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SEX DIFFERENCES IN QUADRICEPS MUSCLE AND FEMORAL BONE CROSS SECTIONAL AREAS IN ADOLESCENT AND MATURE VOLLEYBALL ATHLETES

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Purpose: Adequate muscle strength is important for proper knee function. It is also well known that quadriceps muscle strength and anatomical cross sectional areas (CSA) are compromised in knee OA. To what extent muscle atrophy is related to pain or central inhibition, and to what extent lack of muscle strength and mass is responsible for incident and progressive knee symptoms or radiographic change in knee OA is controversial. However, recent findings indicate that there may be a relationship between muscle and incident or progressive symptoms and structural change in women but not in men. Yet, little is known about sex differences of muscle development at various stages of human development, particularly in relation to local bone size.

Methods: 20 young (baseline age 16.0±0.6y) and 20 mature (46.3±4.7y) top volleyball athletes were studied: 10 young men (BMI 22.3±0.9) and women (20.9±2.0), and 10 mature men (BMI 26±2.6) and women (22.7±1.9). The adolescent athletes trained twice per day (each session approx. 2 hours), and the former (mature) volleyball athletes trained about twice per week. Axial MR images (T1-weighed spin echo) of both thighs were acquired at baseline and 2 year follow-up, extending from the femoral neck proximally to the quadriceps tendon distally. Quadriceps muscle, total femoral and cortical bone CSAs were determined in the dominant leg (the one used for takeoff), in an MR image that was located 30% from proximal to distal (where quadriceps CSA was previously shown to correlate best with quadriceps volume). Differences between men and women and between adolescent and mature athletes were explored using unpaired t-tests, and longitudinal difference during the 2-year observation period using paired t-tests.

Results: At baseline, men had significantly ($p<0.001$) greater quadriceps, total femoral bone, and cortical femoral bone CSAs than women, both in adolescent and in mature athletes (Table 1).However, the ratio between quadriceps vs. total femoral (or cortical) femoral bone area did not differ significantly between men and women at either age (Table 1; $p>0.25$). Mature women and men had smaller quadriceps ACSAs than the adolescent men and women (Table 1), but the difference only reached statistical significance in the women ($p<0.05$). The ratio of quadriceps vs. total and cortical femoral bone area was significantly ($p<0.05$) smaller in mature than in adolescent athletes, both in men and women (Table 1). No difference in the percent cortical (of total) femoral area was seen between sexes or age groups (Table 1; $p>0.18$). No significant changes in quadriceps CSA were observed during the 2 year observation period, although the increase in adolescent men (5.0±7.1%) reached borderline significance ($p=0.08$). A significant increase in cortical (3.2±2.8%) and total femoral area (2.8±2.6%) was noted in adolescent men (both $p<0.01$), but not in adolescent women ($p>0.24$) or mature study athletes ($p>0.23$). The increase in quadriceps CSA in the adolescent men was associated with the increase in femoral cortical bone area (Pearson correlation coefficient $r=0.70$; 95%CI -0.02,0.94; $p=0.06$).

Table 1: Muscle and bone CSA in volleyball athletes (W = women; M = men): mean±SD at baseline

	Adoles. W	Adoles. M	Mature W	Mature M
Quadriceps (cm2)	67.7±9.9	87.2±7.5	59.6±5.3	80.3±7.6
Tot fem bone (cm2)	6.10±0.88	7.77±0.98	6.24±0.67	8.12±0.80
Radio (Quad/tot fem)	11.16±1.41	11.32±1.17	9.66±1.30	9.96±1.17
Cort fem bone (cm2)	4.80±0.63	6.11±0.66	5.03±0.40	6.40±0.63
% Cort/tot fem bone (%)	78.9±4.6	79.0±6.2	80.9±4.2	78.9±1.8

Conclusions: These findings reveal sex-specific muscle vs. bone relationships in active adults at different stages of maturation. It is important to note that the observed relationships may be specific to subjects with intense training and loading histories, and may not apply to less active individuals. The observed changes of muscle and bone tissue in adolescent men appear to be coupled, whereas no (more) change was observed in women at this stage of maturity. Although men obviously had larger quadriceps and bone CSAs than women, the ratio between muscle and bone tissue did not display sex-specific differences at either stage of maturity. The cross sectional results suggests that in adulthood (i.e. 30 years after adolescence) approx. 92% of the muscle mass of very well trained young men, and approx. 88% of that of young women, can be maintained when regular sportive activity is continued. Future studies need to explore to what extent these relationships may be relevant to the incidence and progression of symptoms and degenerative structural change in knee OA.

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