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Effect of Age upon the Cellular Phases of Skeletal Muscle.

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Preliminary to a quantitative study of the functional capacity of muscle at various ages, it was desirable to know the relative amounts of muscle cell and non-muscle cell tissue present at any given age. A fairly accurate quantitative approach to this problem can be had from calculations based upon the chloride and water concentration in muscle and blood serum. These calculations are based on the premise that all the tissue chloride is present in the non-muscle cell phases in concentrations approximating that of an ultra filtrate of blood plasma. The distribution of water between the muscle cell phase and non-muscle cell phase has been estimated from the data on rat's gastrocnemius muscle and blood serum using the equations as described by Hastings and Eichelberger.[1] In our calculations of the amounts of muscle cell and non-muscle phases and the concentration of water in the former, it is assumed that the tissue chlorides are associated with connective tissue having a water concentration of 80%. In these calculations the total neutral fat is assumed to be contained within the connective cells. Thus the total solids contained in 100 g of non-muscle cell phase is considered to be 20 g plus the amount of neutral fat found in 100 g of muscle.

The animals were killed by hemorrhage and the removal of blood from the tissues was aided by limb vein section and massage. The muscles were weighed after being dissected as free as possible from tendon and superficial fascia. The water content of tissues was determined by drying to a constant weight in an electric oven at 106°C. The neutral fat was determined according to the method described by Hastings and Eichelberger.[1] The blood samples were centrifuged under oil and the serum removed for analysis. The determination of the chlorides in muscle and serum was made by the method of Sunderman and Williams.[2] In order to obtain sufficient material for analysis the muscles from several animals in the younger groups were pooled.

The average values and standard errors for the analyses and calculations are given in Table I. It is to be noted that the approach of maturity is associated with a decreased concentration of chloride

1 Hastings, A. B., and Eichelberger, L., *J. Biol. Chem.*, 1937, **117**, 73.

2 Sunderman, F. W., and Williams, P., *J. Biol. Chem.*, 1933, **102**, 279.

TABLE I.
Analyses of Rat Muscle and Serum.

Age in days	No. of rats	Per 100 g wet muscle			Per 100 g serum		G per 100 g		% H_2O in muscle cells
		% H_2O	mM Chloride	g fat	% H_2O	mM Chloride	Muscle cell phase	Non-muscle cell phase	
15	20	79.69 ±.14	3.171 ±.023	2.41	93.77	9.416	60.21 ±.83	39.79 ±.83	80.02 ±.23
30	23	77.87 ±.16	2.059 ±.038	2.06	93.39	10.415	76.48 ±.33	23.52 ±.33	79.56 ±.18
60	22	76.62 ±.06	1.588 ±.023	1.25	92.79	10.338	81.81 ±.24	18.19 ±.24	77.09 ±.07
90	16	75.88 ±.11	1.320 ±.021	0.69	92.23	10.158	85.14 ±.22	14.86 ±.22	75.80 ±.15
120	15	75.95 ±.16	1.413 ±.037	0.50	92.49	10.525	84.77 ±.38	15.23 ±.38	75.69 ±.16
180	13	75.72 ±.10	1.309 ±.029	0.67	91.58	10.116	85.33 ±.31	14.67 ±.31	75.61 ±.21
365	13	75.59 ±.14	1.410 ±.074	1.08	92.03	10.087	83.62 ±.79	16.38 ±.79	75.77 ±.45

and water in muscle and serum. This change in muscle composition was pointed out by Yannet and Darrow[3] in a study upon the tissues of young and old cats, the exact ages of which were not known. No appreciable change in chloride and water concentration occurred after 90 days of age. The neutral fat concentration in the muscles tended to follow somewhat the changes in chloride during the growth period but was found to be increased in the muscles of the older animals.

The relative mass of the non-muscle cell phase (connective tissue) decreases with age and reaches a value which is characteristic of the adult when the animals are somewhere between 60 and 90 days of age. The calculated values for the relative mass of muscle cells in the total tissue show a range of 60% at 15 days to 85% at 90 days of age. These differences are of sufficient magnitude to warrant consideration in any quantitative analysis of muscle power exhibited by muscle from animals of different ages. It is apparent that muscle growth is associated with a relative increase in the mass of chloride-free muscle cells and a reduction in the mass of connective tissue.

The lack of information concerning the true water concentration in connective tissue at the various ages prevents an accurate estimation of the concentration of water in the muscle cells. The values given in Table I should be considered as approximations only. However, when any reasonable assumption as to the amount of water in connective tissue is made it appears that the muscle cells from young rats have a higher concentration of water than cells from adult animals.

Summary. Determinations have been made of the concentration of chloride, fat and water in the gastrocnemius muscles and serum from 7 groups of rats ranging from 15 to 365 days of age. From these data calculations have been made concerning the relative masses of connective tissue and muscle cell phases present in the muscles at the various ages. Values characteristic of adult tissue are found at 90 days of age. Thereafter approximately a constant composition was observed. The calculated values for the connective tissue phase show a range of 40% of the total mass at 15 days to 15% at 90 days of age. The calculated percent of water in muscle cells decreases during the growth period.

[3] Yannet, H., and Darrow, D. C., *J. Biol. Chem.*, 1938, **123**, 295.