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Original research

How do leg press exercises comply with limited weight bearing?

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ABSTRACT

Objectives: To investigate foot loadings in different leg press settings with respect to a possible graduation of weight bearing (WB).
Design: Case series.
Settings: Assessing plantar force values by means of dynamic pedobarography taken place in orthopaedic departments' rehab center.
Participants: 15 healthy students (9 men and 6 women, age 23 ± 2, weight 75 ± 6 kg) were recruited as participants from the medical faculty.
Main Outcome Measures: Peak force values from normal gait (referred to as 100%) and single and double leg presses (SLP, DLP) with resistances of 10 kg, 20 kg and 40 kg, obtained with pedobarographic insoles.
Results: Performing DLP produced foot loadings (N) of 37 ± 15 with 10 kg, 91 ± 29 with 20 kg and 203 ± 27 with 40 kg, equal to 5%, 12% and 26% of full WB. SLP result in force values of 195 ± 32 with 10 kg, 308 ± 34 with 20 kg and 516 ± 45 with 40 kg, corresponding to 25%, 40% and 67% baseline.
Conclusions: Leg press exercises can be performed in accordance with a given limitation of foot loading. Above mentioned conditions allow a graduation from 5% to 67% of full WB.

1. Introduction

Limited weight bearing of the lower extremity is commonly recommended by surgeons following trauma surgery, hip or knee arthroplasty, ligament reconstruction, corrective osteotomies or different techniques of chondrocyte implantation. This is intended to assure wound healing, bone healing, tissue maturation and bony ingrowth of implants, although there is limited evidence to support this (Galloway, Lalley, & Shearn, 2013; Jahr, Matta, & Mobasheri, 2015; Mavčič & Antolič, 2012; Nishino et al., 2010). With respect to trauma surgery, there is some previous evidence that partial weight bearing is beneficial for bone healing in the treatment of tibial fractures (Da Costa & Kumar, 1979), and overloading can lead to delayed healing or non-union (Claes & Heigele, 1999). Following total hip arthroplasty, limited weight bearing is widely recommended (Hol, van Grinsven, Lucas, van Susante, & van Loon, 2010) and immediate weight bearing is considered to lead to a subsidence and absence of osseous integration of the femoral stem (Hol et al., 2010), but there is to date no evidence to support this. Partial weight bearing conditions have been established in patients receiving total hip arthroplasty (Boden & Adolphson, 2004; Hol et al., 2010), mostly depending on the surgeon's discretion, the type of implant and the way of implants' anchoring. There is a lack of data that represent high and evidence based grades of recommendation for terms of precise partial weight bearing conditions. In the field of cartilage surgery multiple postoperative rehabilitation programs were introduced, most with graduated weight bearing up to 12 weeks after surgery to secure tissue maturation and adaptation (Ebert, Robertson, Lloyd, Zheng, Wood, & Ackland, 2008; Edwards, Ackland, & Ebert, 2013; Minas & Peterson, 1999; Robertson, Fick, Wood, Linklater, Zheng, & Ackland, 2007; Wondrasch, Zak, Welsch, & Marlovits, 2009). For rehabilitation after anterior or posterior cruciate ligament reconstruction, weight bearing programs are recommended in most studies (Kim, Lee, Yang, Oh, & Yang, 2013; Kruse, Gray, & Wright, 2012). Such rehabilitation protocols commonly include leg press exercises to recover function of quadriceps femoris (Edwards et al., 2013; Kim et al., 2013; Pozzi, Snyder-Mackler, & Zeni, 2013; Schmitt, Quatman, Paterno, Best, & Flanigan, 2014). However, to date no investigations have been established if leg press exercises can comply with a given limitation of weight bearing. The aim of the present study was to assess foot loadings at different leg press settings in order to investigate if such exercises can be performed in accordance with a given limitation of foot loading.

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2. Methods

Our local Institutional Review Board approved the conduct of the study with no requirements. All participants gave informed consent to the work.

15 healthy students (9 men and 6 women, mean age 22 ± 8 years, mean weight 75 ± 6 kg) with no complaints of the lower extremity were recruited from the medical faculty (clinical part of human medicine studies) and asked to participate. There was no leg length discrepancy in any participant (determined with a pelvic scale by T.H.). One-time data collection took place in the rehab centre of our orthopaedic department. The measurement values were obtained by first and senior authors (orthopaedic surgeon) (L.W., T.H.), a proper execution of the performed exercises was controlled by a physical therapist (not an author). Firstly the participants were asked to walk normally across an even floor with full body weight to obtain reference values defined as 100%. Walking speeds were kept constant (1.5 m/s ± 5% tolerance), controlled by photoelectric barrier (Timy 2, Alge Timing, Lustenau, Austria). Data recording began when the participants reached their full walking speed. Afterwards a series of leg press exercises (BP0902, Bullinger & Weber GmbH, Offenbach, Germany) with graduated increasing resistances was performed. Cycles of leg press exercise began with the knee in 90° flexion, manually set by goniometer, followed by extension of the knee to 0° and return to the start position (Fig. 1). The sled (45 kg mass) was arranged at an angle of 10° to horizontal. A resistance of 10 kg was applied, followed by 20 kg and 40 kg respectively. For each weight, participants performed single leg (preferred leg) and double leg (both legs) exercises, each including 15 assessed cycles. Pedobarographic data were obtained using the pedar® X system (novel Inc., Munich, Germany), consisting of insoles holding 99 capacitive sensors that monitor local loads from the foot–sole interface at a frequency of 50 Hz. The size of the soles was adjusted individually based on each participant's foot size. The system was calibrated by the manufacturer immediately before data collection. A so-called "neutral shoe" (Fuss und Schuh Breidbach® Inc., Fulda, Germany) (Fig. 2) was utilised, which has recently been described as a reference shoe for insole-based pedobarography (Kluger, Carl, Jendrissek, Swoboda, & Hotfiel, 2014).

This shoe is made of Aerolastic® (Nora Systems GmbH, Weinheim, Germany). Its major component is ethylenvinylacetate-polymer, with a material thickness of 4 mm. At a density of 0.38 g/cm^3, the shore hardness is up to 50 Shore. These shoes have a heel pitch of 0 mm. Maximum force values (N, highest values during trial under foot) were obtained from 12 steps per foot during walking, following a previously published protocol (Arts & Bus, 2011) and 15 cycles during leg presses for each trial.

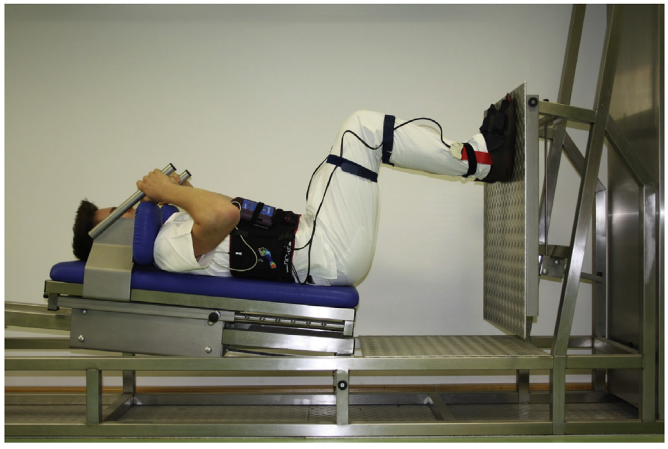

Fig. 1. Illustration of leg press exercises monitored by means of dynamic pedobarography.

Fig. 2. Illustration of the neutral shoes that were used to assess reference values for dynamic pedobarography.

Absolute values of peak force were transferred to GraphPad Prism® 5 software (GraphPad Software Inc., San Diego, USA). Values were checked for normality with the D'Agostino-Pearson test. In cases of normality, the paired t-test was applied, otherwise the Wilcoxon matched-pairs signed rank test was used, p-values of <0.05 were regarded as statistically significant. When 15 participants completed the study we calculated the SD of the before-after difference of peak force for each of the six trials. We are able to describe a difference of 20% between means (referred to results from baseline) with a power of more than 90%.

3. Results

Fig. 3 illustrates a summary of foot loads of different leg press conditions (referred to normal gait as 100%). Values were normally distributed. For the calculated peak force data, there were a number of significant differences recorded. Detailed results for normal gait and each leg press conditions are listed below.

3.1. Normal gait (reference values)

Peak force values obtained from normal gait were 774 ± 110 N (left foot) and 767 ± 100 N (right foot), no statistical significance was found ($p = 0.87$).

3.2. Double leg presses

With 10 kg we observed force values of 37 ± 15 N ($p < 0.0001$ to baseline), equal to a mean of 5% from full weight bearing. The corresponding values for 20 kg and 40 kg were 91 ± 29 N and 203 ± 27 N ($p < 0.0001$ to baseline for both), or a mean of 12% and 26% from full weight bearing.

3.3. Single leg presses

For SLP peak force values with 10 kg were 195 ± 32 N ($p < 0.0001$ to baseline), equal to a mean of 25% from full weight bearing. The corresponding values for 20 kg and 40 kg were 308 ± 34 N ($p < 0.0001$ to baseline) and 516 ± 45 N, or a mean of 40% and 67% from full weight bearing.