

RISK FACTORS FOR OVERUSE INJURIES IN CHILDREN: A MODELING & MOVEMENT SIMULATION APPROACH

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INTRODUCTION

Many children participate in organized sports programs involving year-round repetitive training that can lead to overuse musculoskeletal injuries. Developmental factors have been suggested to contribute to these injuries such as tissue strength imbalances and tissue growth rate differences, (Tipton 1978, Woo 1990, Edwards 1995). However no scientific studies have been conducted to test these ideas and there has been little work done to determine cause-effect relationships between growth and development, injury and movement performance (Tipton 1978).

The objective of this research was to develop an approach to investigate the interactions between growth and the loads imposed on specific tissues during jumping. This approach was then used to test the hypotheses that growth-spurt induced muscle strength and limb inertial property changes increase the stresses in tendons and apophyses. Tissues of the lower extremity are common sites of overuse injuries in children and jumping is a common movement associated with many children's activities. Thus, a musculoskeletal model of the lower extremity and simulated jumping movements were considered in this study.

METHODS

The lower extremity bone model provided with Software for Interactive Musculoskeletal Modeling (SIMM, Motion

Analysis Corporation) was modified to represent the anatomy of a 12-13 year old child. This was achieved by scaling the nodal bone mesh of the femur and tibia. Nodes near the growth plates were longitudinally translated to represent an average growth spurt (Figure 1). Muscle-tendon insertions and slack lengths were scaled accordingly. Data from Jensen (1987, 1988), and Seger (2000), were used to estimate segmental mass, center of mass, moments of inertia, and length for the foot, shank, thigh and head-arms-torso(HAT) segments of the model pre- and post-growth spurt.

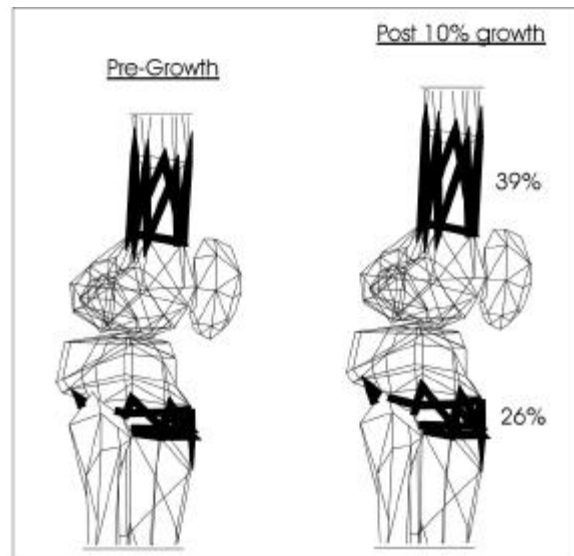


Figure 1. Illustration of growth model. 10% leg growth has been partitioned such that 39% occurs in the distal femoral epiphysis and 26% in the proximal tibial epiphysis (Martin, 1998).

Sample kinetic, kinematic, and muscle activation data were collected on an individual performing a maximum effort vertical jump (Figure 2). These data are being used to define the movement profile of a jumping child in SIMM.

Once the movement parameters are defined, then the jumping movement is simulated using SIMM for both the pre- and post-growth spurt anthropometry and strength characteristics. Joint moments and tissue loading curves will be compared between the pre- and post-growth spurt simulations to test the stated hypotheses.



Figure 2. Data collection setup of an adolescent subject performing a maximum effort vertical jump.

RESULTS & DISCUSSION

The growth modeling approach has been developed, and the vertical jump simulations are currently underway. Forward dynamic analyses are being run in SIMM, with joint moments and tissue loads output and compared between the pre- and post-growth spurt input conditions.

It is anticipated that these growth/movement simulations will result in an increase in tendon and apophysis loading following the growth spurt. Higher loads are expected to result from shifts in limb inertial properties that require greater muscular effort to produce the same jump height performance.

The advantage of this approach is that it allows the decomposition of the interactions between tissue loading factors. For example, tendon preload changes, as a result of asynchronous bone-tendon growth, may be modeled independently of muscle strength changes or limb inertial properties, to test the affects such changes have on tissue loads and movement dynamics.

This study provides the foundation to thoroughly and accurately simulate the biomechanical behavior of an active adolescent. This approach is valuable for identifying factors that do and do not contribute to adolescent injury, thereby facilitating a decreased cost of study of this phenomenon in-vivo. In the future, this approach may be altered to investigate other growth or atrophy related phenomena.

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