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ORIGINAL RESEARCH

Effects of Leg-Press Training With Moderate Vibration on Muscle Strength, Pain, and Function After Total Knee Arthroplasty: A Randomized Controlled Trial

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Abstract

Objectives: To examine the effects of a time-saving leg-press training program with moderate vibration on strength parameters, pain, and functional outcomes of patients after total knee arthroplasty (TKA) in comparison with functional physiotherapy.

Design: Randomized controlled trial.

Setting: Outpatient rehabilitation department at a university teaching hospital.

Participants: Patients (N=55) with TKA were randomly allocated into 2 rehabilitation groups.

Interventions: Six weeks after TKA, participants either underwent isokinetic leg-press training combined with moderate vibration (n=26) of 15 minutes per session or functional physiotherapy (n=29) of 30 minutes per session. Both groups received therapy twice a week for a period of 6 weeks. Participants were evaluated at baseline (6wk after TKA) and after the 6-week rehabilitation program.

Main Outcome Measures: The main outcome measure was maximal voluntary contraction (MVC) of the involved leg. Secondary outcome measures were pain assessed with a visual analog scale (VAS), range of motion, stair test, timed Up and Go test, and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC).

Results: Both groups showed statistically significant improvements in MVC of knee extensors measured on the knee dynamometer (leg-press group: from 0.8±.06 to 1±.09Nm/kg body weight [BW], physiotherapy group: from 0.7±.06 to 0.9±.06Nm/kg BW; $P<.05$) and in closed kinetic chain on the leg press (leg-press group: from 8.9±.77 to 10.3±1.06N/kg BW, physiotherapy group: from 6.7±.54 to 9.1±.70N/kg BW; $P<.05$) and in pain at rest (leg-press group: from 2±.36 to 1.3±.36 on the VAS, physiotherapy group: from 1.2±.28 to 1.1±.31; $P<.05$), WOMAC scores, and functional measurements after 6 weeks of training. There was no significant difference between the 2 groups concerning strength, pain, and functional outcomes after training ($P>.05$).

Conclusions: Isokinetic leg-press training with moderate vibration and functional physiotherapy are both effective in regaining muscle strength and function after TKA; however, isokinetic leg-press training is considerably less time consuming.

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Osteoarthritis of the knee is a growing financial burden to the health care systems of industrial countries because of increasing treatment costs. In 2013, the countries with the highest rate of knee replacement surgery per 100,000 inhabitants in the European Union were Austria (215/100,000), Finland (201/100,000), and

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Germany (188/100,000).[1] The number of total knee arthroplasties (TKAs) in Austria increased from 15,598 in 2008 to 18,260 in 2013.[1]

The positive outcomes after TKA regarding reduction of pain are well documented. However, muscle weakness and functional impairments in walking and stair climbing and a reduced quality of life often persist for years after TKA.[2-4] Best rehabilitation results were achieved with outpatient programs, including strengthening and functional exercises,[5-8] but the applied rehabilitation protocols differ regarding structure and methods.[7]

Most studies show short-term (3−6mo after TKA) benefits regarding functional capacity,[7-11] reaching a plateau 6 to 12 months after TKA, with remaining deficits compared with the contralateral leg or age-matched controls.[2,4,8,12-19] Quadriceps and leg extensor strength as main factors contributing to functional performance after TKA are well correlated to functional outcome measures.[19-22] Excellent results of early progressive strength training on a leg-press machine after TKA were reported.[23,24] Untrained women, older people with knee osteoarthritis, and patients after TKA achieve improvements of knee muscle strength through whole-body vibration (WBV) training and progressive resistance training.[25-30] Recent studies have presented good results of leg-press training combined with vibration in older athletes.[31] However, little is known concerning the effects and safety of leg-press training with moderate vibrations applied shortly after TKA in comparison with therapy without vibration.[32-34] The aim of this study was to evaluate the effects and feasibility of a time-saving leg-press training protocol with moderate vibrations compared with functional physiotherapy in an outpatient setting regarding the improvement of muscle strength, pain, and functional parameters after elective primary TKA.

Methods

Participants

The data presented in this article are part of a multinational European Union project named Interreg-IIIa, where patients were observed before TKA and during postoperative rehabilitation.

There were 350 subjects scheduled for their first TKA at the Otto Wagner Orthopaedic Hospital in Vienna, Austria, between 2010 and 2013, who were sent a letter to invite them to participate in the study. Before the first tests, all volunteers were required to undergo thorough medical examinations to exclude patients who might face a high health risk during maximum strength measurement in the context of this study. Other specific exclusion criteria were body mass index ≥40kg/m^2; previous knee replacement; pain in the contralateral leg ≥5 (visual analog scale [VAS]); recent deep vein thrombosis or any infection; myopathy; neurologic, pulmonary, or symptomatic cardiovascular diseases; vertigo or impaired cognitive function; recent or past cancer; rheumatism; or any other relevant limitations of the musculoskeletal system.

All participants were informed about the testing procedures and possible risks, and written informed consent had to be signed prior to inclusion in this study. In addition, ethical approval was obtained from the ethical commission of the municipality of Vienna (EK 07-057-0407).

List of abbreviations:

BW	**body weight**
MVC	**maximal voluntary contraction**
ROM	**range of motion**
TKA	**total knee arthroplasty**
TUG	**timed Up and Go**
VAS	**visual analog scale**
WBV	**whole-body vibration**
WOMAC	**Western Ontario and McMasters University Osteoarthritis Index**

Table 1 Baseline characteristics of study subjects

Variable	PT (n=29)	LP (n=26)	P*
Sex (male/female)	9/20	9/17	—
Bilateral osteoarthritis	27	20	—
Age at surgery (y)	68.3±6.7	64.9±6.0	.06
Height (cm)	167.1±7.8	169.8±9.3	.25
Weight (kg)	78.2±13.0	83.0±14.0	.20
BMI (kg/m^2)	28.0±3.8	28.7±4.1	.47

NOTE. Values are mean ± SD unless otherwise indicated.
Abbreviations: BMI, body mass index; LP, leg-press group; PT, physiotherapy group.
* *P* values are based on 2-tailed *t* tests for independent samples.

Prosthesis

All participants had received an unconstrained, bicondylar implant through standard surgical procedure. Both types of implants consisted of either fully cemented or hybrid components (tibia cemented, femur uncemented), with a rotating mobile bearing platform.

Study design

All sixty-two participants were randomly assigned to 1 of 2 groups by using shuffled sealed envelopes. The leg-press group (n=31) underwent a supervised strength training program on a computer controlled linear motor driven leg-press machine, whereas the physiotherapy group (n=31) followed a functional physiotherapy program. The rehabilitation program consisted of 2 weekly sessions for a period of 6 weeks, therefore summing up to a total of 12 training sessions for both groups. All measurements were obtained at baseline (7wk after surgery) and at the end of the training regimen. The groups did not show any significant differences at baseline. Table 1 presents the demographic data of the subjects.

Interventions

Immediately after surgery, both groups underwent a standard inpatient physiotherapy program for 2 weeks. The postoperative rehabilitation protocol included standing on the first day, walking with 2 crutches, and climbing a flight of stairs from day 7 on. Patients were given instructions for lower-limb strengthening exercises (knee extensors and flexors, hip abductors, and adductors) and exercises to increase range of motion (ROM) and retrain proper gait patterns.

From weeks 3 to 6 after the operation, a standard outpatient rehabilitation protocol was applied consisting of progressive strengthening and ROM exercises during 30-minute functional physiotherapy sessions twice a week.