ORIGINAL ARTICLE

Effectiveness of Audio Feedback for Partial Weight-Bearing in and Outside the Hospital: A Randomized Controlled Trial

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ABSTRACT. Hurkmans HL, Bussmann JB, Benda E, Verhaar JA, Stam HJ. Effectiveness of audio feedback for partial weight-bearing in and outside the hospital: a randomized controlled trial. Arch Phys Med Rehabil 2012;93:565-70.

Objective: To determine the effectiveness of partial weight-bearing (PWB) training with audio feedback in patients after total hip arthroplasty (THA).

Design: Randomized controlled trial.

Setting: Orthopedic clinic and patients' homes.

Participants: Patients (N=38) after THA with trochanteric osteotomy.

Intervention: Patients were trained with (n=18) or without (n=20) audio feedback to perform PWB at a 10% body weight (BW) target load. PWB training started on day 2 or 3 postoperatively and was given once per day during the entire hospital stay.

Main Outcome Measures: Mean peak load (%BW), and the percentage of steps below, equal to, and above the target load. Weight-bearing was measured using an insole pressure system on postoperative day 7 in the hospital during PWB training (condition 1 [C1]) and when patients walked unsupervised (condition 2 [C2]), and on postoperative day 21 at home (condition 3 [C3]).

Results: PWB training with audio feedback resulted in better PWB (11.1% BW vs control, 21.9% BW; P=.006) at C1. The audio feedback group had more steps below the target load (21.4% vs control, 7.8%; P=.020) and fewer steps above the target load (15.6% vs control, 45.0%; P=.015). For C2 and C3, no significant differences were found between the patients receiving PWB training with and without audio feedback, for all outcome measures.

Conclusions: Patients with THA who received audio feedback were able to accurately perform PWB at the prescribed target load during PWB training, but were unable to replicate the prescribed target load when they walked unsupervised in the hospital or at home.

Key Words: Audio feedback; Weight-bearing; Randomized controlled trial; Rehabilitation.

PARTIAL WEIGHT-BEARING (PWB) is frequently instructed to patients after lower limb surgery (eg, fractures or joint replacements). The general concept behind PWB is that limiting the amount of body weight (BW) placed on the operated leg will enable proper fracture healing or fixation of a prosthesis, and will prevent complications such as bony nonunion or loosening of a prosthesis.[1-6] Although the relationship between the load under the foot and the load in the lower limb (eg, hip and knee joint load) is complex, the conventional therapy is to restrict weight-bearing. The amount of restricted weight-bearing usually ranges from 10% to 50% BW. The prescribed weight-bearing load depends on the individual decision of the operating surgeon, even for standardized procedures such as total hip surgery.

Physical therapists usually train patients to perform PWB for a period of 6 to 8 weeks. At the start of rehabilitation, PWB training takes place with the patient walking with the physical therapist in the hospital. At a certain point during rehabilitation in the hospital, the physical therapist decides that the patient is able to perform PWB unsupervised (ie, without a physical therapist). After the hospital stay, which nowadays is short (5–7d), patients perform PWB unsupervised at home (or in a nursing home).

Physical therapists mostly use verbal instructions, a bathroom scale, or both, to train patients how to perform PWB. Verbal instructions were found to be ineffective for training PWB, especially when using low weight-bearing limits.[7,8] Laboratory studies with mostly healthy young subjects have shown good[9,10] and poor results[11-13] for PWB training with a bathroom scale. Clinical studies reported that patients were unable to follow the weight-bearing restrictions when using the scale method.[14,15]

Knowledge of results (KR) and concurrent feedback are the types of feedback commonly used for PWB training. The fundamental difference between the 2 forms of feedback is timing. With KR the patient is given feedback about the outcome of PWB after performing PWB. KR is generally given in a verbal form[16] but can also be given in a visual (objective) form.[17] With concurrent feedback, the feedback is given during PWB. Concurrent feedback can be given verbally[18] or by using biofeedback devices that can provide immediate objective feedback.[14,19-21] Currently, there is no consensus on which type of feedback is the most appropriate for PWB training. Concurrent (auditory) feedback is described as an accurate performance tool,[14,19,21,22] but does not contribute to (long-term) learning of PWB and other motor skills.[13,18] In contrast, KR

List of Abbreviations

BW	body weight
CI	confidence interval
KR	knowledge of results
PWB	partial weight-bearing
THA	total hip arthroplasty

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seems to enhance learning of the PWB skill but is inaccurate for PWB performance.[18,23] Most studies evaluating KR and concurrent feedback have used healthy young persons performing simple motor skills in a laboratory setting, which makes generalization to a clinical setting with older postoperative patients difficult.[24,25] Because KR is permissive of exceeding PWB target levels, Schon et al[21] stated that this learning method is inappropriate for patients in whom exceeding these weight-bearing limits could have devastating effects.

According to Schon,[21] Hershko,[19] and colleagues, audio feedback is necessary in older patients to instruct PWB, particularly when low weight-bearing limits are used. Hershko[19] performed a randomized controlled trial and found that patients who had undergone total hip arthroplasty (THA) could retain the prescribed PWB level in the hospital after 10 days when audio feedback training was given for 5 days.[19] Both studies, however, evaluated the amount of weight-bearing in the clinic and by performing walking trials with a limited amount of steps. Therefore, it is unknown whether patients are able to replicate the prescribed weight-bearing in a natural setting and at home.

The aim of this study was to determine the effectiveness of PWB training with audio feedback in patients with a THA and trochanteric osteotomy by performing long-term weight-bearing measurements in and outside the hospital. A low weight-bearing limit of 10% BW was chosen because this target load is used at our hospital, and because lower target loads (10–15kg, 10%–30% BW) tend to result in larger differences between prescribed and actual weight-bearing than higher target loads (50% BW).[7,13,20,26]

We hypothesized that PWB training with usual verbal instructions and audio feedback results in more accurate weight-bearing than with verbal instructions alone. We evaluated this for 3 conditions: on postoperative day 7 in the hospital during PWB training (condition 1 [C1]) and during unsupervised walking (condition 2 [C2]), and on postoperative day 21 when the patient walked at home (condition 3 [C3]). A validated insole pressure system was used for the long-term weight-bearing measurements.[27,28]

METHODS

Design

The present study was a prospective randomized and controlled trial. Patients were randomly allocated into 2 training groups: group 1, PWB training with audio feedback (audio feedback group); and group 2, PWB training without audio feedback (control group). Randomization was performed using a table with random numbers, a block size of 10 patients, and sealed envelopes.[29] A blinded study protocol was not feasible.

Patient Population

Patients with a THA and trochanteric osteotomy for the treatment of osteoarthritis of the hip, between the ages of 40 and 80 years, and from whom a written informed consent was obtained were included in the study. Exclusion criteria were medical conditions or social problems due to which patients could not perform or could not be instructed to perform PWB (eg, Parkinson's disease, epilepsy, alcoholism), determined by the physical therapist; postoperative bed rest for more than 3 weeks; foot orthosis; foot deformities that needed special footwear; and a shoe size (European) smaller than 36 or larger than 45. The patients were recruited from the orthopedic departments from 2 hospitals: the Erasmus MC Rotterdam and the Ruwaard van Putten Hospital. The institutional review boards of the Erasmus MC Rotterdam and the Ruwaard van Putten Hospital approved the study.

Protocol

PWB training. The PWB training protocol was the same for both hospitals in which patients with a THA and trochanteric osteotomy have to perform PWB for a total of 6 to 8 weeks. Patients were trained by a physical therapist to perform PWB with a walker or elbow crutches (3-point gait[30]), depending on the walking ability of the patient. PWB training started on day 2 or 3 postoperatively, and was given once per day during the entire hospital stay. The prescribed target load was 10% BW, which is usually recommended by the orthopedic surgeons at the participating hospitals for this procedure. Both the audio feedback group and the control group received verbal instructions from the physical therapist on how to perform PWB. The audio feedback group was trained with an audio feedback system, and for the control group, visual observation was used to control the amount of weight-bearing. After PWB training, both groups received verbal feedback (KR[16,23]) on how well they performed.

For audio feedback the Pedalert system[a] was used. This lightweight device (.34kg) consists of 2 sensors placed in the forefoot and hindfoot of a cast shoe and uses a 9-V battery (fig 1). The adjustable warning tone signals when the desired target load (range, 2.3–45.4kg [5–100lb]) is met or exceeded, and can be set at a desired volume level. A bathroom scale is needed to set the target load. During PWB training, the Pedalert system was placed on the foot of the operated leg. The physical therapist informed patients beforehand that a "beep tone" meant too much load on the operated leg, and the absence of a "beep tone" meant that the patient had not exceeded the target load.

Measurements. The Pedar Mobile system[b] was used to measure the peak vertical force for each footstep. The system has been validated to measure the vertical force during walking over a long-term period.[27,28] All weight-bearing measurements were performed on postoperative day 7 (±2d) in the hospital during PWB training (C1) and when the patient walked unsupervised (ie, without a physical therapist) (C2), and on postoperative day 21 (±5d) at the patient's home (or in a nursing home) 2 weeks after discharge (C3). Before each measurement, the Pedar insoles were calibrated using the Trublu calibration device[b] and a GDH 14AN digital manometer.[c] The pressure

Fig 1. The Pedalert audio feedback system.