'Functional muscle-bone unit' in osteoporotic patients

H. T. Ma[1,2], J. F. Griffith[2], L. Xu[3], and P-C. Leung[2]

[1]Harbin Institute of Technology Shenzhen Graduate School, Shenzhen, Guangdong, China, People's Republic of, [2]The Chinese University of Hong Kong, Hong Kong, China, People's Republic of, [3]Beijing Jishuitan Hospital, Beijing, China, People's Republic of

Introduction: Bone is an architecturally adaptive tissue which responds to external forces through bone remodeling. Any understanding of osteoporosis is not complete without comprehending the relationship between bone and muscle. To reflect this relationship, the concept of a 'functional muscle-bone unit' was proposed [2]. The 'functional muscle-bone unit' is defined as the ratio of bone mineral content (BMC) to muscle cross-sectional area (CSA) and it gives an indication of bone strength relative to muscle strength as both BMC and muscle CSA are recognized surrogates of bone and muscle strength respectively. This study uses the functional muscle-bone unit concept to evaluate the relationship between bone strength and muscle mass of the lumbar spine in young normal females and healthy elderly females of varying bone mineral density (BMD).

Methods: 177 volunteers (comprising 22 young females (mean age ± SE) and 155 elderly females (mean age ± SE)) were recruited. BMC and BMD of the lumbar spine (L1~L4) was measured by dual x-ray absorptiometry (DXA) and, based on these criteria, subjects were classified into 4 groups: young normal, elderly normal, elderly osteopenia, and elderly osteoporosis.
MRI examination of the lumbar spine examination was performed on a 1.5-T whole body imaging system (Intera NT; Philips Medical Systems). The cross-sectional area of the paraveretebral muscles (psoas major, quadratus lumborum, and erector spinae muscle complex) was measured on T1-weighted (TR/TE, 450/11 ms; 4 mm thick) axial images (Fig.1). Both whole and lean muscle mass were measured. Whole muscle mass of the individual muscle groups was determined at each lumbar level from L2/3 to L5/S1. Lean muscle mass was obtained from whole muscle CSA minus segmented fat areas. The 'functional muscle-bone unit' of the lumbar spine was calculated for both whole and lean muscle respectively.

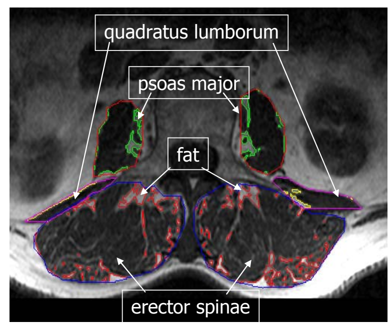

Fig.1. T1-weighted axial MR image showing muscle CSA area measurement

Results: Compared to normal young subjects, the erector spinae muscle mass was larger in elderly normal subjects (p=0.001), while that of the psoas major ($p<0.001$) and quadratus lumborum ($p<0.001$) muscle groups was smaller. The 'functional muscle-bone unit' for all three muscles was smallest in elderly osteoporotic subjects ($p<0.001$) for both whole and lean muscle, implying relatively more muscle mass per unit bone mass in osteoporotic patients. For most muscle groups, muscle mass was mild to moderately correlated ($0.26<r<0.41$, $p<0.01$) with bone mass, irrespective of whether whole muscle or lean muscle CSA was used. Regression analyses confirmed that the 'functional muscle-bone unit' decreases as BMD decreases ($p<0.001$) with the highest correlation being found with erector spinae muscle (Fig.2).

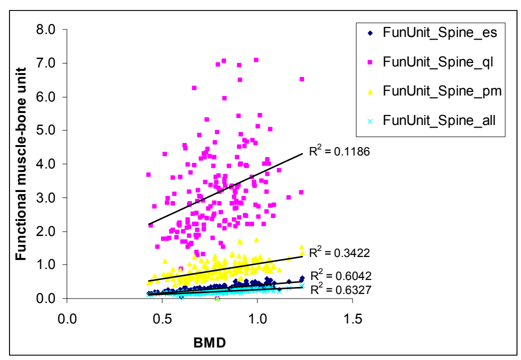

Fig.2. Correlation between functional muscle-bone unit and BMD.

Discussion: There are two new clinically relevant findings from this study. First, is the recognition that the 'functional muscle-bone unit' decreases as BMD decreases. This implies that as BMD decreases, the relative muscle bulk acting upon the increasing fragile lumbar vertebrae increases. This apparent deteriorating imbalance in bone strength to muscle bulk may well be contributory to the occurrence of vertebral fracture in elderly patients particularly as the majority of osteoporotic vertebral fractures are clinically silent and known to occur in the absence of any trauma.
Second, is the recognition that there was a differential loss or gain of muscle bulk in the elderly with erector spinae muscle mass increasing while psoas and quadratus lumborum muscle mass decreases to the extent lumbar paravertebral muscle mass as a whole remained unchanged compared to young subjects. This differential effect on muscle mass may be the cause of effect of known changes in balance and movement coordination that occur in elderly subjects.

References: [1] H. M. Frost, Bone, 20:385-391(1997); [2] E. Schoenau, et al, J Bone Miner Res, 17:1095-1101 (2002);

Acknowledgment: This study is supported by the National Natural Science Foundation of China, Ref: 81000647