

Table 1-3

Architectural Properties of the Human Arm and Forearm

| Muscle | Muscle Mass (g) | Muscle Length (cm) | Fiber Length (cm) | Pennation Angle (°) | Cross-sectional Area (cm ²) | L _f /L _m Ratio |
|-------------------|-----------------|--------------------|-------------------|---------------------|---|--------------------------------------|
| Deltoid | 129.5 ± 8.0 | 16.5 ± 1.0 | 107.1 ± 8.0 | 13.7 ± 0.7 | 10.9 ± 1.3 | 0.65 ± 0.02 |
| Anterior Portion | 31.6 ± 4.8 | 15.7 ± 0.8 | 103.3 ± 11.5 | 12.2 ± 1.5 | 3.2 ± 0.6 | 0.65 ± 0.05 |
| Middle Portion | 57.6 ± 5.6 | 17.2 ± 1.3 | 108.9 ± 7.4 | 10.6 ± 1.8 | 4.5 ± 0.5 | 0.64 ± 0.03 |
| Posterior Portion | 36.1 ± 4.7 | 16.0 ± 1.4 | 109.1 ± 7.0 | 18.3 ± 2.2 | 3.1 ± 0.4 | 0.68 ± 0.04 |
| SS (n = 10) | 34.0 ± 4.3 | 8.5 ± .4 | 4.5 ± 0.3 | 5.1 ± .8 | 6.7 ± 0.6 | 0.53 ± .03 |
| IS (n = 10) | 78.0 ± 7.5 | 12.1 ± 0.5 | 6.6 ± 0.3 | 1.4 ± .4 | 10.7 ± 1.0 | 0.55 ± 0.02 |
| SUB (n = 10) | 101.8 ± 11.5 | 13.0 ± 0.6 | 6.0 ± 0.5 | 0 ± 0 | 15.5 ± 1.4 | 0.45 ± 0.02 |
| TM (n = 10) | 21.2 ± 2.0 | 10.8 ± 0.6 | 6.1 ± 0.4 | 0.6 ± 0.3 | 3.2 ± 0.3 | 0.57 ± 0.03 |
| BRACH (n = 10) | — | 21.2 ± 2.9 | 9.9 ± 1.6 | 0 ± 0 | 5.4 ± 1.3 | 0.47 |
| BIC (n = 10) | — | 23.4 ± 4.2 | 13.6 ± 3.2 | 0 ± 0 | 5.1 ± 1.6 | 0.58 |
| BR (n = 8) | 16.6 ± 2.8 | 17.5 ± 8 | 12.1 ± 8 | 2.4 ± 0.6 | 1.33 ± 0.22 | 0.69 ± 0.062 |
| PT (n = 8) | 15.9 ± 1.7 | 13.0 ± 5 | 3.64 ± 1 | 9.6 ± 0.8 | 4.13 ± 0.52 | 0.28 ± 0.012 |
| PQ (n = 8) | 5.21 ± 1.0 | 3.9 ± 2 | 2.3 ± 2 | 9.9 ± 0.3 | 2.07 ± 0.33 | 0.58 ± 0.021 |
| EDC I (n = 8) | 3.05 ± 0.45 | 11.4 ± 3 | 5.69 ± 4 | 3.1 ± 0.5 | 0.52 ± 0.08 | 0.49 ± 0.024 |
| EDC M (n = 5) | 6.13 ± 1.2 | 11.2 ± 5 | 5.9 ± 4 | 3.2 ± 1.0 | 1.02 ± 0.20 | 0.50 ± 0.014 |
| EDC R (n = 7) | 4.70 ± 0.75 | 12.5 ± 1.1 | 5.12 ± 2 | 3.2 ± 0.54 | 0.86 ± 0.13 | 0.42 ± 0.023 |
| EDC S (n = 6) | 2.23 ± 0.32 | 12.1 ± 8 | 5.3 ± 5 | 2.4 ± 0.7 | 0.40 ± 0.06 | 0.43 ± 0.029 |
| EDQ (n = 7) | 3.81 ± 0.70 | 15.2 ± 9 | 5.5 ± 4 | 2.6 ± 0.6 | 0.64 ± 0.10 | 0.36 ± 0.012 |
| EIP (n = 6) | 2.86 ± 0.61 | 10.5 ± 7 | 4.8 ± 2 | 6.3 ± 0.8 | 56 ± 0.11 | 0.46 ± 0.023 |
| EPL (n = 7) | 4.54 ± 0.68 | 13.8 ± 7 | 4.4 ± 3 | 5.6 ± 1.3 | 0.98 ± 0.13 | 0.31 ± 0.020 |
| PL (n = 6) | 3.78 ± 0.82 | 13.4 ± 1.2 | 5.2 ± 3 | 3.5 ± 1.2 | 0.69 ± 0.17 | 0.40 ± 0.032 |
| FDS I(P) (n = 6) | 6.0 ± 1.1 | 9.3 ± 8 | 3.2 ± 3 | 5.1 ± 0.2 | 1.81 ± 0.83 | 0.34 ± 0.022 |
| FDS I(D) (n = 9) | 6.6 ± 0.8 | 11.9 ± 6 | 3.8 ± 3 | 6.7 ± 0.3 | 1.63 ± 0.22 | 0.32 ± 0.013 |
| FDS I(C) (n = 6) | 12.4 ± 2.1 | 20.7 ± 1.1 | 6.8 ± 3 | 5.7 ± 0.2 | 1.71 ± 0.28 | 0.33 ± 0.025 |
| FDS M (n = 9) | 16.3 ± 2.2 | 18.3 ± 1.2 | 6.1 ± 4 | 6.9 ± 0.7 | 2.53 ± 0.34 | 0.34 ± 0.014 |
| FDS R (n = 9) | 10.2 ± 1.1 | 15.5 ± 8 | 6.0 ± 3 | 4.3 ± 0.6 | 1.61 ± 0.18 | 0.39 ± 0.023 |
| FDS S (n = 9) | 1.8 ± 0.3 | 10.3 ± 6 | 4.2 ± 2 | 4.9 ± 0.7 | 0.40 ± 0.05 | 0.42 ± 0.014 |
| FDP I (n = 9) | 11.7 ± 1.2 | 14.9 ± 4 | 6.1 ± 2 | 7.2 ± 0.7 | 1.77 ± 0.16 | 0.41 ± 0.018 |
| FDP M (n = 9) | 16.3 ± 1.7 | 20.0 ± 8 | 6.8 ± 3 | 5.7 ± 0.3 | 2.23 ± 0.22 | 0.34 ± 0.011 |
| FDP R (n = 9) | 11.9 ± 1.4 | 19.4 ± 7 | 6.5 ± 3 | 6.8 ± 0.5 | 1.72 ± 0.18 | 0.33 ± 0.009 |
| FDP S (n = 9) | 13.7 ± 1.5 | 15.0 ± □ | 6.1 ± 4 | 7.8 ± 0.9 | 0.20 ± 0.30 | 0.40 ± 0.015 |
| FPL (n = 9) | 10.0 ± 1.1 | 16.8 ± 1.0 | 4.5 ± 2 | 6.9 ± 0.2 | 2.08 ± 0.22 | 0.24 ± 0.010 |
| FCR (n = 5) | 10.9 ± 1.7 | 16.4 ± 3.9 | 5.1 ± 0.2 | 3.1 ± 1.2 | 1.99 ± 0.27 | 0.31 ± 0.01 |
| FCU (n = 5) | 15.4 ± 1.3 | 22.8 ± 1.6 | 4.2 ± 0.2 | 12.1 ± 0.6 | 3.42 ± 0.23 | 0.19 ± 0.01 |
| ECRB (n = 5) | 13.8 ± 0.9 | 12.7 ± 1.0 | 4.8 ± 0.4 | 8.9 ± 2.0 | 2.73 ± 0.18 | 0.38 ± 0.03 |
| ECRL (n = 5) | 11.8 ± 1.2 | 9.4 ± 0.7 | 7.6 ± 0.6 | 2.5 ± 0.7 | 1.46 ± 0.11 | 0.82 ± 0.04 |
| ECU (n = 5) | 13.6 ± 3.3 | 18.2 ± 0.6 | 5.1 ± 0.3 | 3.5 ± 0.3 | 2.60 ± 0.71 | 0.28 ± 0.01 |

Abbreviation: BIC: biceps brachialis; BR: brachioradialis; EDC I, EDC M, EDC R, and EDC S: extensor digitorum communis to the index, middle, ring, and small fingers, respectively; ECRB: extensor carpi radialis brevis; ECRL: extensor carpi radialis longus; ECU: extensor carpi ulnaris; EDQ: extensor digiti quinti; EIP: extensor indicis proprius; EPL: extensor pollicis longus; FCR: flexor carpi radialis; FCU: flexor carpi ulnaris; FDP I, FDP M, FDP R, and FDP S: flexor digitorum profundus muscles; FDS I, FDS M, FDS R, and FDS S: flexor digitorum superficialis muscles; FDS I (P) and FDS I (D): proximal and distal bellies of the FDS I; FDS I (C): the combined properties of the two bellies as if they were a single muscle; FPL: flexor pollicis longus; PQ: pronator quadratus; PS: palmaris longus; PT: pronator teres; TRI: triceps brachii.

Source: Lieber, R. L., Fazeli, B. M., & Botte, M. J. (1990). Architecture of selected wrist flexor and extensor muscles. *Journal of Hand Surgery*, 15A, 244–250; Lieber, R. L., Jacobson, M. D., Fazeli, B. M., Abrams, R. A., & Botte, M. J. (1992). Architecture of selected muscles of the arm and forearm: Anatomy and implications for tendon transfer. *Journal of Hand Surgery*, 17A, 787–798; Ward, S. R., Hentzen, E. R., Smallwood, L. R., Eastlack, R. K., Burns, K. A., Fithian, D. C., et al. (2006). Rotator cuff muscle architecture: Implications for glenohumeral stability. *Clinical Orthopaedics and Related Research*, 448, 157–163; and Murray, W. M., Buchanan, T. S., & Delp, S. L. (2000). The isometric functional capacity of muscles that cross the elbow. *Journal of Biomechanics*, 33, 943–952.