Efficacy of Multimodal Training to Alter Bone Mineral Density and Body Composition in Persons with Spinal Cord Injury: A Case Study.

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ABSTRACT

Approximately 12,000 spinal cord injuries (SCI) occur annually, with 80 % of injuries occurring in men. A severe complication of acute SCI is osteoporosis, which is localized at the proximal tibia and distal femur that typically receive loading. Bone loss enhances fracture occurrence at the knee and hip in everyday activities involving little to no trauma. Because bone loss and subsequent fractures elicit severe clinical, psychological, and financial complications, early intervention to slow rate of bone loss in persons with SCI is essential. Efficacy of exercise training to slow bone loss or promote new bone formation in this population is equivocal, as many studies have failed to provide a sufficient 'mechanostat' threshold to promote bone growth.

In this study, one subject participated in a preliminary investigation in which DXA scans were performed at baseline and after 6 mo to assess bone mineral density (BMD). A 21 year-old woman two months post-SCI (ASIA A complete injury at C5) underwent 6 mo of intense training 2 – 3 d/wk, 2 – 3 h/d, consisting of vibration training, body weight support treadmill training, resistance training, electrical stimulation, and load- bearing exercise. Her training program was developed and supervised by experienced personnel certified in activity-based recovery of persons with SCI.

Results demonstrated that distal femur BMD was increased by 10 % with training, yet proximal tibia (- 14 %) and total body leg BMD (- 10 %) were reduced. Dramatic losses in BMD were observed for the right/left femoral neck (6.8 – 11.4 %) and greater trochanter (19.2 – 21.9 %). Body mass was increased by 6.4 kg, with the excess mass attributed to a 35 % increase in fat mass (FM) and minimal decrement (- 1.5 %) in lean body mass (LBM). Percent body fat increased from 33.5 – 41.2 %, with increased FM revealed in the arms (10 %), legs (27 %), and trunk (52 %). LBM was increased in the legs (11 %), although attenuated in the arm (- 14 %) and trunk (- 7 %).

Leg LBM is typically decreased soon after SCI, and total-body and regional depots of fat mass are typically increased. The observed increase in leg LBM highlights the benefits of intense, multi-modal training to preserve muscle mass. The marked bone loss at the hip has inspired modification of her current training to increase loading at this site to potentially slow bone loss and reduce fracture risk.

BACKGROUND

1. Bone loss at weight-bearing sites of the lower extremities is a severe complication in persons with SCI.
2. Increased fat mass (FM) is typical in persons with SCI, which increases risks for chronic disease in this population.
3. Common modes of rehabilitation include electrical stimulation, load-bearing, vibration, and body weight support treadmill training.
4. Efficacy of training to slow bone loss and deleterious changes in body composition (BC) in the SCI is equivocal, with protocols showing significant preservation, or small increases, in BMD characterized by intense training volumes (> 4 d/wk, ~ 1 h/d, for at least 6 mo) rather than less rigorous training.
5. It has been reported (Clark et al., 2007) that single-mode exercise may not elicit the mechanostat threshold (Frost, 1987) needed for bone to respond to training .
6. No study has examined efficacy of intense multi-modal training to alter BC and BMD in persons with SCI.

AIM

To investigate the effects of intense multi-modal training on changes in regional and whole-body body composition and bone mineral density in a person with acute SCI.

METHODS

Subjects

- 21 year-old woman 2 mo post-SCI (ASIA A complete injury at C5).
- She completed 6 mo of training, 2 - 3 d/wk, 2 - 3 h/d, consisting of:
  - electrical stimulation
  - load-bearing exercise
  - body weight support treadmill training
  - resistance training
  - vibration training
- Training focused on improving overall physical function, with 80% of training focusing on the trunk and lower extremities
- Training supervised by certified personnel with 10 yr of experience in activity-based training for SCI

Pre-exercise Assessments

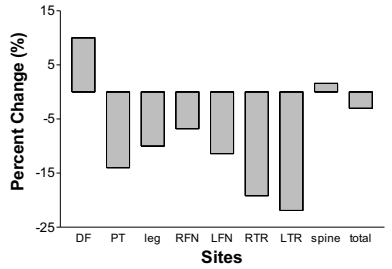
- Subject provided informed consent and completed a health-history questionnaire prior to participation.

Assessment of BMD and BC

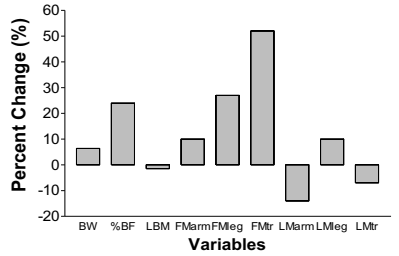
- DXA (GE Lunar Prodigy Advance) scan was completed at 0 and 6 mo.
- BMD assessed at the following sites: (Shields et al., 2005)
  - distal femur (DF)
  - proximal tibia (PT)
  - proximal femur (PF)
  - lumbar spine (L1-L4)
  - femoral neck (FN) and greater trochanter (TR)
  - whole body
- Body composition was assessed using DXA
- LBM, BW, and FM
  - Regional sites including the legs, trunk (tr), and arms

RESULTS

Change in BMD in response to multi-modal training



Change in body composition in response to multi-modal training



CONCLUSIONS

1. Increased body mass and FM were evident, although LBM in the leg was increased in response to 6 mo of rigorous multi-modal training.
2. Distal femur BMD was increased in response to training, yet BMD at the hip and proximal femur was reduced.
3. Future long-term studies are needed in larger populations to confirm this increase in distal femur BMD in persons with acute SCI in response to intense, multi-modal training.