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Muscle area, muscle mass and muscle power in a pre-pubertal and an elderly population

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Background/purpose

Many studies reporting muscle-bone relationships use muscle area as a surrogate measure for muscle strength. The purpose of this study is to compare muscle-bone relationships in children and in an aging population using three different muscle measures as predictors to estimate bone strength of the tibia: Cross-sectional muscle area (CSMA) from 66% distal tibia slice measured by pQCT; leg lean mass (LLM) measured by whole body DXA; and muscle power (Power) measured by ground reaction force from a two-footed jump. Bone strength (polar strength strain index, pSSI) of the tibia was measured by pQCT at the 20% distal tibia site. In growing children, the amount of muscle (CSMA, LLM) may influence bone strength more than function of the muscle (power) while in adults, the amount of muscle may not be as influential as the function of the muscle.

Hypotheses

In growing children, CSMA and LLM vs. pSSI will have higher correlations than Power vs. pSSI. pSSI predicted by models controlling for age, sex, height and weight will have higher partial-R values for CSMA and LLM than for Power. In an aging population, Power vs. pSSI will have higher correlations than CSMA and LLM vs. pSSI. Adult pSSI predicted by models controlling for age, sex, height and weight, will have higher partial-R values for Power than for CSMA and LLM.

The authors have no conflict of interest.

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Methods

pQCT (XCT2000) slices at 20 and 66% tibia length from the distal end and whole body DXA (Hologic) images were obtained on 106 (54 male) self-assessed Tanner 1 healthy children aged 6-11 years (8.5±1.5 yr, mean±SD) and on 48 healthy adults; 27 women aged 51-74 years (58±6 yr) and 21 men aged 54-80 years (67±8 yr). The adult women were all postmenopausal with 9 women using hormone replacement therapy. Correlations from linear regression models and partial-R values from multiple regression models controlling for age, sex, height and weight were obtained for each of the muscle predictors.

Results

Children: CSMA, LLM and Power were significantly correlated with pSSI (R=0.85, 0.92, 0.85; respectively, all $p<0.001$). Correlations remained significant when tested by male and female groups. In multiple regression models controlling for age, sex, height and weight, partial-R values for CSMA, LLM were similar (Partial-R=0.21, 0.22, 0.21) in predicting pSSI. In predicting cortical content at the 20% tibia site, partial-R values for power were higher than those for LLM and CSMA (Partial-R=0.35, 0.28, 0.26, respectively).

Adults: CSMA, LLM and Power were correlated with pSSI (R=0.71, 0.81, 0.62; respectively, all $p<0.001$). Only LLM in females correlated with pSSI (R=0.52, $p<0.01$) when tested in male and female groups. In multiple regression models controlling for age, sex, height and weight, partial-R values were greater for LLM than for Power (Partial-R=0.38, 0.14, respectively) in the prediction of pSSI and for cortical content (Partial-R=0.35, 0.25). CSMA did not add any predictive contribution to these models in adults.

Conclusions

Cross-sectional muscle area, leg muscle mass and muscle power measured from a two-footed jump all predict bone strength (measured as pSSI) in cortical bone of the tibia in pre-pubertal children. In aging adults, correlations between muscle predictors (CSMA, LLM and Power) and pSSI were significant for the population as a whole, but did not remain significant when tested by male and female groups. In multiple regression models controlling for age, sex, height and weight in pre-pubertal children, partial-R values were similar in predicting pSSI, but muscle power had a higher partial-R than cross-sectional area or leg lean mass in predictions of cortical bone content of the tibia. In adults, leg lean mass and muscle power had partial-R values that contributed to the prediction of pSSI and cortical content, but CMSA did not.