LOWER BODY POSITIVE PRESSURE AFTER KNEE SURGERY: DECREASED EXTREMITY LOAD WITH PRESERVATION OF GAIT MECHANICS

*Eastlack, R; *Groppo, E; *Cutuk, A; *Noh, H; *Langemack, A; **Quigley, E; *Steinbach, G; *Hargens, A; +*Pedowitz, R
+*Department of Orthopaedics, University of California San Diego, San Diego, CA. 350 Dickinson St (8894), San Diego, CA 92103-8894, 619 543-5555, Fax: 619 543-2540, rpedowitz@ucsd.edu

Introduction: Lower extremity rehabilitation after injury or orthopedic surgery frequently requires limited weight bearing in order to protect healing tissues. This situation can be complicated by medical conditions and by concurrent injuries that interfere with optimal rehabilitation. Current methods for lower extremity unloading include support harnesses and water therapy, but these modalities have serious practical limitations. Lower body positive pressure (LBPP) is a recently introduced technique that unloads the lower extremities.

Positive pressure within the LBPP chamber creates a force that unloads the patient and reduces effective body weight. LBPP decreases ground reaction force and maintains gait patterns during treadmill walking in normal volunteers (1). This novel rehabilitation method has not been evaluated postoperatively. The objective of this study was to evaluate effects of LBPP upon gait, heart rate, and subjective experience after knee arthroscopy.

Methods: The study was approved by the UCSD Human Subjects Committee. Nine patients (4 female, 5 male) with an age range of 28-73 volunteered to undergo LBPP testing 1 week after unilateral arthroscopic meniscectomy (surgery performed by RP). In random order each subject walked for 2 minutes at 2 different treadmill speeds (1.5mph, 2.0mph) under three LBPP conditions (100%, 60%, 20% of bodyweight (BW)).

Prior to exercise, subjects stood on a treadmill in the chamber with a neoprene waist seal that isolated the pelvis and lower extremities within the chamber. With the subject standing on a standard spring scale, pressure was increased within the chamber to determine the pressure needed to achieve 60% and 20% of baseline body weight. Calibrated, force sensitive shoe inserts were used to measure GRF during treadmill walking and data was recorded by computer. Time-synchronized surface EMG was monitored from the vastus medialis obliquous (VMO) and biceps femoris (BF) bilaterally. Knee range of motion was measured and recorded using calibrated surface electrogoniometers. Heart rate was measured via a pulse sensitive wrist device. Subjects rated levels of exertion and discomfort after each exercise condition using a 10 point visual analog scale.

EMG data were sampled at 2000Hz, full wave rectified, amplitude normalized to the maximum activity during walking at 100%BW. EMG data were standardized to the gait cycle for stance and swing phases using GRF data derived from the insoles. For each exercise condition, EMG data were then averaged at 100 uniform time points over six or seven sequential gait cycles. EMG patterns and peak amplitude were evaluated for each condition.

Data were analyzed using a one-way repeated measures ANOVA, and post-hoc tests were adjusted using the Bonferroni approximation. Visual analog data were analyzed using the Wilcoxon rank sums test. Statistical significance was set at p < 0.05.

Results: LBPP caused a significant decrease in GRF bilaterally during treadmill walking (Figure 1). Peak EMG amplitude of the VMO decreased significantly under LBPP conditions. However VMO muscle activity was quite high and activation patterns relatively conserved even at 20% body weight (Figure 2). Peak activity of the BF remained unchanged with LBPP. Range of motion (ROM) decreased significantly with LBPP, however the magnitude of this decrease was relatively small (average decrease 11 degrees from full body weight to 20% body weight). Stance time remained constant between LBPP conditions, without a difference between the operated and contralateral leg. There was no difference in gait parameters as a function of walking speed. Heart rate decreased significantly with LBPP (approximately 12 beat per minute decrease at 20% body weight). There was a statistically significant decrease in perceived exertion with LBPP. Seven of nine patients had less knee pain while walking at 20%BW versus 100%BW.

Discussion: This study is the first to evaluate the utility of lower body positive pressure in a postoperative population. LBPP markedly reduced the ground reaction forces on the postoperative limb, while maintaining relatively normal gait mechanics. Although there were some changes in EMG activity and knee ROM, ambulation during LBPP resulted in significant joint motion and muscle activation, with decreased heart rate and lower exertion ratings.

Decreased ground reaction force should correlate with decreased bone and joint loads during ambulation on the treadmill. This technique will therefore facilitate gait recovery and physical rehabilitation in clinical conditions that require decreased lower extremity loading (for example after fracture fixation or ingrowth arthroplasty). LBPP was well-tolerated in our patients and is a safe method of facilitating gait recovery after surgery.

Frequently, postoperative patients must compromise optimal rehabilitation because of logistical, medical, or safety issues. Assist devices, such as crutches or walkers, markedly alter joint and gait mechanics, and can be particularly difficult for elderly, poly-traumatized, and spinal cord injury patients. Water therapy cannot reproduce normal motion mechanics, and is inappropriate during the immediate postoperative period. Future studies will examine the clinical efficacy of LBPP for rehabilitation after severe orthopedic injury and orthopaedic surgery that require limitation of lower extremity loads.

Acknowledgement: Supported by NASA and UCSD Chancellors Associates. Special thanks to Ramford Ng for his technical contributions.


**Childrens Hospital, San Diego, CA.