Thigh Muscle Regional Size: Relationships With Countermovement Jump Performance

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INTRODUCTION

The ability to achieve high movement velocities is critical to athletic performance. Recently, evidence has been presented indicating that greater quadriceps femoris mass distal to the hip is associated with greater thigh moment of inertia (MoI) (Earp et al., 2023). Increased limb MoI is expected to increase motive force requirements necessary to achieve high joint angular velocities (2,3). However, associations between regional muscle size, reflecting regional mass, and performance during sporting movements are currently poorly understood.

PURPOSE

The purpose of this investigation was to explore relationships between regional muscle size in the thigh and the expression of muscular force, movement velocity, and performance characteristics during the countermovement jump (CMJ).

METHODS

Subjects: Resistance-trained males (n = 7) and females (n = 4) participated in this study (age = 23 ± 2.5 yrs, body mass = 81.9 ± 15.9 kg, height = 175.9 ± 9.3 cm, training age = 7.8 ± 3.3). ***Procedures:*** In one testing session, subjects completed hydration testing prior to the collection of ultrasound images of the right vastus lateralis (VL) and rectus femoris (RF) at 33%, 50%, and 66% femur length (Logiq E9, General Electric). Subjects then completed a standardized warm-up followed by CMJ testing performed on dual force plates sampling at 1,000 Hz (ForceDecks, VALD, Newstead, Queensland). Subjects used no arm swing and were instructed to jump as high as possible during CMJ testing. Jump height from flight time (JH-FT), concentric peak velocity (ConPV), force at zero velocity (Force-0V), and reactive strength index modified (RSImod), were quantified and averaged across two trials (ForceDecks). Shapiro-Wilk testing indicated RSImod was not normally distributed ($p < 0.05$); therefore, non-parametric methods were used to evaluate relationships involving this metric. Pearson product-moment (r) or Spearman's rank correlations (rho) were used to evaluate relationships between regional muscle size (VL33, VL50, VL66 or RF33, RF50, RF66) and CMJ performance (JH-FT, ConPV, Force-0V, RSImod). Correlation coefficient magnitudes were interpreted as: trivial < 0.10, small = 0.10–0.29, moderate = 0.30–0.49, strong = 0.50–0.69, very strong = 0.70–0.89, or nearly perfect ≥ 0.90 (1). Statistical analysis was conducted using JASP (ver. 0.19.3, JASP team, 2025).

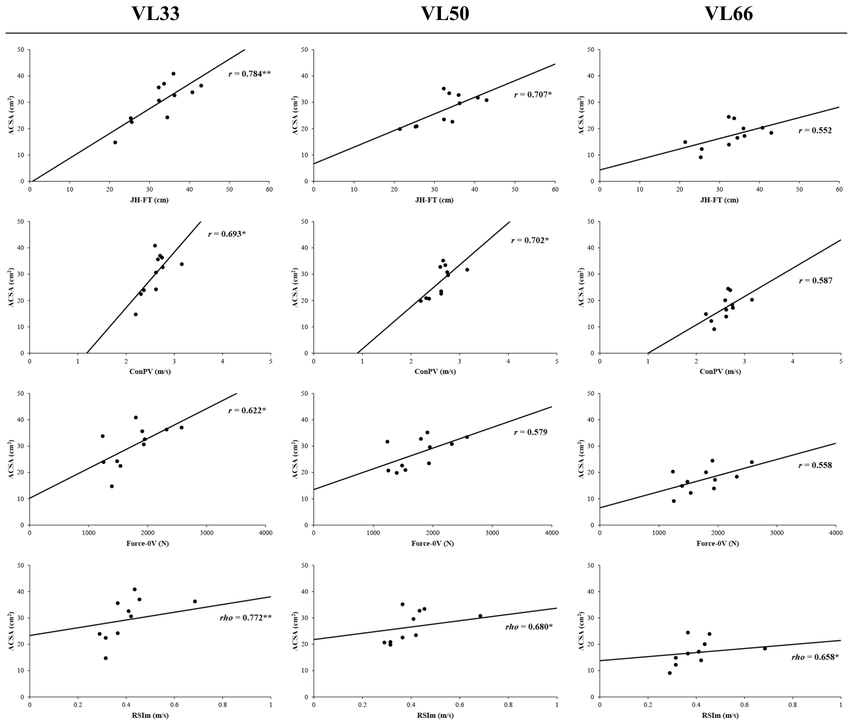
RESULTS

Statistically significant strong and very strong relationships were observed between regional VL size and CMJ performance (Figure 1). Statistically significant relationships were also observed between RF33 and RSImod (rho = 0.776, p = 0.005) and between RF50 and JH-FT (r = 0.803, p = 0.003), ConPV (r = 0.726, p = 0.011), and RSImod (rho = 0.845, p = 0.001). Relationships between RF66 and CMJ performance metrics were not statistically significant ($p > 0.05$).

MAIN FINDINGS

In the thigh, proximal measures of muscle size are more strongly related to CMJ performance compared to distal measures.

Figure 1. Relationships Between Vastus Lateralis Regional Muscle Size and Countermovement Jump Performance



*Note: Correlations between vastus lateralis (VL) regional muscle size and CMJ performance metrics are presented from left to right as 33% (VL33), 50% (VL50), and 66% (VL66) femur length; *, ** indicate statistically significant relationships, p < 0.05 or p < 0.01, respectively.*

DISCUSSION

Although many neuromuscular factors likely contribute to CMJ performance, in the thigh, greater VL muscle mass proximal to the hip may be advantageous, perhaps due to greater contributions of work at the hip (4) and reduced thigh MoI (2). At every regional site investigated, strong or very strong relationships were observed between VL muscle size and ConPV. Importantly, proximal and mid-muscle measures of muscle size were more closely associated with movement velocity compared to distal measures. Due to the absence of statistically significant relationships observed for distal measures of muscle size, muscle mass distal to the hip is likely not advantageous to CMJ performance. These observations support the rationale that mass distribution throughout a given muscle is an important consideration for athletic populations.

CONCLUSION

The relationships observed align with prior evidence, indicating that regional muscle size, reflecting regional mass, may influence limb mechanics and athletic performance (2,3). Specifically, proximal mass in the thigh is associated with superior CMJ performance, perhaps due mainly to positive effects on movement velocity. However, additional research is needed to elucidate any potential causal relationships between regional measures of muscle size and athletic performance.

PRACTICAL APPLICATION

Considering these observations, it is recommended for sports scientists to monitor muscle size at multiple regions, particularly the proximal region, due to the strong associations with CMJ performance. Strength and conditioning professionals should carefully consider resistance exercise selection. These prescribing exercises closely emulate sport-specific movements with the expectation that doing so may promote muscle growth patterns that are advantageous to athletic performance.

REFERENCES

1. Cohen, J. Statistical power analysis for the behavioral sciences (2nd ed.). Hillside, NJ; Lawrence Erlbaum Associates, 1988.
2. Earp, J. E., Angelino, D., Hatfield, D. L, et al. (2023). Differing hypertrophy patterns from open and closed kinetic chain training affect quadriceps femoris center of mass and moment of inertia. *Frontiers in Physiology, 14*, 1074705.
3. Earp, J. E., Newton, R. U., Cormie, P., & Blazevich, A. J. (2015). Inhomogeneous quadriceps femoris hypertrophy in response to strength and power training. *Medicine & Science in Sports & Exercise, 47*(11), 2389-2397.
4. Robertson, D. G., & Fleming, D. (1987). Kinetics of standing broad and vertical jumping. *Can J Sport Sci, 12*(1), 19-23.