SA5

Myotendinous Changes with Disuse and Ageing

M.V. Narici

Institute for Biophysical and Clinical Research into Human Movement, Manchester Metropolitan University, Alsager, UK

Muscle weakness and atrophy are well known consequences of disuse and ageing. Whereas reduced physical activity, hormonal, and possibly, nutritional factors are the primary causes of the loss of muscle mass in disuse; in ageing, neuropathic processes, as well as well as the above factors, contribute to the condition of sarcopenia. In both conditions, however, the loss of muscle mass exceeds that of muscle size and a decrease in force per unit of muscle cross-sectional area (F/CSA) is observed. Several factors contribute to this phenomenon but, generally, these may be of muscular, tendinous and neural origin. What seemed less known up to date, was the role of changes in muscle architecture and in tendon mechanical properties in the decrease of F/CSA with disuse and ageing. However, recent evidence shows that both muscle architecture and tendon mechanical properties are markedly modified in both conditions. MRI-determined muscle volume of the gastrocnemius medialis (GM) and ultrasound-based measurements of fibre fascicle length, pennation angle and GM tendon stiffness were obtained in vivo in: 1) a population of elderly individuals aged 70-81 years and compared to a group of height-matched young adults aged 27-42 years, and 2) in a group of 19 young adults undergoing a 90-day bed rest period (ESA LTBR 2001-2 study). The two studies received ethical approval by the host institutions were the experiments were performed. In ageing, sarcopenia, represented by a 25% loss of muscle volume, was associated both with a decrease in GM fascicle length (10%) and in pennation angle (13%). Also, tendon stiffness was 14% lower in the elderly. In disuse, the 90-day bed rest period resulted in a 9% and 14% decrease in GM fascicle length and pennation angle, respectively and, similarly to ageing, tendon stiffness was reduced by 32%. These myotendinous alterations are expected to influence the length-force relation of muscle fibres and, as such, may play a role in the decrease in intrinsic muscle force with disuse and ageing.

The author is particularly grateful to Drs Constantinos Maganaris and Neil Reeves for their contribution to the work described in the abstract

SA6

Skeletal Adaptation to Mechanical Stimuli - Genes, Molecules and Mechanics

S. Judex

Biomedical Engineering, State University of New York at Stony Brook, Stony Brook, NY, USA

The plasticity of bone to mechanical forces is critical to the success of the muskuloskeletal system. While a link between mechanical forces and skeletal morphology was first recognized by Galileo Galilei in the early 1600's, our incomplete understanding of mechanotransduction from the organ- down to the molec-

ular/genetic level has crippled our efforts to design effective mechanical (and pharmaceutical) interventions that can promote bone formation without significant side-effects. The current tenet is that mechanical stimuli have to be large in magnitude to elicit an adaptive response. High-impact exercise, when applied for few loading cycles, may indeed be anabolic but among those who are most vulnerable to osteoporosis, low compliance and the possibility of large magnitude forces damaging an already frail skeleton have prevented its widespread use. We have recently shown that even extremely low-magnitude mechanical signals, an order of magnitude below those associated with vigorous exercise, can readily stimulate bone formation and ameliorate mechanical properties. These signals are effective in the growing as well as adult skeleton and may not only be anabolic but also anti-catabolic, even when they are applied for as little as 10 min/day. Interestingly, these low-level vibrations are also sensed in surrounding muscles, highlighting the close functional relation between muskuloskeletal tissues. We have further identified strong interrelations by which gender and genetics influence the efficacy of anabolic as well as catabolic mechanical signals. In particular genetics can greatly affect bone's plasticity to changes in its mechanical milieu, allowing for the determination of genes underlying this trait. Correlating the molecular response to mechanical stimuli with the induced changes at the tissue level may uncover novel drug targets that are not addressed by current pharmacological interventions and may also enable rapid advances in tissue engineering. In summary, bone's plasticity to mechanical stimuli is apparent and the identification of the involved genes, molecules, and mechanics will lead to diagnostic, prophylactic, and therapeutic measures (tailored to an individual's genotype) to combat bone diseases.

This work was kindly supported by NASA, NSBRI, NSF, Army, and the Whitaker Foundation.