☐
4. Are you currently receiving physiotherapy treatment or hydro-therapy?	☐	☐
5. Are you currently participating in any regular exercise class?	☐	☐
If so, please describe the type of exercise _____		
How many times do you usually exercise in a week _____		
6. Are you on the waiting list for a knee/hip joint replacement?	☐	☐
If "Yes", approximately how many months until your operation _____		
7. Are you on the waiting list for any other surgery?	☐	☐
If "Yes", approximately how many months until your operation _____		
8. Have you any of the following;		
(a) Incontinence	☐	☐
(b) Open wounds	☐	☐
(c) Skin diseases	☐	☐
(d) Paralysis	☐	☐

	YES	NO
9. Have you read the enclosed information about our research project?	☐	☐
10. Would you like to take part in the study?	☐	☐

If you would like to speak to someone about the project, please contact Dr Rachel Davey, Tel: 01782 295986.

Thank you for completing this questionnaire.
Please return in the envelope provided which does *not* require a stamp.

Appendix 3

Control semi-structured telephone interview questionnaire

ID Code _____

STRUCTURED TELEPHONE FOLLOW-UP (CONTROL GROUP)

Subject's name [ ] **Date [/ /]**

Researcher introduces herself/himself and explains that they wish to ask some follow-up questions relating to the water exercise and arthritis study.

1. Have you visited your doctor in the last three months specifically relating to your arthritis?

No ☐

Yes ☐ If yes, how many times _____?

2. Have you visited your doctor in the last 3 months for reasons other than your arthritis?

No ☐

Yes ☐ If yes, how many times _____?

3. Have you changed your medication in the last 3 months?

No ☐

Yes ☐ If yes, please record details below

4. Have you received physiotherapy or other therapy for your arthritis in the last 3 months?

No ☐

Yes ☐ If yes, please record details below

5. Have you had any surgery or been in hospital in the last 3 months?

No ☐

Yes ☐ If yes, please record details below

6. Have you started any exercise in the last 3 months?

No ☐

Yes ☐ If yes, please record details below

7. Are there any other circumstances relating to your arthritis or your general health in the last 3 months that you would like to report?

No ☐

Yes ☐ If yes, please record details below

Researcher thanks subject for their help and asks if it will be OK to contact again in 3 months time or, at end of study, thanks them for their participation and informs them when results are likely to be available.

Appendix 4

Programme evaluation questionnaires

CONTROL GROUP

CONFIDENTIAL

Staffordshire
UNIVERSITY

PROJECT ROAR

RESEARCH INTO OSTEOARTHRITIS RELIEF

STOKE-ON-TRENT

PROGRAMME EVALUATION

Now that you have completed the full 18 months of our programme, we would like to obtain some feedback and give you the opportunity to comment on various aspects of the project.

As always your name will not appear on any of the pages of the questionnaire and your replies will be confidential.

Thank you

PARTICIPATION

1. Please list the main reason(s) why you volunteered to take part in our research programme.

_____

_____

2. Of the total number of eligible people in North Staffordshire who were contacted to take part in our programme, only about a third have participated in the project even though there was no cost involved. It is important for us to find out the reasons why only a few people volunteered to participate and to find ways of encouraging older people to become more active.
From your experience of the people you know, which of the following factors do you think would prevent people from joining us? (only tick the boxes that you feel are appropriate).

(a) Too old to benefit from exercise ☐

(b) No transport to get to the classes ☐

(c) Too embarrassed ☐

(d) Afraid to go alone without friends/relatives to go with them ☐

(e) The venues were not suitable ☐

(f) The days and times were inconvenient ☐

(g) Too ill ☐

(h) Too disabled ☐

(i) Did not want to socialise ☐

(j) The weather is always bad ☐

(k) Too many other commitments ☐

(l) Don't believe exercise is good for you ☐

Have you any other suggestions as to why people might not participate?

_____

_____

3. In what ways might we encourage more people to participate?

_____

_____

4. Are there any other health-related services you would like to see provided locally for older people?

(Please list below)

_____

_____

5. We would like to encourage people to take more exercise independently, on their own in addition to the group exercise classes. What other activities e.g. walking, bowling, swimming, tea-dancing etc. would you consider doing on your own, or with a friend/relative?

_____

_____

6. Since enrolling on the OA Project, have you started any new physical activity(ies)/exercise classes?

Yes ☐

No ☐

If you answered "Yes", please name the activity(ies)/exercises, when started and number of times per week.

_____

_____

6a. Since your last test 6 months ago, have you started any new physical activity(ies) or exercise classes?

Yes ☐

No ☐

If you answered "Yes", please name the activity(ies)/exercises, when started and number of times per week.

_____

_____

7. If the current programme were to continue, would you wish to participate in the exercise programme?

Yes ☐

No ☐

If you answered "No", please give your reasons:

_____

_____

8. Would you be interested in a different physical activity, or at another venue not offered in the current programme?

Yes ☐

No ☐

If Yes, please give details of new activity or venue _____

_____

_____

If No, please give your reasons _____

_____

_____

9. Have you any other comments to make about exercise in general or "Project Roar" in particular?

_____

_____

THANK YOU FOR FILLING IN THIS QUESTIONNAIRE AND FOR PARTICIPATING IN OUR PROGRAMME.

Please return your completed questionnaire in the envelope provided (which does not need a stamp)

WATER EXERCISE GROUP

CONFIDENTIAL

Staffordshire
UNIVERSITY

PROJECT ROAR

RESEARCH INTO OSTEOARTHRITIS RELIEF

STOKE-ON-TRENT

PROGRAMME EVALUATION

Now that you have completed the full 18 months of our programme, we would like to obtain some feedback and give you the opportunity to comment on various aspects of the project

As always your name will not appear on any of the pages of the questionnaire and your replies will be confidential.

Thank you

PARTICIPATION

1. Please list the main reason(s) why you volunteered to take part in our exercise programme.

_____

_____

2. Have you had any difficulties getting to the classes?

Yes ☐

No ☐

If you answered "Yes" to this question, please state what has caused you difficulty.

_____

_____

3. How do you usually get to the exercise class? (Please tick appropriate box)

Car ☐

Bus ☐

Taxi ☐

Bicycle ☐

Walk ☐

Other ☐

Please specify _____

_____

4. Of the total number of eligible people in North Staffordshire who were contacted to take part in our programme, only about a third have participated in the project even though there was no cost involved. It is important for us to find out the reasons why only a few people volunteered to participate and to find ways of encouraging older people to become more active.
From your experience of the people you know, which of the following factors do you think would prevent people from joining us? (only tick the boxes that you feel are appropriate).

(a) Too old to benefit from exercise ☐

(b) No transport to get to the classes ☐

(c) Too embarrassed ☐

(d) Afraid to go alone without friends/relatives to go with them ☐

(e) The venues were not suitable ☐

(f) The days and times were inconvenient ☐

(g) Too ill ☐

(h) Too disabled ☐

(i) Did not want to socialise ☐

(j) The weather is always bad ☐

(k) Too many other commitments ☐

(l) Don't believe exercise is good for you ☐

Have you any other suggestions as to why people might not come to the sessions?

_____

_____

5. In what ways might we encourage more people to participate?

_____

_____

THE EXERCISE CLASS

6. Which aspects of the exercise class did you enjoy the most?

Try to indicate your level of enjoyment using numbers, 0,1,2,3,4,5 where the 0 = least enjoyable, and the number 5 = most enjoyable.
(please put a circle around the appropriate number)

	Least enjoyable			**Most enjoyable**		
(a) The exercises using floats	0	1	2	3	4	5
(b) The strength and range of movement exercises	0	1	2	3	4	5
(c) Group activities/exercises	0	1	2	3	4	5
(d) The relaxation	0	1	2	3	4	5
(e) The social aspects	0	1	2	3	4	5

7. Are there any other health-related services you would like to see provided locally for older people? (Please list below)

_____

_____

8. For a successful programme, it is obviously essential to have a person leading the class who has the right type of personality.
What personal qualities should we look for if we wish to train other people to take exercise classes for older adults?
Please list below those attributes which you feel are most important.

_____

_____

9. In what way do you feel you have benefited from participating in the exercise programme? Please list below.

_____

_____

10. Are there any factors that you feel have been made worse by participating in the exercise programme.

Yes ☐

No ☐

If you answered "Yes", please list the things which have been made worse by exercise.

_____

_____

11. We would like to encourage people to take more exercise independently, on their own in addition to the group exercise classes. What other activities e.g. walking, bowling, swimming, tea-dancing etc. would you consider doing on your own, or with a friend/relative?

_____

_____

12. Since beginning the exercise programme, have you started any new physical activity(ies)/or exercise classes?

Yes ☐

No ☐

If you answered "Yes", please name the activity(ies)/exercises, when started, and the number of times each week.

_____

_____

12a. Since your last test 6 months ago, have you started any new physical activity(ies)/exercise classes?

Yes ☐

No ☐

If you answered "Yes", please name the activity(ies)/exercises, when started and number of times each week.

_____

_____

13. If the current exercise programme was discontinued, would you continue taking regular exercise by joining a different class elsewhere, or beginning a new physical activity on your own?

Yes ☐

No ☐

If you answered "No", please give your reasons:

_____

_____

14. Have you any other comments to make about exercise in general or "Project Roar" in particular?

_____

_____

THANK YOU FOR FILLING IN THIS QUESTIONNAIRE AND FOR PARTICIPATING IN OUR PROGRAMME.

Please return your completed questionnaire in the envelope provided (which does not need a stamp)

Appendix 5

Costs and consequences questionnaire

CONFIDENTIAL

Staffordshire
UNIVERSITY

PROJECT ROAR

RESEARCH INTO OSTEOARTHRITIS RELIEF

STOKE-ON-TRENT

COSTS AND CONSEQUENCES OF YOUR ARTHRITIS

The following questions concern the costs and consequences of your arthritis and its treatment. Please note that individual questions may relate to different time periods. Please read each question carefully and answer the question for the time period to which it refers.

Impact on Work

1. Are you still in regular work? (circle one)

Yes	1	Answer part (b) below
No	2	Answer part (a) below; then go to Question 2

(a) **If No**, is this because of your arthritis?

Yes	1	
No	2	Go to question 2

(b) **If Yes**, have you had any of the following consequences <u>because of your arthritis or your participation in this research project?</u> (please tick all options that apply and provide additional information requested)

Time off work (not including holiday) in the last month ☐ Number of days _____

Worked less hours (not including holiday) in the last month ☐ How many hours less per week? _____

Been restricted in what you can do at work over the last month ☐ In what way? _____

Approximately how many hours do you work per week? _____

What is your approximate rate of pay/hour for this work? Rate/Hour £ _____

Hip or Knee Replacement

2. **Before** starting on the present research project, had you already had (please tick all options that apply)

A right hip replacement ☐ A left hip replacement ☐

A right knee replacement ☐ A left knee replacement ☐ ?

3. **Since** starting on the present research project, have you had (please tick all options that apply)

A right hip replacement ☐ A left hip replacement ☐

A right knee replacement ☐ A left knee replacement ☐ ?

4. **Since** starting on the present research project, have you been placed on a waiting list for (please tick all options that apply)

A right hip replacement ☐ A left hip replacement ☐

A right knee replacement ☐ A left knee replacement ☐ ?

Medications

5. In the past week, please indicate what, and what dosage (if known) of, medications you took under the following categories because of your arthritis.

	Medication	**Dosage** No of Tablets	Strength (if known)
Prescribed medication for your arthritis, associated pain or depression			
Over the counter medicines			
Complementary medicines or supplements			
Other remedies not mentioned above			

6. In the last 12 months, how would you say your use of medications for your arthritis has changed? (tick option that applies)

Using much more	Using somewhat more	Using about the same	Using somewhat less	Using much less
☐	☐	☐	☐	☐

Hospital Usage

7. In the past year, please indicate which of the following hospital services you have needed to access because of your arthritis.

	Tick only options that apply	No. of visits	Total length of stays or visits	Unit Days or Hours (*delete as appropriate*)
In-patient	☐	_____	_____	days/hrs
Day patient	☐	_____	_____	days/hrs
Outpatient	☐	_____	_____	days/hrs
Accident & Emergency	☐	_____	_____	days/hrs

Family Health Services

8. In the past 2 weeks, how many visits have you made to your GP surgery because of your arthritis? _____

9. In the past 2 weeks, how many home visits have you had from your GP because of your arthritis? _____

Community Services

10. In the past month, please indicate which and how many times you have accessed the following services because of your arthritis. (Tick options that apply and provide the additional information requested)

	Tick **only** options that apply	No. of visits in the past month	Costs to you per visit (if any)
District nurse	☐	_____	_____
Health visitor	☐	_____	_____
Home help/carer	☐	_____	_____
Private domestic help	☐	_____	_____
Meals on wheels	☐	_____	_____
Social worker	☐	_____	_____
Luncheon club	☐	_____	_____
Day centre	☐	_____	_____
Helper from a voluntary organisation	☐	_____	_____

Paramedical Services

11. In the past 3 months, please indicate which and how many times you have accessed the following services because of your arthritis. (Tick options that apply and provide the additional information requested)

	Tick **only** options that apply	No. of visits in past 3 months	Costs to you per visit (if any)
Primary care nurse	☐	_____	_____
Specialist nurse	☐	_____	_____
Physiotherapist	☐	_____	_____
Occupational therapist	☐	_____	_____
Complementary therapist	☐	_____	_____
Other (please specify below)	☐	_____	_____

_____

Aids and Adaptations

12. In the past year, have you purchased or been prescribed aids to help with your arthritis? (Such as bath/toilet aids, walking sticks, etc.) (circle one answer)

Yes 1

No 2

If Yes, please indicate what _____

_____

13. In the past year, have you made adaptations to your home or lifestyle because of your arthritis? (Such as stopping paid work, taking taxis more frequently, installing chair lifts, etc.) (circle one answer)

Yes 1

No 2

If Yes, please indicate what adaptation(s) you have made

_____

Personal and friends or family costs associated with your arthritis

14. Do you pay prescription charges? (circle one answer)

Yes 1

No 2

15. Do you incur personal costs (*not including travel*) associated with hospital visits? (circle one answer)

Yes 1

No 2

If Yes, please estimate how much it costs you for each visit £_____

16. Do you incur travel costs associated with hospital visits? (mileage, public transport, etc.) (circle one answer)

Yes 1

No 2

If Yes, please estimate how much it costs for each return visit £_____. If using the car, please give approximate return mileage _____.

17. Do your friends or family incur costs *other than travel* associated with accompanying you on hospital visits? (Time off work, car parking fees, etc.) (circle one answer)

Yes 1

No 2

If Yes, please estimate what these costs are _____

_____

and estimated cost per visit £_____

18. Do your friends or family incur **travel costs** associated with accompanying you on hospital visits? (circle one answer)

Yes 1

No 2

If Yes, please estimate how much it costs for each visit £_____. If using the car, please give appropriate return mileage _____.

19. If there are other costs or consequences of your arthritis or if you have any comments you would like to share with us regarding any aspect of the Osteoarthritis Research Project please provide them in the space below.

_____

_____

Please turn over to complete the instructions on the final page.

THANK YOU FOR FILLING IN THIS QUESTIONNAIRE AND FOR PARTICIPATING IN OUR PROGRAMME.

Please return your completed questionnaire in the envelope provided (which does not need a stamp)

Appendix 6

Unit costs of items included in the economic evaluation

TABLE 38 *Costs of prescribed medications*

Code	Prescribed medicines (BNF, March 2003 prices)	Dose	No. in pack	Cost (£)
D01	**1: Gastrointestinal**			
D01.1.1.1	Maalox®		50 ml	2.38
D01.1.2.1	Gaviscon®		60	2.25
D01.1.2.2	Peptac®	10–20 ml	500 ml	2.16
D01.2.1	Mebeverine (np)	135 mg	20	1.54
D01.3.1.1	Cimetidine (np)	400 mg	60	5.58
D01.3.1.2	Ranitidine (np)	150 mg	60	8.15
D01.3.5.1A	Lansoprazole	15 mg	28	12.98
D01.3.5.1B	Lansoprazole	30 mg	28	23.75
D01.3.5.2	Losec®	10 mg	28	18.91
D01.3.5.3A	Omeprazole (np)	10 mg	28	18.91
D01.3.5.3B	Omeprazole (np)	20 mg	28	28.56
D01.3.5.4A	Pantoprazole	20 mg	28	12.88
D01.3.5.4B	Pantoprazole	40 mg	28	23.65
D01.3.5.5A	Rabeprazole	10 mg	28	12.43
D01.3.5.5B	Rabeprazole	20 mg	28	22.75
D01.6.2.1	Bisacodyl (np)	5 mg	20	0.59
D01.6.2.2	Manavec®		400 g	5.76
D01.6.2.3	Senna (np)	7.5 mg	20	0.29
D01.6.2.4	Sodium picosulphate elixir	5 mg/5 ml	100 ml	1.85
D01.6.4.1	Lactulose (np)		500 ml	2.43
D02	**2: Cardiovascular**			
D02.1.1.1A	Digoxin (np)	125 μg	20	0.42
D02.1.1.1B	Digoxin (np)	250 μg	20	0.42
D02.12.1	Atorvastatin (Lipitor®)	10 mg	28	18.03
D02.12.2	Pravastatin	40 mg	28	29.69
D02.12.3A	Simvastatin	20 mg	28	29.69
D02.12.3B	Simvastatin	40 mg	28	29.69
D02.2.1.1A	Bendrofluazide (np)	2.5 mg	20	0.53
D02.2.1.1B	Bendrofluazide (np)	5 mg	20	0.52
D02.2.2.1	Frusemide (np)	500 mg	20	6.44
D02.2.4.1	Co-amilofruse 5/40 (np)	2.5/20 mg	28	4.53
D02.3.2.1	Quinidine sulphate (np)	200 mg	100	32.95
D02.4.1	Atenolol (np)	50 mg	28	0.85
D02.4.2	Bisoprolol (np)	5 mg	28	8.30
D02.4.3	Monocor®	5 mg	28	8.56
D02.4.4A	Tenoretic®	100/25 mg	28	8.12
D02.4.4B	Tenormin®	50 mg	28	5.11
D02.5.4.1	Prazosin (np)	500 μg	56	2.09
D02.5.5.1.1	Coversyl®	4 mg	30	10.31
D02.5.5.1.2A	Enalapril (np)	10 mg	28	5.19
D02.5.5.1.2B	Enalapril (np)	20 mg	28	6.13
D02.5.5.1.3A	Ramipril	2.5 mg	28	7.51
D02.5.5.1.3B	Ramipril	10 mg	28	13.00
D02.5.5.2.1A	Candesartan	2 mg	7	2.99
D02.5.5.2.1B	Candesartan	8 mg	28	14.95
D02.5.5.2.2	Losartan	50 mg	28	17.23
D02.5.5.2.3	Valsartan	160 mg	7	4.92

continued

TABLE 38 *Costs of prescribed medications (cont'd)*

Code	Prescribed medicines (BNF, March 2003 prices)	Dose	No. in pack	Cost (£)
D02.6.1.1A	Glyceryl trinitrate (np)	5 mg/ml^{-1}	5 ml	6.49
D02.6.1.1B	Glyceryl trinitrate (np)	5 mg/ml^{-1}	10 ml	12.98
D02.6.1.2	Isosorbide mononitrate (np)	20 mg	56	2.10
D02.6.2.1A	Angitil SR®	90 mg	56	8.45
D02.6.2.1B	Angitil SR®	180 mg	56	14.08
D02.6.2.2	Diltiazem (np)	60 mg	100	5.25
D02.6.2.3	Felodipine	2.5 mg	28	6.09
D02.6.2.4	Istin®	5 mg	28	11.85
D02.6.2.5	Nisoldipine	10 mg	28	9.36
D02.6.3.1	Nicorandil	10 mg	60	8.16
D02.8.2.1A	Warfarin (np)	1 mg	20	0.99
D02.8.2.1B	Warfarin (np)	3 mg	20	1.11
D02.8.2.1C	Warfarin (np)	5 mg	20	1.21
D02.9.1	Clopidogrel	75 mg	28	35.31
D03	**3: Respiratory**			
D03.1.1.1.1	Salamol®	100 μg	200	6.30
D03.1.1.1.2	Salbutamol®	100 μg	200	1.90
D03.1.1.1.3	Salmeterol	50 μg	60	28.60
D03.1.2.1	Ipratropium bromide (np)	250 μg/ml^{-1}	20	6.14
D03.10.2.1	Miconazole		30 g	2.07
D03.2.1	Beclomethasone (np)	250 μg		
D03.4.1.1	Neoclarityn®	5 mg	30	7.57
D04	**4: Central nervous system**			
D04.1.1	Buprenorphine	2 mg	7	6.72
D04.1.1.1	Nitrazepam (np)	5 mg	20	0.59
D04.1.1.2	Temazapan (np)	10 mg	20	0.37
D04.1.1.3	Zimovane®	7.5 mg	28	4.48
D04.1.2.1A	Diazepam (np)	2 mg	20	0.38
D04.1.2.1B	Diazepam (np)	5 mg	20	0.41
D04.1.2.2	Oxazepam (np)	10 mg	20	0.23
D04.3.1.1A	Amitriptyline (np)	10 mg	20	0.56
D04.3.1.1B	Amitriptyline (np)	25 mg	20	0.58
D04.3.1.2	Dothiepin (np)	25 mg	20	0.72
D04.3.1.3	Tofranil®	25 mg	84	3.66
D04.3.3.1	Cipramil®	20 mg	28	16.03
D04.3.3.2	Fluoxetine (np)	20 mg	30	7.61
D04.3.3.3	Lustral®	50 mg	28	16.20
D04.3.3.4	Paroxetine (np)	20 mg	30	14.50
D04.3.3.5	Seroxat®	20 mg	30	17.76
D04.6.1	Betahistine	8 mg	120	6.58
D04.6.2	Prochlorperazine maleate (np)	5 mg	20	1.19
D04.7.1.1A	Aspirin (np)	75 mg	20	0.13
D04.7.1.1B	Aspirin (np)	300 mg	20	0.39
D04.7.1.2A	Co-codamol (np)	8/500 mg	20	0.23
D04.7.1.2B	Co-codamol (np)	30/500 mg	100	7.52
D04.7.1.3	Co-dydramol (np)	10/500 mg	20	0.27
D04.7.1.4	Co-proxamol (np)	32.5/325 mg	20	0.24
D04.7.1.5	Kapake®	30/500 mg	100	7.53
D04.7.1.6	Paracetamol (np)	500 mg	20	0.15
D04.7.1.7	Remedeine®	500/20 mg	112	12.42
D04.7.1.8	Solpadol®	30/500 mg	100	7.54
D04.7.2.1	Codeine Phosphate (np)	30 mg	20	0.96
D04.7.2.2	Dihydrocodeine (np)	30 mg	20	0.71
D04.7.2.3	Oramorph®	10 mg/5 ml	100 ml	2.08
D04.7.2.4	Tramadol (np)	50 mg	30	2.61
D04.7.2.5	Tramake®	50 mg	60	8.95
D04.7.4.1.1A	Migraleve®		48 p	5.56
D04.7.4.1.1B	Migraleve®		48 y	4.70

continued

TABLE 38 *Costs of prescribed medications (cont'd)*

Code	Prescribed medicines (BNF, March 2003 prices)	Dose	No. in pack	Cost (£)
D04.7.4.2.1	Dixarit®	25 mg	112	7.11
D04.8.1.1A	Clonazepam	500 μg	20	0.84
D04.8.1.1B	Clonazepam	2 mg	20	1.12
D04.8.1.2	Tegretol®	100 mg	84	2.43
D04.8.1.3	Gabapentin	400 mg	100	61.33
D04.9.1.3A	Pergolide	50 μg	100	27.03
D04.9.1.3B	Pergolide	250 μg	100	40.77
D05	**5: Infections**			
D05.1.1.3.1	Amoxycillin (np)	500 mg	21	1.08
D05.1.8.1	Co-trimoxazole (np)	480 mg	28	4.06
D06	**6: Endocrine**			
D06.1.1.2.1	Human insulatard®		10 ml	10.50
D06.1.1.3.1	Monolet lancets		100	3.28
D06.1.6.1	Clucotide®		50	14.84
D06.1.6.2	Medisense strips®		50	14.14
D06.2.1.1	Thyroxine (np)	50 μg	28	0.57
D06.2.2.1	Carbimazole	5 mg	100	2.87
D06.3.2.1	Prednisolone (np)	5 mg	28	0.67
D06.4.1.1.1	Elleste Solo®	1 mg	3 × 28	5.34
D06.4.1.1.2	Nuvelle®		3 × 28	15.15
D06.4.1.1.3	Premarin®	625 μg	3 × 28	9.72
D06.4.1.1.4	Premique®		3 × 28	27.14
D06.4.1.1.5	Prempak-C®		3 × 40	17.67
D06.6.2.1	Didronel pmo®	400 mg + 1.25 mg	14	40.20
D06.6.2.2A	Fosamax®	10 mg	28	23.12
D06.6.2.2B	Fosamax®	70 mg	4	23.12
D07	**7: Obstetrics, gynaecology, and urinary tract**			
D07.1.1.1.1	Indocid PDA®		3 × 1 mg	22.50
D07.2.1.1	Vagifem®	25 μg	15	6.62
D07.4.1.1	Indoramin (Doralese®)	20 mg	60	12.30
D07.4.2.1	Tolterodine	1mg	56	29.03
D08	**8: Malignant disease and immunosuppression**			
D08.1.3.1	Methotrexate (np)	2.5 mg	100	11.41
D08.2.1.1	Azathioprine (np)	50 mg	56	9.97
D08.3.4.1.1	Tamoxifen (np)	20 mg	30	2.24
D08.3.4.2.1	Bicalutamide	50mg	28	128.00
D09	**9: Nutrition and blood**			
D09.1.2.1	Folic acid (np)	5 mg	20	0.44
D09.2.1.1.1	Slow-K®	600 mg	20	0.55
D09.5.1.1.1	Cacit®	1.25 g	76	10.92
D09.5.1.1.2	Calcichew®	1.25 g	100	9.33
D10	**10: Musculoskeletal and joint diseases**			
D10.1.1.1	Acoflam Retard®	100 mg	28	12.72
D10.1.1.2A	Allopurinol (np)	100 mg	28	0.91
D10.1.1.2B	Allopurinol (np)	300 mg	28	2.17
D10.1.1.3A	Arthrotec®	50 mg	60	13.31
D10.1.1.3B	Arthrotec®	75 mg	60	17.59
D10.1.1.4	Brufen retard®	800 mg	56	7.24
D10.1.1.5A	Celebrex®	100 mg	60	18.34
D10.1.1.5B	Celebrex®	200 mg	30	18.34
D10.1.1.6A	Celecoxib	100 mg	60	18.34
D10.1.1.6B	Celecoxib	200 mg	30	18.34
D10.1.1.7	Diclomax®	75 mg	56	13.01
D10.1.1.8	Ibuprofen (np)	400 mg	84	2.46
D10.1.1.9A	Indomethacin (np)	25 mg	20	0.51
D10.1.1.9B	Indomethacin (np)	50 mg	20	0.40
D10.1.1.10A	Ketoprofen (np)	50 mg	28	4.49

continued

TABLE 38 *Costs of prescribed medications (cont'd)*

Code	Prescribed medicines (BNF, March 2003 prices)	Dose	No. in pack	Cost (£)
D10.1.1.10B	Ketoprofen (np)	100 mg	100	15.80
D10.1.1.11	Lodine SR®	600mg	30	15.50
D10.1.1.12A	Mefanamic acid (np)	250 mg	20	0.50
D10.1.1.12B	Mefanamic acid (np)	500 mg	28	2.54
D10.1.1.13A	Mobic®	7.5 mg	30	10.00
D10.1.1.13B	Mobic®	15 mg	30	13.90
D10.1.1.14	Motifene®	75 mg	56	14.99
D10.1.1.15	Nabumetone (np)	500 mg	56	17.83
D10.1.1.16A	Naprosyn®	250 mg	56	4.89
D10.1.1.16B	Naprosyn®	500 mg	56	9.77
D10.1.1.17A	Oruvale® capsules	100 mg	56	26.77
D10.1.1.17B	Oruvale® capsules	200 mg	28	26.69
D10.1.1.18	Relifex®	500 mg	56	17.29
D10.1.1.19A	Rofecoxib	12.5 mg	28	21.58
D10.1.1.19B	Rofecoxib	25 mg	28	21.58
D10.1.1.20A	Vioxx®	25 mg	14	10.79
D10.1.1.20B	Vioxx®	50 mg	7	5.39
D10.1.1.21A	Voltarol®	25 mg	84	3.94
D10.1.1.21B	Voltarol®	50 mg	84	6.13
D10.1.1.22	Ketoprofen gel (np)	100 mg	100	15.80
D10.1.1.23	Etoricoxib	60 mg	28	22.96
D10.1.3.1	Plaquenil	200 mg	60	4.55
D10.1.3.2	Ciclosporin	25 mg		
D10.3.2.1A	Feldene		60 g	5.00
D10.3.2.1B	Feldene		112 g	7.84
D10.3.2.2	Ibugel®		100 g	6.50
D10.3.2.3	Traxam		100 g	7.00
D11	**11: Eye**			
D11.6.1	Brimonidine		5 ml	10.31
D11.6.2	Latanoprost		2.5 ml	11.95
D11.6.3	Pilocarpine eye drops		10 ml	1.58
D11.8.1.1	Hypotears®		15 ml	1.09
D11.8.1.2	Hypromellose eye drops (np)		10 ml	0.75
D11.8.1.3A	Lacri-Lube®		3.5 g	1.90
D11.8.1.3B	Lacri-Lube®		5 g	2.47
D11.8.1.4	Tears naturale®		15 ml	1.68
D11.8.1.5	Viscotears®		10 g	3.12
D12	**12: Ear, nose and oropharynx**			
D12.3.1.1A	Difflam®		200 ml	2.83
D12.3.1.1B	Difflam®		300 ml	3.92
D13	**13: Skin**			
D13.10.1.2.1A	Fucidin cream®		15 g	2.74
D13.10.1.2.1B	Fucidin cream®		30 g	4.62
D13.10.2.1	Miconazole nitrate cream		30 g	2.07
D13.2.1.1	Aqueous cream		100 g	0.21
D13.2.1.1.1A	Oilatum®		11	15.30
D13.2.1.1.1B	Oilatum®		500 ml	7.86
D13.4.1	Timodine cream®		30 g	2.38
D13.4.2	Betamethasone valerate cream (np)		30 g	1.54
D13.9.1	Finasteride (propecia®)	1 mg	28	22.49
D13.9.2	Selenium		100 ml	196

BNF, British National Formulary; np, non-proprietary; p, pink tablets; y, yellow tablets.

TABLE 39 *Costs for health and social care services*

Health and social care (PSSRU, 2002)	Cost (£)	Comments
GP (patient costs per visit)	6.70	
GP (home)	61	
GP (surgery)	20	
Day-patient	57	
Outpatient (rheumatology)	86	
Accident & emergency	75	
Day centre	27	
Practice nurse	18	
District nurse	20	
Specialist nurse	27	
Physiotherapist	17	
Complementary therapist	20	
Home help/carer	18.58	Assumes 2 h per patient
Domestic	15.78	Assumes 2 h per patient
Voluntary helper	26	
Social worker	38.24	Assumes 2 h per patient

TABLE 40 *Costs of over-the-counter and other medications*

Other medications (local retail prices)	Cost per 7 (£)	Cost per 14 (£)	Cost per 16 (£)	Cost per 21 (£)
Selenium	0.18	0.36		0.54
Cod liver oil	0.18	0.36		0.54
Seven Seas	0.40	0.80		1.20
Glucosamine sulphate	0.34	0.68		1.02
Chondroitin	0.34	0.68		1.02
Glucosamine and chondroitin	0.34	0.68		1.02
Calcium supplement	0.18	0.36		0.54
Garlic tablets	0.18	0.35		0.54
Brewers yeast	0.18	0.36		0.54
Multivitamins	0.18	0.36		0.54
Oil of evening primrose	0.18	0.36		0.54
Multivitamins and minerals	0.18	0.36		0.54
Vitamins E and C	0.18	0.36		0.54
Gingko biloba	0.23	0.46		0.69
Cod liver oil and evening primrose	0.30	0.60		0.90
Omega fish oil	0.35	0.70		1.05
MSM	0.34	0.68		1.02
Anadin extra			1.38	
Nurofen			1.14	

TABLE 41 *Costs of purchased or prescribed aids*

Purchased or prescribed aids (catalogue or local retail)	Average cost (£) (inc. VAT)	Typical lower cost (£)	Typical higher cost (£)
Armchair raisers	16.45		
Back door grab rails	7.05		
Bath board	25.79		
Bath lift	1250.00		
Bath rails	16.00		
Bath seat	39.50		
Bath stool	39.00		
Bed leveller	14.00		
Bed rails	116.33		
Commode	181.77		
Crutch sticks	27.00		
Crutches	19.00		
Elastic knee bandage	5.99		
Electric scooter	1499.00	949	2649
Grab	14.39		
Handrail	8.21		
Heel cushion	13.00		
Helping hand	13.39		
Innersole for shoe	19.99		
Knee supports	18.00		
Magnetic belt	18.19		
Metatarsal support	8.5		
Moving tray	12.25		
Raised WC seat	32.67		
Reclining chair	899.00	600	1300
Shoe horn	7.95		
Shower board	23.44		
Shower rails	10.58		
Shower seat	64.62		
Shower stool	32.95		
Spa bath	500.00	300	950
Stair rail	30.00		
Stool – ironing	44.65		
Stool – perching	44.65		
TENS machine	35.19		
Toilet chair	35.19		
Toilet handrails	10.58		
Toilet seat handles	37.60		
Walk-in shower	1000.00	500	2000
Walking frame	34.66		
Walking stick	6.60		
Walking trolley	68.15		
Wheelchair	276.12		
Wheelchair – lightweight	475.00	445	525
Wheeled walker	82.25		
Wrist supports	10.95		
Zimmer frame	135.00		

TABLE 42 *Costs of inpatient treatments for lower limb OA*

HRG code	HRG label	Mean average (£)	Range for all NHS trusts (£)	Average length of stay (days)
H02	Primary hip replacement	4,356	2,076–8,150	10
H04	Primary knee replacement	4,818	1,961–8,805	10
H06	Revision procedures to hips or knees	5,756	1,039–11,489	14
H27	Non-inflammatory back, bone, or joint disorders >69 or w cc	1,794	251–6,314	7
S22	Planned procedures not carried out	559	204–2,565	1

w cc, with complications.

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The HTA Programme and the authors would like to know your views about this report.

The Correspondence Page on the HTA website (http://www.ncchta.org) is a convenient way to publish your comments. If you prefer, you can send your comments to the address below, telling us whether you would like us to transfer them to the website.

We look forward to hearing from you.

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