Clin Orthop Relat Res (2017) 475:966–968 / DOI 10.1007/s11999-017-5268-y

Clinical Orthopaedics and Related Research®
A Publication of The Association of Bone and Joint Surgeons®

Published online: 3 February 2017

From Bench to Bedside

From Bench to Bedside: Ischemia is Bad … Right?

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Physicians and other medical personnel learn early in their training that ischemia is, well, bad. Insufficient oxygen in tissues leads to potentially fatal events such as myocardial infarctions and cerebrovascular accidents. From an orthopaedic perspective, ischemia is associated with muscle necrosis, neuropathy, and compartment syndrome—function- and extremity-threatening conditions that can lead to serious disability and even death. Interestingly, though, blood flow restriction training represents one of the promising trends in physical therapy. Essentially, patients perform low-resistance exercises with a partially inflated tourniquet or a blood pressure cuff on the proximal extremity in a supervised setting.

While rehabilitation may not be "sexy," supervised rehabilitation and physical therapy remain a critical component of the surgeon's preoperative, postoperative, and nonoperative treatment armamentarium. Indeed, most of us have seen great successes when a motivated patient partners with a knowledgeable and diligent therapist. And excellent surgical results often depend as much on events that take place before or after the procedure in the therapy suite.

But for all that physical therapists do, we remain all-too-aware that strength deficits often persist after routine procedures such as TKA or intramedullary nailing of a femur fracture [8, 14]. It is surprising, then, to note that there exists a dearth of randomized or high-quality nonrandomized trials within physical therapy, and those that are available compare supervised physical therapy to no therapy at all or a "home exercise program" [3, 10]. Anyone who has ever failed to keep a New Year's resolution can imagine the likely compliance with the latter approach.

As a profession, we often, almost reflexively, believe that more of a good thing is better. Stiff knee after arthroplasty? More therapy! Weak quadriceps after femur fracture? More therapy! However, less supervised therapy may certainly be adequate, and potentially equivalent, for many patients [10, 11].

Early results of blood flow restriction training do suggest that less can be

A note from the Editor-in-Chief:
I am pleased to present the next installment of "From Bench to Bedside," *a quarterly column written by Benjamin K. Potter MD, FACS. Dr. Potter is a clinician-scientist in the Department of Orthopaedics at Walter Reed National Military Medical Center and in the Department of Surgery at the Uniformed Services University of Health Sciences. His column investigates important developments that are making—or are about to make—the transition from the laboratory to clinical practice, as well as technologies and approaches that have recently made that jump.*

The institution of the author (BKP) has received, during the study period, funding and personnel support from the Major Extremity Trauma Research Consortium (METRC).
All ICMJE Conflict of Interest Forms for authors and *Clinical Orthopaedics and Related Research*® editors and board members are on file with the publication and can be viewed on request.

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more. Low-load strengthening with 20% of one repetition maximum demonstrated equivalent results to normal training with 80% load [1, 15], representing an appealing regimen in terms of potential efficacy. Additionally, higher loads may not be desirable, tolerated, or even permitted in some cases, such as following surgery for unstable or articular fractures. Further appeal comes from the relative ease of implementation—generally just routine, closed-chain exercises plus a tourniquet. Last, because all that is needed is a safe blood flow occlusion device, blood flow restriction training is cheap.

Assuming that blood flow restriction training really works, how does it work (if ischemia is bad)? Relative ischemia during blood flow restriction exercise may simulate the inadequate energy and oxygen supply-demand circumstances and resulting physiologic responses which occur when we approach muscle failure at higher loads. Studies have demonstrated an increase in myonuclei via PAX7 activation and increased S6K1 phosphorylation following blood flow restriction training, with resulting augmented myoprotein synthesis and, ultimately, muscle hypertrophy [4, 12]. Furthermore, animal models have shown improved bone healing with the use of blood flow restriction, with one current hypothesis being that venous occlusion results in increased intraosseous pressure, effectively simulating mechanical loading and the resulting osseous response [6, 13].

Early clinical results have been promising [1, 7], and although high-quality studies are currently lacking, prospective, randomized trials are underway [2]. What about safety? More evidence from large studies is needed, but results from numerous studies to date have been reassuring [9].

Even NASA has gotten into the game, researching the ability of blood flow restriction to reduce muscle and bone mineral density loss associated with the prolonged weightlessness inherent to space travel [5]. Thus, while counterintuitive (remember, ischemia is bad), with ease of execution, low expense, sound translational research foundation, and evolving body of supporting evidence, practicing orthopaedic surgeons need to become familiar with blood flow restriction training. Here's to hoping that less really can be more.

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in the presentation implies any Federal/DOA/DON/DOD endorsement. The author received no financial support for this editorial.

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