The relationship between muscle strength and bone outcomes in ageing UK men

Zengin A\textsuperscript{a}, Pye SR\textsuperscript{b}, Cook MJ\textsuperscript{b}, Adams JE\textsuperscript{c}, Wu FCW\textsuperscript{d}, O’Neill TW\textsuperscript{e,f}, Ward KA\textsuperscript{a,g}

\textsuperscript{a} MRC Medical Research Council Human Nutrition Research, Cambridge, UK
\textsuperscript{b} MRC Medical Research Council Human Nutrition Research, Cambridge, UK
\textsuperscript{c} MRC Medical Research Council Human Nutrition Research, Cambridge, UK
\textsuperscript{d} MRC Medical Research Council Human Nutrition Research, Cambridge, UK
\textsuperscript{e} MRC Medical Research Council Human Nutrition Research, Cambridge, UK
\textsuperscript{f} MRC Medical Research Council Human Nutrition Research, Cambridge, UK
\textsuperscript{g} MRC Medical Research Council Human Nutrition Research, Cambridge, UK

\textbf{Introduction}

- Ageing is associated with sarcopenia, osteopenia and increased fall risk, which together contribute to increased fracture risk.
- Muscle strength is a composite term composed of mass, anatomy (fibre type and distribution) and force generating capacity and power.
- Muscle contractions create peak forces which exert loads on bone resulting in adaptations in mass, geometry and strength.
- The increased risk of falls with ageing has been associated with a decline in muscle power, reflecting the ability of how fast muscles produce force.
- Mechanically, bones change in strength through adaptations to alter stiffness and mass in response to peak muscle forces; while mobility and locomotion are dependent on muscle power in order to prevent falls and consequent fractures.
- There are few data describing the associations between functional measures of muscle and bone during ageing.

\textbf{Aim}

To examine the associations between:
1. Lower-limb muscle strength and age
2. Tibial bone outcomes and muscle force

\textbf{Study Design}

- \textbf{Participants}: men aged 40+ years and living in Manchester, UK were recruited. Participants were of European White, African-Caribbean Black, and South Asian (Indian, Pakistani, Bangladeshi) ethnicity. Recruitment was stratified by 10 year age band.
- \textbf{Peripheral QCT}: performed at the 38\% and 66\% Tibia.
  - Outcome measures: 38\% cortical vBMC (ct. vBMC), cross-sectional area (CSA), cortical area (CT. Area), cross-sectional moment of inertia (CSMI); 66\% cross-sectional muscle area (CSMA).
- \textbf{Jumping mechanography}: single leg jump (sLJ) was performed on the Leonardo Ground Reaction Force Platform to measure muscle force (KN) and power (KW).
- \textbf{Statistical analyses}:
  - Linear regression analyses were used with adjustments for age, ethnicity, weight and height.
  - Muscle force was log transformed to normalise the distribution, β-coefficients were converted to percentages by multiplying with 100.

\textbf{Results}

The relationship between muscle parameters and age

\begin{table}[h]
\begin{tabular}{|c|c|c|c|}
\hline
 & unadjusted & adjusted & \\
\hline
\textbf{B (\%) p value} & \textbf{B (\%) p value} & \\
\hline
\textbf{Force (KN)} & 0.5 (-0.7, -0.3) & <0.0001 & 0.5 (-0.5, -0.2) & <0.0001 \\
\textbf{Power (KW)} & -1.9 (-2.3, -1.7) & <0.0001 & -1.8 (-2.0, -1.6) & <0.0001 \\
\textbf{66\% CSA (mm\textsuperscript{2})} & -0.3 (-0.5, -0.2) & <0.0001 & -0.4 (-0.5, -0.2) & <0.0001 \\
\hline
\end{tabular}
\caption{All values are β-coefficients expressed as a percentage unit change in age with 95\% confidence intervals. Adjusted values are from a linear regression model with adjustments for ethnicity, weight (kg) and height (cm), bold indicates p<0.05.}
\end{table}

The relationship between muscle force and diaphyseal bone outcomes at the tibia

\begin{table}[h]
\begin{tabular}{|c|c|c|c|}
\hline
 & unadjusted & adjusted & \\
\hline
\textbf{B (\%) p value} & \textbf{B (\%) p value} & \\
\hline
\textbf{ct. vBMC (mg/cm\textsuperscript{2})} & 15.8 (11.8, 19.8) & <0.0001 & 8.5 (3.8, 14.4) & 0.001 \\
\textbf{CSA (mm\textsuperscript{2})} & 14.5 (11.2, 17.7) & <0.0001 & 9.3 (5.4, 13.2) & <0.0001 \\
\textbf{CT. Area (mm\textsuperscript{2})} & 16.7 (13.1, 20.3) & <0.0001 & 9.3 (4.8, 13.8) & <0.0001 \\
\textbf{CSMI (mm\textsuperscript{4})} & 29.9 (23.6, 36.2) & <0.0001 & 18.6 (11.1, 26.2) & <0.0001 \\
\hline
\end{tabular}
\caption{All values are β-coefficients expressed as a percentage unit change in muscle force with 95\% confidence intervals. Adjusted values are from a linear regression model with adjustments for ethnicity, age (yr), weight (kg) and height (cm), bold indicates p<0.05. CT, cortical; vBMC, volumetric bone mineral content; CSA, cross-sectional area; CSMI, cross-sectional moment of inertia.}
\end{table}

\textbf{Conclusions}

- Muscle force positively predicts diaphyseal bone outcomes at the tibia reflecting mass, geometry and strength.
- Lower limb muscle strength is negatively associated with age.
- Important area to focus on for prevention of sarcopenia and consequent falls and fracture.
- Strategies should not only be focused on increasing bone strength but also preventing falls and maintaining muscle function by increasing muscle power.

\textbf{Acknowledgments}

This work was supported by the Commission of the European Communities FP7 "Quality of Life and Management of Living Resources" (grant number 222727-4), Antigone Research (grant number 222727-4) and Biomed 2 (grant number 222727-4). The authors declare no conflicts of interest.

\textbf{Conflict of Interest}

The authors declare no conflicts of interest.