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ORIGINAL ARTICLE

Cost Effectiveness of a Two-Year Home Exercise Program for the Treatment of Knee Pain

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Objective. **To assess the cost effectiveness of a 2-year home exercise program for the treatment of knee pain.**
Methods. **A total of 759 adults aged ≥45 years were randomized to receive exercise therapy, monthly telephone contact, exercise therapy and telephone contact, or no intervention. Efficacy was measured using self-reported knee pain at 2 years. Costs to both the National Health Service and to the patient were included.**
Results. **Exercise therapy was associated with higher costs and better effectiveness. Direct costs for the interventions were £112 for the exercise program and £61 for the monthly telephone support. Participants allocated to receive exercise therapy were significantly more likely to incur higher medical costs than those in the no-exercise groups (mean difference £225; 95% confidence interval £218, £232; $P < 0.001$).**
Conclusion. **Exercise therapy is associated with improvements in knee pain, but the cost of delivering the exercise program is unlikely to be offset by any reduction in medical resource use.**

KEY WORDS. Randomized controlled trial; Exercise; Knee osteoarthritis; Social support; Cost effectiveness.

INTRODUCTION

Knee pain is common, occurring in ~20% of patients older than 45 years and is often, but not always, associated with radiographic osteoarthritis (OA) (1). The economic impact of musculoskeletal disorders has been estimated to be as great as the economic consequences of cancer (2), although cost-of-illness studies specific to a particular joint are lacking (3).

Research now suggests that exercise therapy may improve the symptoms of knee OA (4,5), but little is known regarding the cost implications of delivering such an intervention. Previous cost-effectiveness studies have concentrated on the cost effectiveness of surgical management (6,7) or drug treatments (8,9). Although these areas are important elements in the treatment of arthritis, the impact on nonmedical interventions, such as patient education, weight loss, or physical therapy, should not be ignored.

The current study reports cost-effectiveness data collected as part of a randomized controlled trial of a home exercise program for the treatment of knee pain (10). This study controlled for the psychosocial aspects of delivering exercise therapy using a factorial design, in which exercise therapy was compared with monthly telephone support. Data are presented from the perspective of the health provider and the patient.

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SUBJECTS AND METHODS

Participants. Full details of the original trial have been reported elsewhere (10). A total of 786 participants were recruited between January 1996 and January 1997. Participants were enrolled if they reported current knee pain in a postal questionnaire of 9,296 people aged ≥45 years, registered at 2 general practices in Nottingham. Exclusion criteria were having had a total knee replacement, lower limb amputation, cardiac pacemaker, unable to give informed consent, or no current knee pain.

Interventions. Four treatment groups were compared: exercise therapy, monthly telephone support, a combination of exercise and telephone support, and no intervention. To limit the number of dropouts in the trial, participants allocated to the no-intervention control group and the combined exercise and telephone group were further randomized to receive or not receive a placebo health food tablet (Figure 1). Because no differences were found between the groups receiving or not receiving the placebo

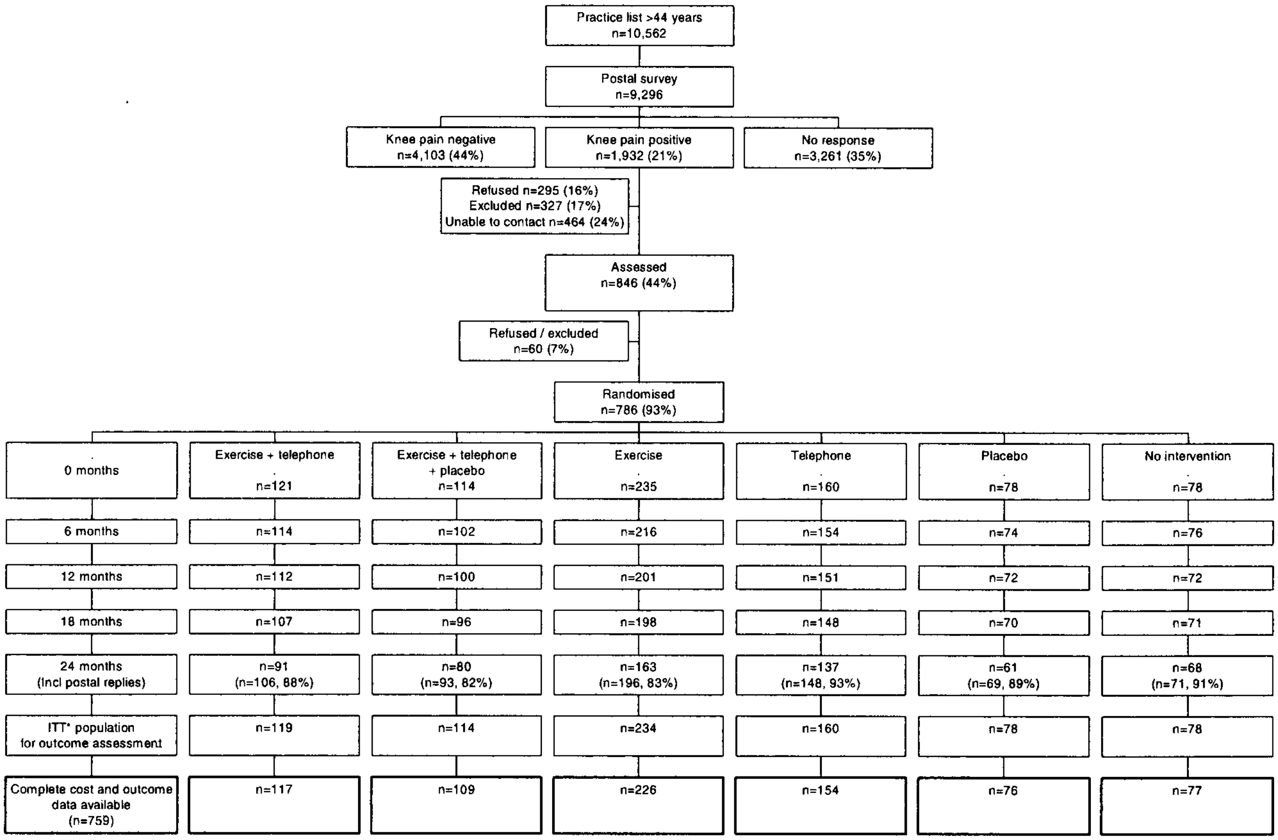

Figure 1. Consolidated Standards of Reporting Trials (CONSORT) flow diagram. ITT = intention to treat.

tablet, all analyses have been presented according to the original factorial design. All interventions were delivered over a 2-year period and provided in addition to normal care.

The exercise program consisted of quadriceps strengthening and aerobic exercise taught in a graded program. Resisted exercises were taught using rubber exercise bands. A research nurse taught the program in the participants' homes. The initial training phase consisted of 4 visits lasting ~30 minutes in the first 2 months, with followup visits scheduled every 6 months thereafter. Participants were encouraged to perform the program daily, taking 20–30 minutes.

Monthly telephone contact was used to monitor symptoms and to offer simple advice on the management of knee pain. This intervention aimed to control for the psychosocial contact of the exercise program. Calls typically lasted 2 minutes (8 minutes for the first call), although the time spent on administration of the calls was considerably more (>4 times). Participants in the no-intervention control group received no contact between the biannual assessment visits.

Outcome measures. The unit of effectiveness for the cost-effectiveness study was clinically significant improvement in knee pain (≥50% improvement) at 24 months, measured using the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) (11). All data are based on an intent-to-treat analysis.

Three categories of costs were included in the analysis: direct treatment costs (the cost of the study interventions), medical costs (secondary and primary care costs), and personal costs (costs incurred by the patient in accessing health services). It was not possible to identify knee-specific costs from the general practitioners' notes. As a result, the figures reported in this analysis reflect total medical costs incurred. Indirect costs are not included because very few people reported having taken time off work due to knee pain at baseline. All costs are reported in pounds sterling at 1996 prices. Unit costs were obtained from Personal Social Services Research Unit (12), the local hospital finance department, and from the September 1996 edition of the British National Formulary. Costs incurred in the second year were discounted at 5%.

Data were collected through a combination of general practitioners' case notes and patient questionnaires. Data abstraction from general practitioners' notes was performed blind to treatment group.

Randomization. Participants were randomized using a computer-generated list with a block size of 10 and stratified by age and sex.

Statistical methods. All data were entered onto a customized database (Access 97, Microsoft, Redmond, WA) and analysis performed in SPSS for Windows, version 8.0 (SPSS Inc., Chicago, IL). Summary data are presented us-

Table 1. Summary of 2-year intervention costs by treatment type*

	Unit cost	Year 1 Units	Year 1 £	Year 2† Units	Year 2† £	Total £/person
Exercise						
Start-up costs						
Initial training, £/hour	18	2 days	260.00			
Development of program, £/hour	18	1 month	2,730.00			
Total £/person			6.35			
Ongoing costs/person						
Personnel, treatment, £/hour	18	3 h 22 min	58.05	49.5 min	14.10	
Personnel, admin, £/hour	18	1 h 10 min	21.00	17 min	4.85	
Travel, £/mile	0.37	8.6 miles	3.18	2.2 miles	0.77	
Booklet, £ each	0.30	1	0.30	0	–	
Exercise band, £/meter	1.76	2.1 meter	3.70	0.1 meter	0.17	
Total £/person			92.58		19.89	112.47
Telephone						
Start-up costs						
Initial training, £/hour	18	1 day	130.00			
Total £/person			0.33			
Ongoing costs/person						
Personnel, phone contact, £/hour	18	20.4 min	6.12	16 min	4.56	
Personnel, admin, £/hour	18	1 h 27 min	26.10	1 h 20 min	22.80	
Telephone charges, £/min	0.04	20.5	0.82	16 min	0.60	
Total £/person			33.37		27.96	61.33

* h = hours; min = minutes; admin = administration.
† Year 2 discounted by 5%.

ing descriptive statistics. Cost-effectiveness data are presented using a cost-effectiveness acceptability curve based on a nonparametric bootstrapping technique (13,14). This technique has been advocated as a way of dealing with uncertainty in economic data (15,16).

RESULTS

Participants. Complete cost and outcome data were available for 759 (97%) patients. Although outcome data are based on an intent-to-treat basis, case notes could not be obtained for 27 patients, and these participants were therefore excluded from the cost-effectiveness analysis. Since these patients represent just 3% of the entire sample, it is unlikely that this decision will have influenced the overall result. The 27 participants who were excluded from the cost-effectiveness analysis were of similar age (mean age 64 years) and sex (59% men, 41% women) to those included in the main analysis. The proportion allocated to each treatment group was similar (18 [67%] were allocated to exercise and 9 [33%] to nonexercise). The mean difference in knee pain between those included in the analysis and those excluded was –3.39 ($P = 0.03$) and is in line with the main findings of the trial.

Two patients incurred extremely high medical costs (£80,440 and £42,226) for conditions unrelated to knee pain. Because these values skewed the dataset, results are presented both with and without these patients. The mean age of participants was 62 years, and 64% were women. Of those who attended radiographic assessment (679), 43% had radiographic evidence of OA (as defined by the presence of definite osteophytes in either compartment of at least 1 knee). The groups were well matched at baseline.

Impact on knee pain. Both the exercise and no-exercise groups had reduced WOMAC pain scores at 2 years (a reduction in WOMAC pain represents an improvement in knee pain). This improvement was significantly greater in the exercise groups compared with the no-exercise groups (mean change compared with no-exercise −0.74; 95% confidence interval [95% CI] –1.22, −0.25; $P = 0.003$). Similar improvements were not observed for the telephone groups compared with the no-telephone groups (mean change compared with no-telephone −0.19; 95% CI −0.67, 0.29; $P = 0.44$), and no interaction between exercise and telephone was seen ($P = 0.72$).

One hundred twenty (27%) participants allocated to receive exercise therapy showed a ≥50% improvement in knee pain compared with 62 (20%) participants allocated to the nonexercise groups ($P = 0.1$). For those allocated to telephone versus no telephone, the numbers showing a ≥50% improvement in knee pain were 91 (24%) and 91 (24%), respectively ($P = 0.87$).

Cost data. The intervention costs to the health care provider for the 2-year period were £112 per person for the exercise program and £61 per person for the telephone intervention (Table 1). For exercise therapy, the majority of costs were incurred during the first 6 months of treatment provision (4 treatment visits). Subsequent periods incurred comparable costs to those of the telephone intervention.

Table 2. Frequency of resource use and total medical costs over the 24-month study period*

	Unit cost £	Unit resource use	Total cost (£) exercise n = 452	Unit resource use	Total cost (£) nonexercise n = 307
GP costs					
Consultations	10	4,084	39,825	2,681	26,137
Telephone contact	5	53	258	28	137
Investigations, treatments	5	1,275	6,209	916	4,449
Radiographs	9 per joint	157	1,373	112	977
Domicilliary visits	30	179	5,243	96	2,802
Mean ± SD			117 ± 110		112 ± 92
GP prescribed drugs					
Arthritis-related drugs, mean ± SD					
NSAIDs			15,558 ± 34.42		10,401 ± 33.88
Topical rubs, gels			2,695 ± 5.96		2,120 ± 6.91
Analgesics			5,591 ± 12.37		3,414 ± 11.12
Gastrointestinal drugs			20,324 ± 44.97		14,804 ± 48.22
Other arthritis-related drugs			987 ± 2.18		761 ± 2.48
Mean ± SD			100 ± 192		103 ± 222
All drugs, mean ± SD			332 ± 461		340 ± 550
Secondary care costs					
Inpatient first day	500	149	277,830	84	203,310
Inpatient subsequent days	300				
Days in ICU	1,000	1	1,000	2	1,950
Daycase surgery	480	56	26,160	30	13,968
Outpatient new referral	100	224	21,845	163	15,880
Outpatient followup	40	813	31,680	550	21,408
A&E	42	58	2,402	33	1,350
Mean ± SD			799 ± 2,485		840 ± 4,712

* Year-2 costs discounted by 5%. GP = general practitioner; NSAIDs = nonsteroidal antiinflammatory drugs; ICU = intensive care unit; A&E = accident and emergency.

Personal costs incurred as a result of the study interventions were limited to the opportunity cost of time spent in therapy because all necessary equipment was provided by the study team. A monetary figure has not been attached to this time.

Unit resource use and total costs are outlined in Table 2. Cost summaries for the exercise groups compared with the nonexercise groups are presented in Table 3. At 2 years, costs were higher for the exercise groups compared with nonexercise, but this was not statistically significant (mean change compared with nonexercise £230; 95% CI –£136, £596; $P = 0.08$). However, the cost data were positively skewed. Bootstrapping cost data using 2000 resample estimates of the sample mean normalized the data and suggested that the exercise groups had significantly higher costs (mean change compared with nonexercise £225; 95% CI £218, £232; $P < 0.001$). The observed difference in cost was generated by the cost of the exercise intervention itself and by secondary care costs. There was little difference between the groups in terms of primary care or personal costs.

Cost effectiveness. The cost-effectiveness acceptability curve, showing the probability that the exercise intervention can be defined as cost effective when units of effect are valued differently, is presented in Figure 2. If decision makers are prepared to pay £8,000 for each patient showing at least a 50% improvement in knee pain, it is almost certain that the exercise intervention will be cost effective. However, if health providers are willing to pay <£500, it is almost certain that it will not be cost effective. Decision makers can decide their willingness to pay for additional effectiveness and then determine whether the level of probability of cost effectiveness is acceptable to proceed. The point estimate given by an incremental cost effectiveness ratio (ICER) is equivalent to where $P = 0.5$ in Figure 2, and equates to £2,570 per patient with a clinically significant improvement.

Sensitivity analysis. Estimates of personnel time were based on physiotherapy pay scales (12). This could have led to a potential overestimation of the actual implementation costs if physiotherapy assistants implemented the program. The use of physiotherapy assistants would reduce the 2-year implementation costs from £112 per person to £71. Bootstrap analysis showed that this reduced the ICER to £2,090 (sensitivity analysis 1 in Figure 2).

In addition, participation in the current study was the result of active recruitment following completion of a postal questionnaire. Upon wide-scale implementation, it is likely that the program would only be delivered to knee pain sufferers who presented to their general practitioner. Analysis based solely on those individuals who presented to their general practitioner for knee pain in the 6 months prior to participation in the study (n = 217) suggested that the program was far more likely to be cost effective in these individuals (sensitivity analysis 2), and resulted in an ICER of £814.

Table 3. Cost analysis, 2 years postrandomization*

Resource variable	Exercise intervention (exercise + exercise with telephone support groups) n = 451†	No-exercise control (telephone support + no-intervention groups) n = 306†	Difference (intervention − control)	*P*‡
Exercise intervention costs§				
Mean ± SD, £	145 ± 32	32 ± 29	113	0.001
95% CI	(142, 148)	(30, 35)	(107, 119)	
Median, £	174	61		
IQR, £	61	55		
Skewness	0.1	−0.3		
Primary care costs¶				
Mean ± SD, £	444 ± 511	454 ± 590	−10	0.82
95% CI	(397, 492)	(399, 508)	(−121, 101)	
Median, £	283	265		
IQR, £	495	424		
Skewness	2.98	3.06		
Secondary + primary care costs				
Mean ± SD, £	1,158 ± 1,947	1,034 ± 1,500	124	0.35
95% CI	(978, 1,337)	(896, 1,172)	(−239, +487)	
Median, £	478	477		
IQR, £	1,002	977		
Skewness	3.49	2.67		
Total costs#				
Mean ± SD, £	1,358 ± 1,962	1,128 ± 1,512	230	0.08
95% CI	(1,177, 1,539)	(989, 1,268)	(−136, 596)	
Median, £	698	588		
IQR, £	1,021	1,050		
Skewness	3.47	2.63		
Bootstrapped total costs**				
Mean ± SD, £	1,354 ± 91	1,129 ± 84	225	0.001
95% CI	(1,350, 1,358)	(1,125, 1,132)	(218, 232)	
Median, £	1,351	1,128		
IQR, £	119	115		
Skewness	0.21	0.07		
Sensitivity analysis 1 (physio costs)				
Mean, £	1,314	1,128	186	0.001
95% CI			(175, 197)	
Sensitivity analysis 2 (self-referral only)††				
Mean, £	1,641	2,329	−688	0.001
95% CI			(−767, −609)	
Sensitivity analysis 3 (not obese)§§				
Mean, £	1,355	1,082	274	0.001
95% CI			(256, 292)	
Sensitivity analysis 4 (no radiographic OA)‡‡				
Mean, £	1,078	954	221	0.001
95% CI			(105, 143)	

* 95% CI = 95% confidence interval; IQR = interquartile range; physio = physiotherapy; OA = osteoarthritis.
† Excludes 1 outlier patient in each group (£42,225 in group 1 and £80,440 in group 2). When these are included, mean total cost for group 1 is £1,448 and mean total cost for group 2 is £1,387. The difference is £61 (95% CI −694, 816; P = 0.82).
‡ *P* values determined by *t*-test.
§ All intervention-related costs.
¶ General practitioner consultations plus prescription drugs.
# Intervention plus medical plus personal costs.
** Mean of 2,000 resampled estimates of sample mean.
†† Sample size for the exercise group was 126. Sample size for the control group was 91.
‡‡ Sample size for the exercise group was 217. Sample size for the control group was 137.
§§ Sample size for the exercise group was 312. Sample size for the control group was 221.

Among the subgroup of patients defined as not obese, exercise therapy was more likely to be cost effective (sensitivity analysis 3). Among the subgroup of patients showing no radiographic evidence of OA, the exercise therapy was most likely of all scenarios to be cost effective (sensitivity analysis 4).

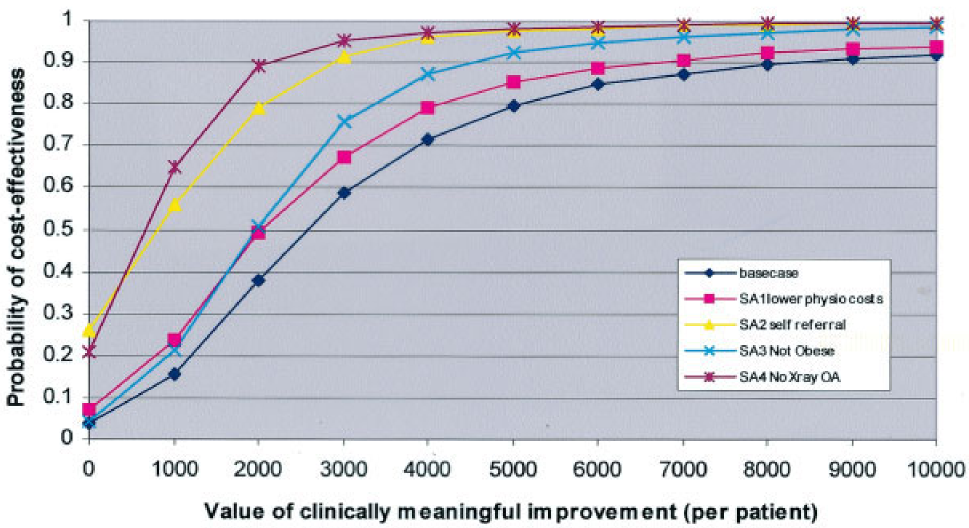

Figure 2. Cost-effectiveness acceptability curve. SA = sensitivity analysis; physio = physiotherapy; OA = osteoarthritis.

DISCUSSION

The direct cost of the 2-year exercise program was £112 per person. The majority of this amount was incurred during the initial 6-month training phase of the program. Subsequent visits were principally designed to encourage continued participation and to ensure that the exercises were performed correctly.

The direct treatment cost of the 2-year telephone intervention was roughly half that of the exercise program. The very low cost of this intervention has led to claims of cost effectiveness by other researchers (17). However, data from the current trial failed to show a significant improvement in health status for the telephone groups.

Although a monetary value was not attached to the opportunity cost of time spent exercising, the importance of the individual burden incurred by exercise therapy should not be ignored. Lack of time or motivation was cited as a major reason for failure to continue with the exercise and is therefore an important factor in determining the efficacy of the program.

Presentation of results as an acceptability curve allows policy decision makers to assess their willingness to implement the program assuming a variety of ceiling limits. Data from this trial suggested that there was an 80% probability that the exercise program would be cost effective (compared with normal care), with an investment of £8,000 per patient showing at least a 50% improvement in knee pain. Sensitivity analysis suggested that this figure may be lower for different patient groups (e.g., those who present to their general practitioner, are not obese, and do not have radiographic OA). However, post-hoc analysis of this kind should be interpreted with caution.

Two American studies have examined the cost implication of providing exercise therapy for patients with OA (18,19). The latter was conducted alongside a large-scale randomized controlled trial (5) that compared aerobic and resistance exercise with an education control for the treatment of knee OA. This study concluded that exercise therapy could provide some small cost savings when compared with the education control group. However, since all groups incurred very similar costs ($323 to $344) and the confidence intervals were wide, it is difficult to assess the relevance of this finding in the absence of a no-intervention control group.

Others have reported potential cost savings for the health provider resulting from the provision of social support or education in the treatment of OA (17,20). Cronan et al (20) reported an increase in health care costs for the control group of almost 100% in year 1 and of 112% in year 2 (n = 86). These dramatic increases were explained by differences in the number of days spent in the hospital between the control and the intervention groups. Caution should be used in interpreting such cost data, because they are based on very high cost but low frequency events.

In contrast, two British studies examining the benefits of health education for the treatment of OA have reported little or no benefit (21,22). The importance of gathering country-specific data has been reported by others (23).

One of the strengths of this study was that it reported prospectively collected resource use data alongside a large-scale randomized controlled trial. However, this approach limited the sample size and period of followup. In addition, health care costs were obtained from medical notes rather than through self-completion questionnaires. This meant that the difficulties associated with missing data and recall bias were largely avoided. However, it was not possible to identify costs specific to the knee joint in this way, and small changes in knee-related costs may have been dwarfed by largely irrelevant changes in overall medical costs.

This study suggests that exercise therapy can provide significant health benefits for people with knee pain, but that the cost of delivering the exercise program is unlikely to be offset by any reduction in medical resource use. If the health provider is willing to pay approximately £8,000 per patient showing at least a 50% improvement in knee pain, then there is an 80% probability that the program will be cost effective. Further work is now needed to identify those patients most likely to benefit from such a program.

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