TOTAL AND LOWER EXTREMITY LEAN MASS PERCENTAGE POSITIVELY CORRELATES WITH JUMP PERFORMANCE

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The current study investigated the relationship between the lower extremity and total body lean mass percentages and the peak vertical ground reaction force (VGRF), peak power, and jump height (JH) in a countermovement jump (CMJ). One hundred and two subjects diverse in age and fitness level underwent Dual Energy X-ray Absorptiometry to determine mass composition and then performed three countermovement jumps which were used to calculate peak VGRF, peak power, and JH; the first two normalized to subject bodyweight. Pearson correlation tests between lean mass percentage and jump performance indicated significant positive correlations ($r > 0.56$), which were consistent with previous literature. However, as not all variance in CMJ measures was accounted for by lean mass percentage, other variables should be taken into account.

KEY WORDS: countermovement, DXA, power

INTRODUCTION: In general populations as well as in athletic performance, muscular strength is highly valued; the value of muscular strength as it pertains to quality of life is also known to increase with age (Sillanpää, Häkkinen, Holviala, & Häkkinen, 2012). While muscular strength is correlated with multiple variables, cross sectional area (CSA) plays an important role in strength capacity (Schantz, Randall-Fox, Hutchison, Tyden, & Astrand, 1983). As CSA is positively correlated with muscular mass (Akagi, Takai, Ohta, Kanehisa, Kawakami, & Fukunaga, 2009), utilizing a tool such as Dual Energy X-ray Absorptiometry (DXA) to assess muscular mass should ultimately reflect upon the muscular strength of the individual, as indicated by similar previous research (Vaara, Kyröläinen, Niemi, Ohrankämmen, Häkkinen, Kocay, & Häkkinen, 2012).

Therefore DXA analysis of lean mass percentages are expected to positively correlate with strength tests such as measures derived from the countermovement jump (CMJ) (Nuzzo, McBride, Cormie, & McCaulley, 2008). As the arm swing in a CMJ has been indicated to significantly contribute to CMJ performance (Lees, Vanrenterghem, & Clercq, 2004), total body lean mass percentage (TBLM%) should correlate more strongly with CMJ performance measures than lower extremity lean mass percentage (LELM%) alone.

The current researchers therefore hypothesized a positive correlation between lean mass percentage and CMJ performance measures, with a stronger correlation of TBLM% compared to only LELM%.

METHODS: The current study utilized 102 adult volunteers aged 18 to 74 years (44 females, 58 males; mean ± standard deviation: age 43.4 ± 16.7 years; height 1.70 ± 0.12 m; mass 74.2 ± 15.0 kg) free from pregnancy, acute injury or illness, chronic exercise limitations, and uncontrolled cardiometabolic disease as subjects. The subject pool was considered diverse, with subjects varying notably in age and fitness level. The current study was approved by the University of Wyoming Institutional Review Board.

The current researchers performed a DXA analysis on all subjects in order to assess fat, bone mineral, and lean mass composition. Compositional analysis was divided into left and right torso (including pelvis), lower extremity, and upper extremity sections; the head was not included in analysis. Total body composition was the resultant combination of all aforementioned sections. TBLM% and LELM% were calculated by dividing the lean mass by the total mass of the respective body sections.

After a warm-up of a three minute step test and shuttle run, subjects performed three recorded CMJs for maximal height with a minimum of 30 seconds rest between trials. Subjects stood with each foot on a Bertec FP4060-10-2000 force plate (Bertec Corporation, Columbus, OH, USA) recording at 1600 Hz. The force data were filtered at a low-pass cut-off frequency of 50 Hz. Peak vertical ground reaction force (VGRF), peak power, and jump height (JH) were calculated; the former two were normalized to the subjects' individual weight.

Pearson correlation tests were performed between lower extremity and total body lean mass percentages and peak VGRF, peak power, and peak JH. Correlations less than 0.5 ($r < 0.5$) were considered weak, while correlations above 0.5 ($r > 0.5$) were considered strong (Buda & Jarynowski, 2010). Statistical significance was set at $\alpha = 0.05$.

RESULTS: As indicated in Table 1, all tested relationships were found to be significantly correlated ($p < 0.0001$), with strong correlation coefficients. Correlation coefficients were similar when assessing relationships between lower extremity lean mass and total body lean mass percentages; for both lean mass percentages the peak power and JH were strongly ($r > 0.7$) correlated and the peak VGRF was strongly ($r > 0.5$) correlated as well.

Table 1. Pearson correlation coefficients between lower extremity and total body lean mass percentages and peak VGRF, peak power, and peak JH.

	Lower extremity lean mass	Total body lean mass
Peak VGRF	r = 0.567*	r = 0.591*
Peak Power	r = 0.732*	r = 0.732*
Peak JH	r = 0.748*	r = 0.739*

*p < 0.0001

The visual relationships of the peak VGRF (Figure 1), peak power (Figure 2), and peak JH (Figure 3) to the LELM% and the TBLM% can be seen below. A distinct positive relationship is evident in all figures.

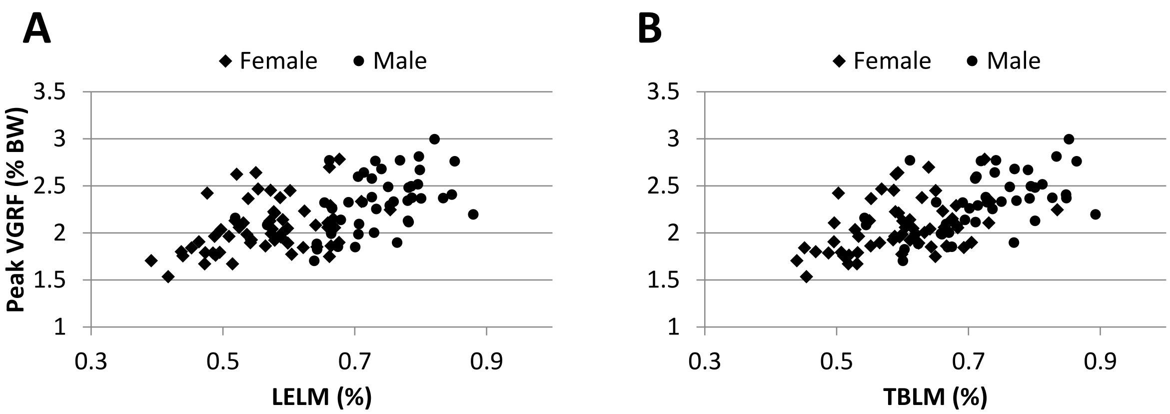

Figure 1. Lower extremity (A) and total body (B) lean mass percentages compared to peak VGRF normalized to subjects' individual weight in a CMJ.

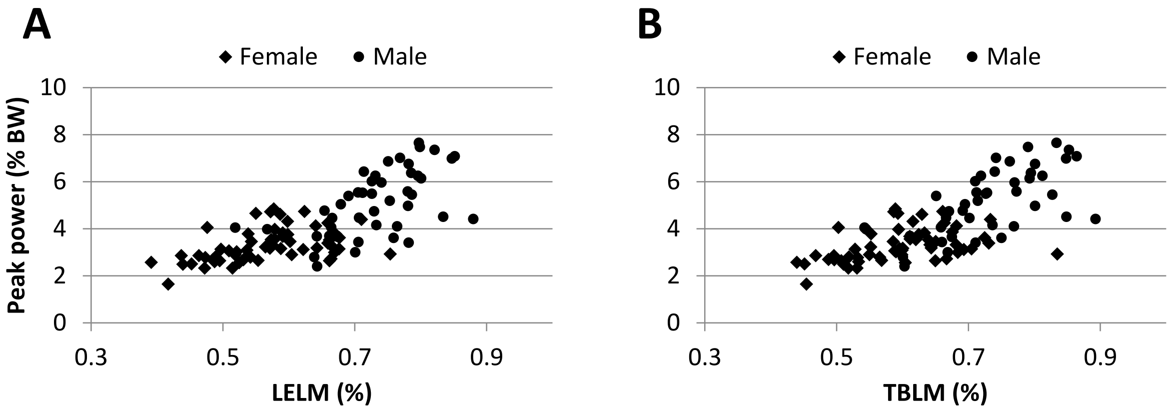

Figure 2. Lower extremity (A) and total body (B) lean mass percentages compared to peak power normalized to subjects' individual weight in a CMJ.

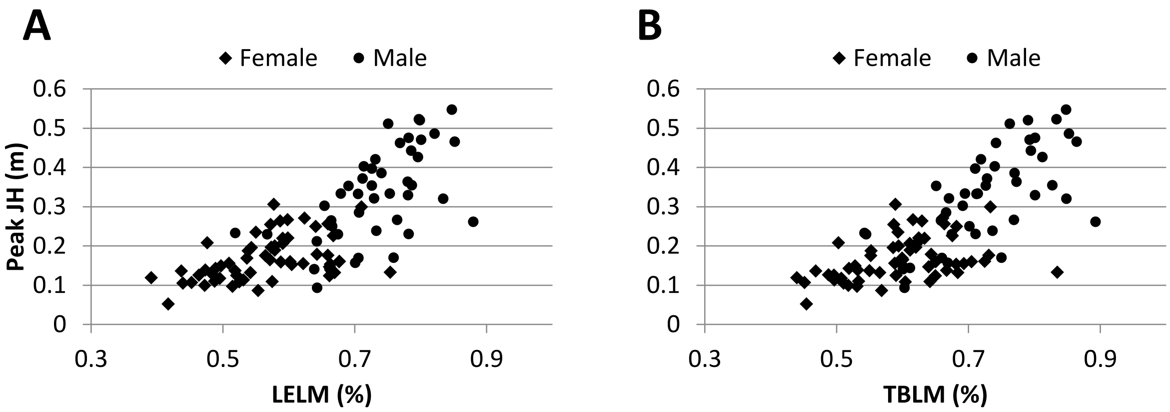

Figure 3. Lower extremity (A) and total body (B) lean mass percentages compared to peak JH (m) in a CMJ.

DISCUSSION: The current researchers expected a positive correlation between lean mass percentage and CMJ performance measures, with a stronger correlation of TBLM% compared to LELM%. As seen in Table 1, a positive correlation did exist in the general population utilized for the current study, consistent with previous literature concerned with college-aged subjects (Ferragut, Cortadellas, Arteaga, & Calbet, 2003). The current results were also consistent the conclusions of Abidin and Adam (2013), that body fat percentage negatively affects peak JH, as an increase in body fat percentage would result in a decrease of lean mass percentage. Vaara *et al* (2012) found similar but more weakly correlated results, possibly due to the lack of normalization of lean mass to their subjects' individual bodyweight with their varied subject pool.

In contrast to the current researchers' hypothesis however, there was little difference in correlation between LELM% and TBLM% and the CMJ measures despite the previous literature illustrating a benefit of arm swing in jump performance (Lees *et al*, 2004). It was found in the current study that LELM% was highly correlated with TBLM% (r = 0.960), indicating that LELM% was sufficient to represent TBLM%. As such, the addition of upper extremity and torso lean mass percentage to LELM% did not drastically increase the coefficient of correlation.

It should be noted that the coefficients of determination (r^2) were less than 0.6 with the reported variables, indicating that lean mass percentage cannot account for all variance in CMJ performance. As previous research has indicated that CSA is only one component in determining jump performance, the remaining variance is most likely due to variance in other components such as neuromuscular activation (Hoy, Zajac, & Gordon, 1990).

CONCLUSION: LELM% and TBLM% were significantly positively correlated with CMJ normalized peak VGRF, power, and JH in a diverse subject pool. This indicates a general relationship between lean mass percentage and muscular strength that may be able to be utilized in strength training, performance predictions, and quality of life assessment.

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