Title:

Early self-managed focal sensori-motor rehabilitative training enhances functional mobility and sensori-motor function in patients following total knee replacement. A controlled clinical trial.

The names of all authors in the order in which they appear in the above manuscript are:

M. Moutzouri, PT[1]

N. Gleeson[2]

F. Coutts[3],

E.Tsepis[4]

J. Gliatis, MD[5]

[1] MSc, PhD (cand) Department of Physiotherapy, Technological Educational Institute (TEI) of Western Greece,

[2.] PhD, Professor of Exercise and Rehabilitation Sciences and Postgraduate Research Coordinator in the School of Health Sciences, Queen Margaret University, UK,

Postal: Queen Margaret Dr, Musselburgh EH21 6UU, UK.

Email: nglesson@qmu.ac.uk

[3.] PT, PhD, Dean of School of Health Sciences, Queen Margaret University, UK **Postal:** Queen Margaret Dr, Musselburgh EH21 6UU, UK.

Email: fcoutts@qmu.ac.uk

[4.] PT, PhD, Associate Professor at Technological Educational Institute (TEI) of Western Greece,

Postal: Psaron 6, Aigion, 25100, Greece

Email:tsepis@teiwest.gr

[5] MD, Orthopedic Surgeon, Associate Professor at University Hospital of Patras,

Postal: Orthopedic Surgery Department, University Hospital of Patras, Greece. Rion, PC: 265 04

Email: igliat@upatras.gr

Author contributions

1	Involved in the conception, design, data acquisition, analysis, interpretation of data and drafting the manuscript. (>75%)
2	Involved in the conception, design, analysis, interpretation and critical review of the manuscript. (>75%)
3	Involved in the conception, and critical review of the manuscript. (25%)
4	Involved in the data analysis, interpretation and critical review of the manuscript. (25-75%)
5	Involved in the conception, design, data acquisition, coordination of the study and critical review of the manuscript. All authors read and approved the final manuscript. (25-75%)

Author statement

I affirm that all authors have read and agreed the Statement for Authors.

Please address all correspondence to:

Maria Moutzouri PT, MSc, MMACP, PhD candidate Queen Margaret University, UK

Lecturer in Physiotherapy
Department of Physiotherapy, Branch Department of Aigion,
Technological Educational Institute (T.E.I.) of Western Greece
Psaron 6, Aigion, 25100, Greece
Tel. +030 2691061150, 00306977073125
Fax. +030 26910 61250
Email: moutzouri_marie@yahoo.com

Abstract

Objective: To assess the effects of early self-managed focal sensori-motor training compared to functional exercise training after total knee replacement on functional mobility and sensori-motor function.

Design: A single-blind controlled clinical trial.

Setting: University Hospital of Rion, Greece.

Subjects: Fifty-two participants following total knee replacement.

Outcome Measures: The primary outcome was the Timed Up and Go Test and the secondary outcomes were balance, joint position error, the Knee Outcome Survey Activities of Daily Living Scale, and pain. Patients were assessed on 3 separate occasions (pre-surgery; 8 weeks; and 14 weeks post-surgery).

Intervention: Participants were randomised to either focal sensori-motor exercise training (experimental group) or functional exercise training (control group). Both groups received a 12-week home-based programme prescribed for 3-5 sessions/week (35-45 min).

Results: Consistently greater improvements ($F_{(2,98)}$ = 4.3 to 24.8; $p < 0.05$) in group mean scores favour the experimental group compared to the control group: Timed Up and Go (7.8 ± 2.9 s vs 4.6 ± 2.6 s); balance (2.1 ± 0.9° vs 0.7 ± 1.2°); joint position error

($13.8 \pm 7.3^{\circ}$ vs $6.2 \pm 9.1^{\circ}$); Knee Outcome Survey Activities of Daily Living Scale (44.2 ± 11.3 vs 26.1 ± 11.4); and pain (5.9 ± 1.3 cm vs 4.6 ± 1.1 cm). Patterns of improvement for the experimental group over time were represented by a relative effect size range of 1.3 to 6.5.

Conclusions: Overall, the magnitude of improvements in functional mobility and sensori-motor function endorses using focal sensori-motor training as an effective mode of rehabilitation following knee replacement.

Introduction

Despite partial improvements in functional mobility and balance, the rate of falls remains high (~45%) for patients following total knee replacement[1]. The latter partial restoration in sensori-motor function, including proprioception, postural control and dynamic balance[1,2,3], may persist long after surgery unless it can be targeted and counteracted effectively by novel rehabilitation[4].

Neuromuscular rehabilitation techniques aiming at increased proprioceptive input to improve motor response in dynamic environments have received increasing therapeutic attention in recent years[5]. This focal training is broadly known as sensori-motor training. It typically comprises stimuli for muscular strengthening and for improved control of movement by means of enhanced regulation of motor-unit recruitment by the central nervous system[5-7]. Early adoption of focal sensori-motor training has been shown to promote safe post-surgery milestones of functional recovery compared to contemporary functional therapy[8,9]. However, its optimal delivery characteristics and efficacy remains partially unresolved due to the ongoing experimental design of the study[4]. Thus far, the contributing evidence has not included sufficient control for the corresponding volume of training between conditions. Furthermore, no previous study has sought to investigate the effectiveness of early implementation of focal sensori-motor rehabilitative training within environments in which the preferred mode of delivery increasingly requires self-managed care by patients[10,11].

Given the above factors, the purpose of this study was to compare the effects of focal sensori-motor and functional (usual care) exercise training on patients' functional mobility and sensori-motor function following total knee replacement. Both rehabilitation programmes were adopted early after surgery by patients, matched for prescribed exercise volume, and delivered by means of self-managed care.

Methods

A single-blind (group-allocation concealed from participants) controlled clinical trial was undertaken at a primary care university hospital in Greece (International Standard Randomised Control Trial Registration: ISRCTN12101643), having been ethically approved by two Institutional Committees (University Hospital of Patras, Greece and Queen Margaret University Edinburgh, UK [7052/4-7-2011]).

Allocation of participants to the two groups was concealed to participants and investigators by means of an independent confidential assignment (concealed coded listing, maintained until after data analyses). Ten blocks of 5 patients were randomly assigned to the two groups using a computer-generated number sequence overseen by an independent statistician. Groups were subsequently augmented by 2 patients presenting for surgery immediately prior to the study's deadline for recruitment and assigned in the original block-allocation order, leading to a total of 52 patients in the study.

Participants

Seventy consecutive patients (May 2012 – May 2014) undergoing primary standardised cemented unilateral total knee replacement (single surgeon; 15-years experience of knee replacement; 50 knee replacements per annum) were invited to participate in the study. The inclusion criteria for participants were that they had elected to undergo primary unilateral total knee replacement as a result of advanced osteoarthritis and they had been ambulatory at the time of surgery. Patients were excluded from the study if they had the following conditions: a) neurological conditions; b) vestibular disorders that might affect balance; c) other lower extremity orthopedic problems; and d) unable to communicate or follow instructions. All the participants gave written informed consent.

Iso-volumetric rehabilitative procedures

Participants received a standardised hospital-based post-surgery care-pathway, initiated with bedside physiotherapy. After discharge, at approximately 2 weeks after surgery (range 15-20 days), patients performed a 12-week programme of self-managed home-based exercises designed to enhance functional capabilities (modified from Piva *et al.*[12]; see Appendix 1). From week 3 to week 8, patients undertook 5 exercise sessions per week. Sessions increased progressively in duration from 35 to 45 minutes and involved an increase in the prescribed duration of walking from 10 to 20 minutes. Weeks 9 to 14 required patients to complete 45-minute sessions of exercise 3 times per week. Each patient's training programme was prescribed and delivered in a standardised manner using an illustrated guidebook of 14 exercises to regulate exercise-specific dosages. Progression within training involved the exercise intensity being adjusted progressively to calibrate with changes in each patient's capabilities, which were assessed weekly. Clinical oversight, by telephone and within scheduled practical sessions, involved patients freely reporting effusion or discomfort and clarifying the delivery (accuracy, dose or safety) of the self-managed exercises. Patients' compliance with the prescribed intensity, duration and frequency of exercise was verified by 7-day recall activity diaries.

Experimental group: Focal sensori-motor training

Patients in the experimental group undertook exactly the same procedures and volume of exercises as had been prescribed for the control group. However, the experimental group undertook exercises that focused predominantly on enhancing sensori-motor function capabilities of patients. The exercises included novel formulations of agility and perturbation training techniques[5-7,12] and substituted for a proportion of training (50% – 7/14 exercises) within usual practice in order to maintain an iso-volumetric comparison of training between the experimental and control groups.

Control group

Usual care exercise sessions involved strengthening, stretching, and task-oriented functional exercises of the lower-extremity[13,14]. Appendix I offers a detailed description of the programmes of training undertaken by the experimental and control groups.

Outcome measures

Randomly-ordered assessments of outcome data were collected at pre-surgery, at 8 weeks post-surgery and at 14 weeks post-surgery.

The Timed Up and Go Test was selected as the study's primary outcome measure of functional mobility, whilst also reflecting participants' neuromuscular capabilities for power, agility, balance and risk of falls[15,16]. The test involves patients rising from a chair with armrests, walking 3 m, turning, and walking back to sit down. The Timed Up and Go Test has shown good clinimetric properties (minimum detectable change: 2.49 s)[16], and is a time-efficient task that reflects multiple themes of activities of daily living[17].

Single-limb standing to measure sensori-motor function was assessed in the operated and non-operated leg using the protocol described by Cachupe *et al.*[18]. A Biodex Stability System (Biodex Medical Systems, Shirley, NY; platform deflection: 12) was used with feedback limited to an eye-level visual target during concurrent platform tilting over anterior-posterior and mediolateral axes.

Sensori-motor function was also evaluated by knee joint positional error using a passive-active angle reproduction test (tibial bubble inclinometer [Fabrication Enterprises, Inc., USA]) conducted at 25^{o} and 60^{o} of knee flexion and described in detail elsewhere[19-21]. Joint position error was recorded as the mean angular discrepancy from the target during three replicates at each of the two target knee angles, performed in random order (6 trials, 15 s inter-trial recovery), using the following expression (absolute values of estimated errors were used for analysis):

Joint position error = absolute (trial knee angle – target knee angle) / target knee angle) × 100%.

Patient-reported functional balance capabilities were assessed by the number of falls experienced in the year immediately prior to surgery, and during the study's follow-up period. Self-reported functional performance was assessed using the Knee Outcome Survey Activities of Daily Living Scale (minimal detectable change = 12.5–17.2 scale units)[22]. Pain was assessed by a Visual Analogue Scale (minimal detectable change = 1.1 cm)[23].

Statistical Analysis

The effects of the focal sensori-motor exercise training were assessed for each outcome measure using separate factorial ANOVAs involving group (experimental; control) by leg (non-operated; operated) and by test occasion (pre-surgery; 8 weeks post-surgery; 14 weeks post-surgery) comparisons, with repeated measures on the latter two factors. Assumptions underpinning the use of ANOVA were assessed and corrections used

(GG), where appropriate. For outcomes that had focused on bilateral limb capabilities (such as the Timed Up and Go), group (experimental; control) and by test occasion (pre-surgery; 8 weeks post-surgery; 14 weeks post-surgery), interactions were assessed using ANOVA with repeated measures on the latter factor.

Effect size (ES; Cohen's *d*) was calculated using pooled standard deviations[24]. A sample size of 30 participants per group was computed to achieve an experimental design sensitivity of 0.80 for the primary outcome of the Timed Up and Go Test (Type I and Type II error rates, 005 and 0.20, respectively) in discriminating a moderate relative effect size[25] between the performance of the groups at the study's primary endpoint (14 weeks post-surgery). Statistical significance was accepted at $p < 0.05$. Analyses used the Statistical Package for Social Sciences (SPSS; v. 16.0).

Results

Results for 51 of the 52 participants completing the study are reported (the exclusion of 1 patient was due to the non-completion of an assessment at 14 weeks). The study's CONSORT flowchart and group mean scores at baseline for experimental and control groups, which were statistically similar ($p > 0.05$), are shown in Figure I and Table I, respectively.

Table I and Figure I

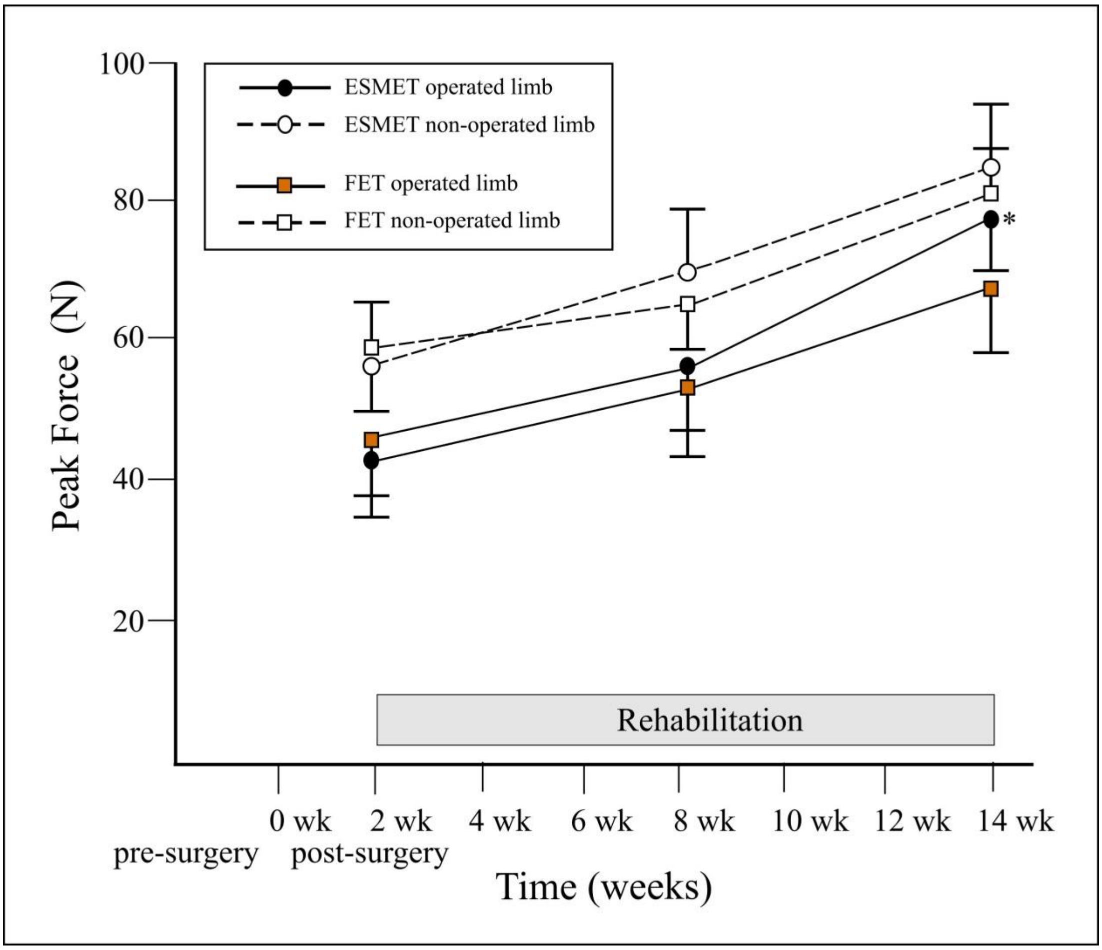
The experimental group yielded superior gains in functional mobility and sensori-motor function and in most other outcomes compared to control. These gains for the experimental group ranged between 20% for the Timed Up and Go Test ($p < 0.001$) and 125% for self-reported performance scores (Knee Outcome Survey Activities of Daily Living Scale; $p < 0.001$) by the end of training. Table II shows group mean scores for experimental and control groups at baseline, 8 weeks and 14 weeks post-surgery. Comparisons using *a priori* orthogonal difference contrasts suggested that the superior gains made by the experimental group for the Timed Up and Go Test were elicited progressively over the period of training, with gains elicited between baseline and 8 weeks post-surgery (29.1%), and between 8 weeks and 14 weeks post-surgery (34.2%). These were similar in magnitude, but significantly greater than control ($F_{(1,49)} > 11.1$; $p < 0.001$, Table II).

Figure II shows individual improvement scores during the period of training exceeding the minimum detectable change criterion for the Timed Up and Go Test (2.49 s)[16] for patients in the experimental and control groups.

Table II and Figure II

Quadriceps muscle' strength as reflected by PF, was amplified by undertaking focal sensori-motor training (~27 % greater improvement compared to the effects of the training undertaken by the control group ($F_{(2, 98)} = 7.15$; $p = 0.001$) (Table II). The relative effect size for group mean change scores for PF confirmed that the experimental group showed more improvement (*d* = 1.5) than the control (*d* = 0.7). Improvements were equivalent for the leg undergoing surgery and for the contralateral control leg (Figure III).

Figure 8.3B Peak force scores of enhanced sensori-motor and functional exercise training groups for both the operated and non-operated legs from pre-surgery (0 weeks), 8 weeks and 14 weeks post-surgery, during TKR rehabilitation.



TKR: total knee replacement; ESMET: enhanced sensori-motor exercise training group (intervention); FET: functional exercise training group (control). Data represent mean ±1SD; *p < 0.05.

Improvements in EMG-derived index (peak amplitude; RMS) were similarly superior for the experimental group, with a relatively greater improvement noted for the leg undergoing surgery (~65 % greater improvement compared to control; peak amplitude: $F_{(1.7,85.6)GG} = 36.2$; $p < 0.001$; RMS: $F_{(2,98)} = 6.9$; $p < 0.005$) (Table II). The relative effect size for group mean change scores of peak amplitude suggested that ESMET showed more improvement over time (d = 1.3) than FET (d = 0.5).

Results using ANOVA (group x time interaction) identified that both groups had shown similar patterns of improvement over time on ROM during knee extension manoeuvres ($F_{(1.3,\ 66.8)GG} = 0.65$; ns). However, a greater rate of gain over time for the experimental group was shown for the knee flexion ROM (~3.5 % greater improvement compared to control; $F_{(1.2,61.2)GG} = 5.6$; $p < 0.005$). Improvements were equivalent for the leg undergoing surgery and for the contralateral control leg.

Accordingly, improvements in RF muscle CSA for both the relaxed and contracted (during isometric contraction in 60 degrees of flexion) state were superior for the group undertaking enhanced sensori-motor exercise training, with a relatively greater improvement noted for the leg undergoing surgery (23 % and 27 % greater improvement respectively, compared to control; CSA_{REL}: $F_{(1.6,\ 82.2)GG} = 19.6$, $p < 0.001$; $CSA_{CONTR.}$: $F_{(2,\ 98)} = 11.3$; $p < 0.001$) (Table II). The relative effect size from pre-surgery to 14 weeks post-surgery for the RF muscle CSA (operated limb) in the contracted state, showed larger improvements ($CSA_{CONTR.}$: d = 3.7) of rectus femoris for the ESMET compared to the FET group ($CSA_{CONTR.}$: d = 2.3), respectively.

Patients' compliance to exercise training showed a ~10 % difference in favour of the experimental group.

Discussion

The principal finding of this study was that patients undergoing total knee replacement and initiating self-managed, focal sensori-motor rehabilitative exercise training soon after surgery demonstrated superior gains in functional mobility and sensori-motor function compared to those who performed the functional exercise training.

As it had been expected, this finding offers confirmation that, when compared to usual practice, a greater proportion of exercises focusing on improving sensori-motor function within a volume-matched prescription of rehabilitative exercises elicited greater efficacy and gains that are likely to be clinically important[16,22,23]. The early initiation and self-management of the novel formulations of rehabilitative exercises were tolerated well by patients.

The clinical efficacy of studies incorporating sensori-motor training within the rehabilitation programme of patients undergoing knee replacement have been tentatively endorsed in a recent systematic review[4]. However, most studies relied on additional volumes (in terms of time-duration) of sensori-motor training on top of the usual practice to deliver effectiveness, thus hindering the ability to attribute gains solely to the focal sensori-motor training.

The iso-volumetric delivery of focal sensori-motor and functional exercise training in the current study suggest that the superior gains in pain reduction in former studies[12,26], together with functional mobility and balance (including a ~50% gain in single limb standing balance), can be attributed to the particular characteristics of exercises promoting improvements in sensori-motor function and not to the effects of a substantially increased volume of sensori-motor training.

Focal sensori-motor exercise training used in the current study produced greater gains (~50%) in objective measures of functional mobility (Timed Up and Go Test) compared to those noted (~25 %) in studies with similar conceptual designs[4]. It is plausible that the superior gains would be attributable to the early initiation of sensori-motor exercise training at 2 to 3 weeks after surgery in the current study, increasing the potential for functional recovery compared to delayed initiation observed typically elsewhere (2 months post-surgery[4]). Furthermore, peak gains in performance were achieved at the end of training for both types of training and these gains had occurred progressively over the 14 weeks of monitored rehabilitation (that is, similar training-related effects between pre-surgery and 8 weeks post-surgery, and between 8 weeks and 14 weeks post-surgery). As a result, the study’s findings suggest that there would be no particular efficacy-related advantage in a cessation of exercise training early, as gains were still being accrued at 14 weeks after surgery. Interestingly, Pohl *et al.*[27] had been unable to detect significant gains in proprioception performance after implementing short duration (3-week) sensori-motor training in patients undergoing both knee and hip replacement surgeries. So, it is not unreasonable to assume a strong link between longer duration rehabilitation programmes and good functional and/or sensori-motor outcomes.

Superior gains in sensori-motor function as measured by joint position sense were shown for the experimental compared to the control group at 25^{o} of knee flexion for the operated leg. The experimental intervention assessed in the current study had substituted a volume-matched novel formulation of sensori-motor stimuli for conventional exercises used in contemporary practice. Instead of focusing on the use of elastic bands or weights for muscle strengthening (conventional practice), patients in the current study were challenged with managing increasing intensity in the use of the whole body, including segmental-mass-related inertia and momentum changes during activities such as step-ups, squats, lateral steps, and obstacle-avoidance. Patients were also challenged with progressively increasing levels of vertical ground reaction forces[28], postural balance[29], and by multi-directional force-stimuli[30]. It is likely that these features facilitated greater gains in sensori-motor function. Indeed, functional re-organisation in sensori-motor brain regions has been observed via training strategies that stimulate the neuromuscular system, and can potentially lead to the acquisition of improved motor control according to the task demands[31].

The combination of superior gains in sensori-motor function associated with undertaking focal sensori-motor exercise training was accompanied by a reduction in the incidence frequency of falls ($X^2_{(2)}$; $p < 0.001$). In the year prior to surgery, all patients had reported at least one fall. After surgery however, whereas 22 patients (~43 % of the total sample) within the control group experienced falling during the follow-up period, only 3 patients (~6 %) undertaking enhanced sensori-motor exercise training reported a fall. Future studies involving sensori-motor training interventions focusing specifically on the incidence of falls following total knee replacement will be able to corroborate these observations. Nevertheless, the favourable change to the frequency of falling associated with focal sensori-motor exercise training may have been driven by the patients' improvement in functional mobility, with Timed Up and Go Test scores at the end of the study (8.1 ± 1.7 s) firmly exceeding a minimally-important clinical criterion (13.5 s) for critical progressions in the risk of falls[32,33]. Further corroborating evidence for the superiority of the experimental group in contrast to the control group was that all participants exceeded the minimum detectable change (2.49 s) for the Timed Up and Go Test[16].

The experimental group elicited a significantly superior reduction in the patients' perceptions of pain (Visual Analogue Scale) compared to the control group. The extent of the reduction (89%; 6.0 cm) for focal training in particular substantially exceeds that noted for studies with a similar conceptual design[4] to that of the current one (33-42%; ~1 cm). As such, the findings suggest that the characteristics of exercises within the focal sensori-motor training as well as the early initiation after surgery are potentially important features underpinning the favourable improvements in the patients' perceptions of pain.

Overall, the results from the current study suggest that enhanced efficacy for sensori-motor exercise training can be achieved by patients self-managing rehabilitation. Early post-surgery initiation of a reasonable volume of exercise training (3 to 5 sessions per week; 35 to 45 minutes per session; 12-week programme) incorporating focal exercise stimuli from the beginning of the training programme as integral components of it (and for them not to be added later as extra features to contemporary functional exercise programmes), improved functional mobility and sensori-motor function. Conclusions within the recent systematic review[4] might usefully be modified to take account of this emerging evidence for optimised timing and volume of sensori-motor exercise training for patients electing total knee replacement surgery.

Limitations to this study were related to its design and delivery. Patients' compliance with exercise training was monitored by self-reported diaries rather than by direct evaluation, which may have led to increased heterogeneity amongst patients' dose-responses. Progression within training was monitored and evolved according to patients' weekly functional and postural control capabilities but not titrated against specific objectively-measured criteria or milestones. This feature of the current study may have hindered the efficacy of its rehabilitative interventions. Nevertheless, this study employed a modestly-sized sample of participants undergoing surgery for total knee replacement, which precludes excessive generalisation of the study's findings.

In summary, patients initiating a novel formulation of self-managed, focal sensori-motor rehabilitative exercise training soon after total knee replacement showed superior gains in functional mobility and sensori-motor function compared to contemporary practice. The novel exercise programme was delivered successfully using home-based care and involved an increased proportion of exercises focusing on improving sensori-motor function integrated within a volume-matched prescription of rehabilitative exercises. This study's findings facilitate informed decision-making within clinical practice and promote the effective use of focal sensori-motor exercise training.

Clinical messages

Focal sensori-motor rehabilitative training implemented early after surgery within a self-managed, home-based environment is more beneficial than functional exercise training for enhancing functional mobility and sensori-motor function in patients following total knee replacement.

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Table I. Pre-surgery (baseline) demographic characteristics, time on waiting list and measures of functional performance and pain.

Variable	**Group mean (SD)**	
	Control (n = 25)	**Experimental (n = 26)**
Age (years)	72.3 (5.6)	71.3 (5.3)
Height (m)	1.64 (0.10)	1.66 (0.10)
Weight (kg)	82.1 (10.3)	82.5 (8.9)
Time to surgery (weeks)	17.2 (14.9)	15.3 (12.8)
Falls (no. of falls during one year pre-surgery)	2.4 (0.8)	1.9 (0.6)
TUG (s)	16.9 (3.8)	15.9 (3.6)
VAS (cm)	7.0 (1.1)	6.7 (1.2)

TUG: Timed Up and Go Test; VAS: Visual Analogue Scale.

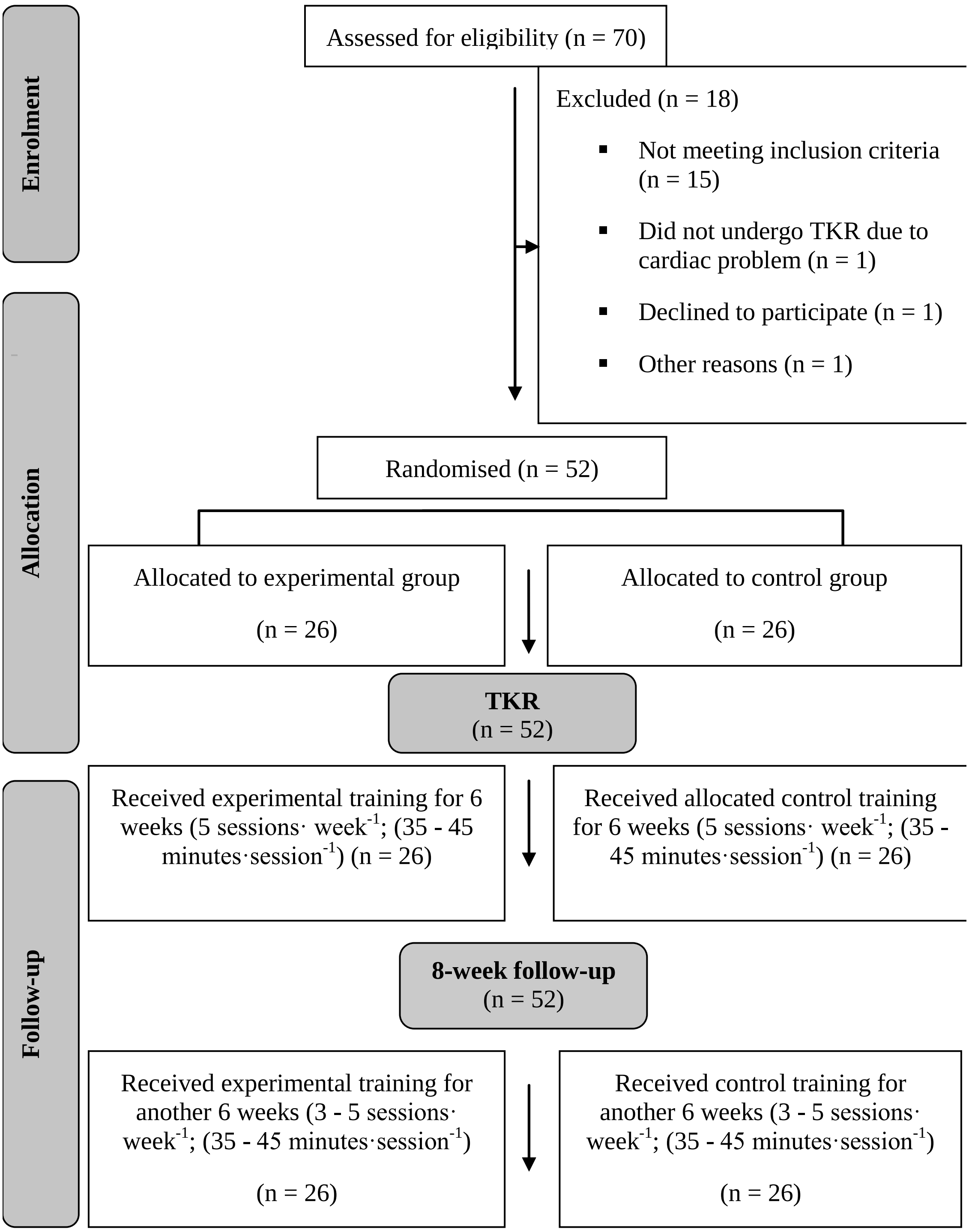
Table II. Group mean scores at pre-surgery, 8 weeks and 14 weeks post-surgery.

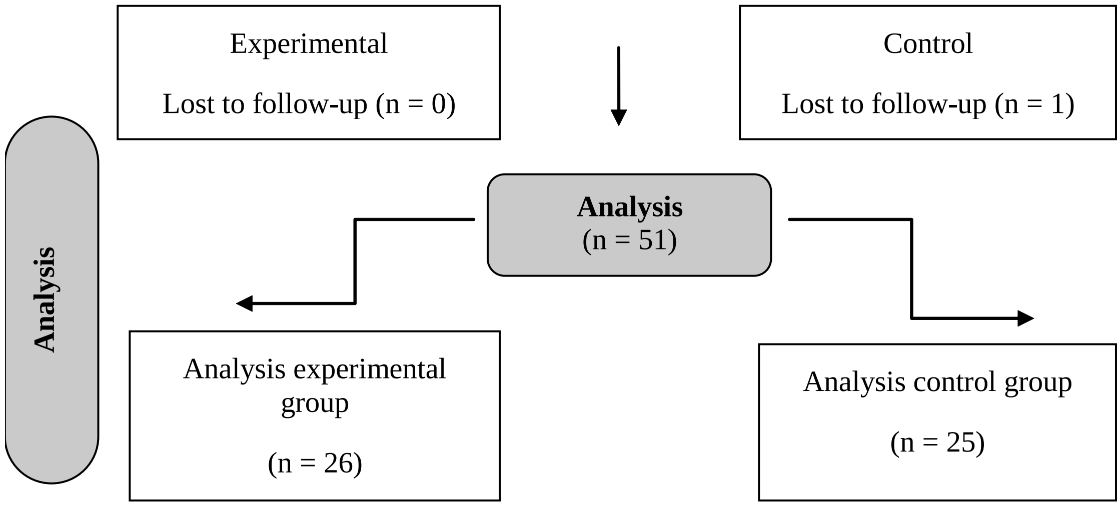
Variable	Group	Pre-surgery Mean (SD)	8 weeks Mean (SD)	14 weeks Mean (SD)	*p* value	F	ES
TUG (s)	experimental	15.8 (3.5)	11.2 (2.9)	8.1 (1.7)	0.002	11.2	2.8
VAS (cm)	control	17.0 (3.7)	15.1 (3.8)	12.4 (2.5)			1.4
KOS-ADL	experimental	6.7 (1.1)	3.0 (1.3)	0.7 (0.7)	0.001	7.0	6.5
	control	7.0 (1.1)	4.1 (1.4)	2.4 (0.8)			4.8
OSI (degrees)	experimental	35.4 (6.9)	56.2 (11.4)	79.6 (9.0)	0.001	19.0	5.5
APSI (degrees)	control	34.0 (7.3)	50.3 (9.4)	60.6 (9.3)			3.2
MLSI (degrees)	experimental	3.8 (1.3)	2.7 (0.9)	1.9 (0.6)	0.001	24.8	1.3
	control	3.4 (1.7)	3.3 (1.4)	3.0 (1.2)			0.3
JPE_{60} (%)	experimental	3.0	2.0	1.5 (0.7)	0.001	16.2	1.4

		(1.4)	(0.8)				
	control	2.2 (1.1)	2.0 (0.6)	2.1 (1.0)			0.1
	experimental	2.1 (1.0)	1.5 (0.6)	1.0 (0.5)	0.001	21.6	1.3
	control	2.0 (1.3)	1.4 (0.6)	2.0 (0.9)			0.0
	experimental	16.3 (6.1)	7.1 (4.1)	5.2 (2.6)	0.001	9.6	1.8
	control	17.1 (9.6)	13.9 (6.6)	12.8 (5.9)			0.4

P-value signifies the statistical significance of the interaction between the groups over time; ES: signifies the absolute difference in outcome measures for each group within the follow-up period (pre-surgery to 14 weeks); TUG: Timed Up and Go Test; VAS: Visual Analogue Scale; KOS-ADL: Knee Outcome Survey Activities of Daily Living Scale; OSI: Overall Stability Index; APSI: Antero-posterior index; MLSI: Medio-lateral index; JPE: Joint Position Error.

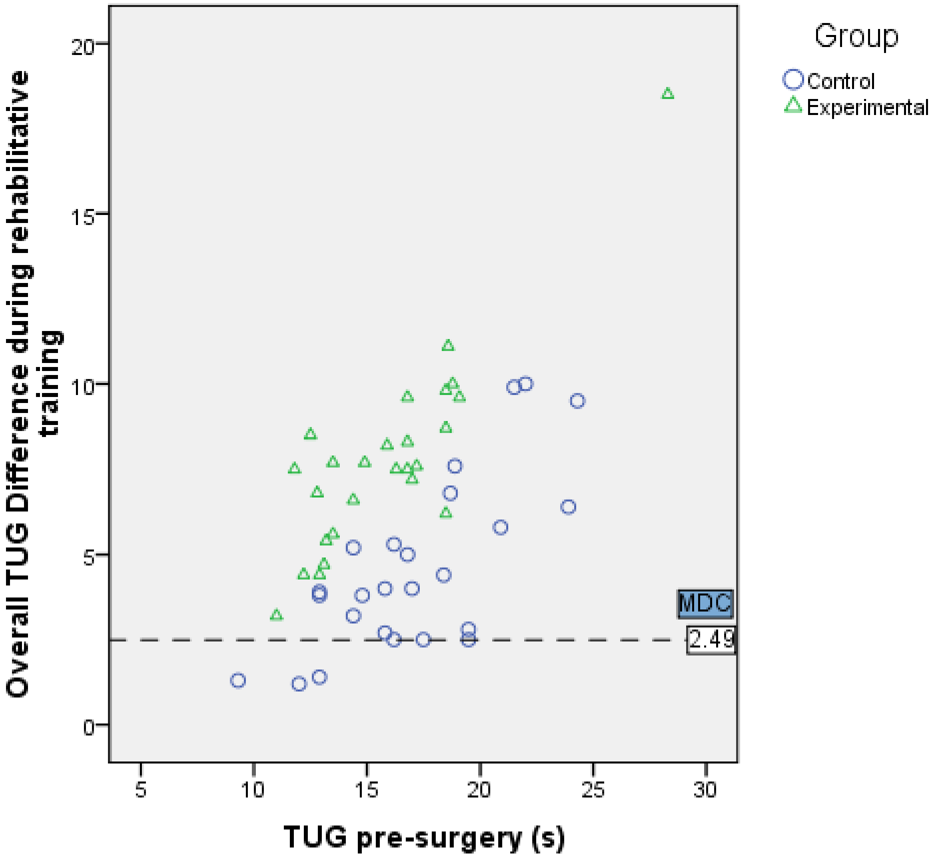
Figure I. Patient CONSORT flow of the study


Enrolment
Assessed for eligibility (n = 70)
Excluded (n = 18)
Not meeting inclusion criteria (n = 15)
Did not undergo TKR due to cardiac problem (n = 1)
Declined to participate (n = 1)
Other reasons (n = 1)
Allocation
Randomised (n = 52)
Allocated to experimental group
(n = 26)
Allocated to control group
(n = 26)
TKR
(n = 52)
Follow-up
Received experimental training for 6 weeks (5 sessions· week-1; (35 - 45 minutes·session-1) (n = 26)
Received allocated control training for 6 weeks (5 sessions· week-1; (35 - 45 minutes·session-1) (n = 26)
8-week follow-up
(n = 52)
Received experimental training for another 6 weeks (3 - 5 sessions· week-1; (35 - 45 minutes·session-1)
(n = 26)
Received control training for another 6 weeks (3 - 5 sessions· week-1; (35 - 45 minutes·session-1)
(n = 26)



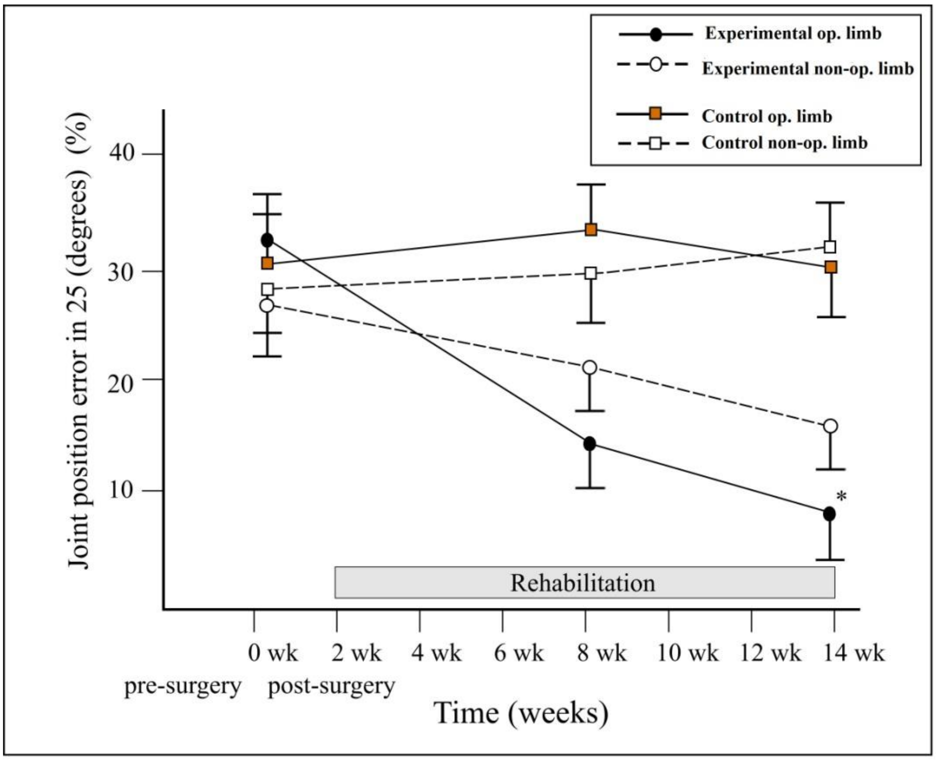
TKR: Total knee replacement

Figure II. Individual patient's improvement scores during the period of training exceeding the minimum detectable change in functional mobility as assessed by the Timed Up and Go Test.



MDC: Minimal detectable change; TUG: Timed Up and Go Test; TKR: Total knee replacement.

Figure III. Group mean (SD) scores from pre-surgery to 8 weeks and 14 weeks following total knee replacement surgery for JPE (%) at 25^{o} of knee flexion of both the operated and non-operated legs for patients undertaking rehabilitation involving focal sensori-motor (experimental) and functional exercise training (control).



JPE: Joint Position Error; wk: weeks; op.: operated. Data represent mean ± SD; *$p < 0.05$.

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We would like to thank the Musculoskeletal Association of Chartered Physiotherapists (MACP) for partially funding the PhD (via a Doctorial Research Award) from which this study has originated.

Conflict of Interest Statement: None Declared.

Author statement

I affirm that all authors have read and agreed the Statement for Authors.

Appendix I. Comparison of exercise training programmes undertaken by the focal sensori-motor exercise training group (experimental) with the functional exercise training group (control).

Exercise training programme	**Sessional volume**	**Control**	**Experimental**
Ankle ROM	10-20 reps	x	
Knee ROM; Stretches 5-10 min.	3-5 reps	x	x
Heel slide on wall	10-20 reps	x	
Straight leg raise	3-5 sets of 10 reps	x	
Quadriceps sets (short arc)	3-5 sets of 10 reps	x	x
Quads strengthening with elastic band (sitting)	3-5 sets of 10 reps	x	x
Quads strengthening with elastic band (standing)	3-5 sets of 10 reps	x	
Hamstrings strengthening with elastic band (standing)	3-5 sets of 10 reps	x	
Abductors (side-lying)	2-4 sets of 10 reps	x	
Sit-to-stand	10-20 reps	x	x
Wall slides	10-20 reps	x	x
Calf raises	10-20 reps	x	
20-30 min walking or stationary cycling	5-20 min.	x	x
Climb on a platform of stairs	10-30 steps	x	x
Marching (walk in place with large amplitude hip and knee flexion and upper limb movements)	10-20 reps		x
Side stepping (step sideways,	10-20 ft course		x

moving right to left and left to right)	length		
Braiding activity (alternate steps front and back cross-over while moving laterally)	10-20 ft course length		x
Square stepping	10-20 ft course length		x
Walk over small obstacles	10-20 ft course length		x
Balance on foam (place a foam or pillow and balance on two legs)	two- to single-leg stance		x
Tandem walking (bring one foot directly ahead of the other so that the heel of front foot touching toes of back foot)	10-20 ft course length		x

reps: repetitions.

CONSORT checklist

Section	Item	Page (on submitted text), and any comment
Title and abstract†	1	Title page and Abstract file
Introduction		1-2
Background	2	1
Methods		2-8
Participants†	3	2
Interventions†	4	3-4
Objectives	5	5

Outcomes	6	5-8
Sample size†	7	3
Randomization–sequence generation†	8	8
Allocation concealment	9	2-3
Implementation	10	4-5
Blinding (masking)†	11A	2
Statistical methods†	12	7-8
Results		8-11
Participant flow†	13	27-28
Implementation of intervention†	New item	8-9
Recruitment	14	8-9
Baseline data†	15	24
Numbers analyzed	16	8-9 & 24-25
Outcomes and estimation	17	9-11
Ancillary analyses	18	10-11
Adverse events	19	9

Discussion		11-17
Interpretation†	20	11-16
Generalizability†	21	16-17
Overall evidence	22	11-16