Excitability and Contractility: Measurements and Interpretations

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The purpose is to describe the hierarchical structure of skeletal muscles and the critical structure-function relationships. The hierarchical structure begins with the number of force generating cross-bridges per half sarcomere and the type of myosin isoform and ends with the total fiber cross-sectional area (CSA), the length and pinnation of fibers, and the muscle mass. A skeletal muscle is composed of fibers with a membrane potential that can be depolarized by an appropriate stimulus and consequently is an excitable tissue. The stimulus for depolarization has characteristics of amplitude (rheobase) and duration (chronaxie) that are stable in mature muscle, but embryonic, neonatal and engineered muscle constructs are less excitable and more variable. The critical structure-function relationships are: force with total fiber CSA and of power with muscle mass. Therefore, maximum isometric tetanic force (P_o) is normalized as kN/m^2 and power, the product of force and velocity, as watts/kg. When activated, skeletal muscles attempt to shorten, but what actually occurs depends on the interaction of the force developed by the muscle and the load against which the muscle is attempting to shorten. The interaction between the magnitude of the force developed by the muscle and the load results in either shortening, a fixed length contraction, or a forced stretch of the muscle. When activated muscles are stretched, either repeatedly, or through single large strains > 40%, muscle fibers are injured. For a complete evaluation of the functionality of engineered muscle constructs, P_o, power, and force deficit after a forced stretch of an activated muscle construct, must be measured, normalized, and compared with control values. Aging, dystrophy, and engineered muscle constructs, each provide examples of variations in excitability and contractility.