CHEMICAL COMPOSITION OF SKELETAL MUSCLE

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The striated muscular tissue constitutes about 50% of the corporal weight. The material to be used for its study may be easily obtained and, if necessary, repeated samples may be collected without damage to the organism.

A review of the pertinent literature on this subject shows that, while there is a large number of references concerning the hydroelectrolytic content of striated muscle in lower chordates, very little information is obtainable concerning man.

The purpose of the present work is to determine the contents of water, sodium, potassium, calcium, magnesium, phosphorus, copper and iron of the tibialis anterior, deltoid and pectoralis major muscles in man. It is hoped that the results obtained may constitute a basis for later comparative studies on the chemical composition of muscles during pathological conditions.

MATERIAL AND METHODS

During necropsy, 53 fragments of muscles were excised from 41 corpses, less than 24 hours after death. Os these samples, 29 were of anterior tibial muscle (26 males and 3 females: 19 white, 9 mulattoes and 1 negro, ages varying from 4 to 63 years); the remaining 12 samples comprised deltoid and pectoral major muscles (10 males and 2 females: 7 white and 5 mulattoes, ages ranging from 9 to 60 years).

The causes of death included: craniocerebral trauma of several types (21 cases), polytrauma (9), drowning (4), post-traumatic internal hemorrhage (4), heart attack (1), asphyxia (1) and lesions in the neck produced by shot-gun (1).

The muscle samples were dried in an oven at 105°C until constant weight. These dry tissues were incinerated in a furnace regulated potentiometrically at 550°C during approximately 12 hours (overnight). Ash solutions were prepared using 2N hydrochloric acid.

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Sodium and potassium were determined by flame spectrophotometry, calcium by the method of Clark and Collip [1] (1925), phosphorus by the method of Fiske and Subbarow [5] (1925), iron by the method of Wong [7] (1928), magnesium by Titan yellow (De Jorge et al., 1964) [3] and copper by diethyldithiocarbamate (De Jorge et al., 1962) [2].

RESULTS

Data obtained by the above mentioned methods were analyzed by conventional statistical tests and the results obtained are presented in Table 1.

COMMENTS

Table 2 summarizes the statistical significance of the difference of the means in the chemical constituents of anterior tibial, pectoral major and deltoid muscles.

The water content of the three muscles is very similar, ranging from 75.18 to 75.91 g/100 g. In spite of the fact that the sodium concentrations ranged only from 3.30 mequiv/100 g in the deltoid muscle to 4.36 mequiv/100 g in the pectoral major muscle, the differences of the means are significant. The anterior tibial muscle presents higher potassioum and iron contents and contents of copper, calcium and phosphorus lower than in the two other muscles.

Previous data do not allow us to make any interpretation of the above results; the differences observed may be due just to the fact that the muscles considered belong to different body regions with different activities and it is advanced that they may be related to results obtained with muscles under different pathological conditions.

Comparing the above mentioned results with those presented by Table 3 in "Documenta Geigy-Scientific Tables" [4] (1956), which presents data obtained by several investigators, it is to be noticed that: a) our results are fairly similar on what concerns sodium (3.74 to 3.14 mg), magnesium (1.86 to 1.92 mEq) and copper (124.1 to 125 mg); b) our values are higher in regard to potassium (11.22 to 9.23 mEq) and calcium (8.90 to 7.0 mg); c) they are lower in regard to phosphorus (220 to 159 mg); the Table 3 mentioned before does not present data on iron.

On the other hand, analyzing the results included on the table mentioned by Lorenzi [6], which includes data obtained by different authors and recalculating these values according to the same units used by us, it is seen that, excluding the series of Eliel et al. and those of Wilson and Lorenzi, the others do not allow a significant comparison, due to the small number of cases examined. In the series of Eliel et al. and Wilson and Lorenzi, the values presented are very similar to those obtained by us; those authors, however, did not determine the contents of Ca, Mg, Cu and Fe.

Muscles	Water g/100 g	Sodium mEq/100 g	Potassium mEq/100 g	Calcium mg/100 g	Magnesium mEq/100 g	Phosphorus mg/100 g	Copper µg/100 g	Iron mg/100 g
Tibialis anterior	75.49 ± 0.95 n = 29	3.74 ± 0.41 n = 29	11.22 ± 1.83 n = 29	8.89 ± 1.22 n = 29	1.86 ± 0.15 n = 29	159.0 ± 11.2 n = 29	124.2 ± 8.5 n = 29	5.54 ± 0.35 n = 29
Pectoralis major	75.18 ± 1.87 n = 12	4.36 ± 0.42 n = 12	3.49 ± 0.45 n = 9	10.49 ± 0.86 n = 12	1.69 ± 0.25 n = 12	193.5 ± 13.5 n = 12	230.0 ± 37.3 n = 12	2.16 ± 0.40 n = 12
Deltoid	75.91 ± 1.57 n = 12	3.30 ± 0.72 n = 12	2.66 ± 0.40 n = 9	10.00 ± 1.09 n = 12	1.59 ± 0.24 n = 12	190.3 ± 11.9 n = 12	343.9 ± 81.4 n = 12	2.49 ± 0.50 n = 12

Table 1 — Results (fresh weight).

	Water g/100 g	Sodium mEq/100 g	Potassium mEq/100 g	Calcium mg/100 g	Magnesium mEq/100 g	Phosphorus mg/100 g	Copper µg/100 g	Iron mg/100 g
				M. tibialis anterior × *M. pectoralis major*				
t	0.704	4.368	12.327	4.112	2.697	8.418	14.600	26.837
P	> 0.40	< 0.001	< 0.001	< 0.001	> 0.001	< 0.001	< 0.001	< 0.001
Degrees of freedom $n_1 + n_2 - 2$ =	39	39	36	39	39	39	39	39
				M. tibialis anterior × *M. deltoid*				
t	1.052	2.481	13.884	2.731	4.426	7.950	14.500	22.082
P	> 0.20	> 0.01	< 0.001	> 0.02	< 0.001	< 0.001	< 0.001	< 0.001
Degrees of freedom $n_1 + n_2 - 2$ =	39	39	36	39	39	39	39	39
				M. pectoralis major × *M. deltoid*				
t	1.033	4.388	4.084	1.219	0.990	0.630	4.328	1.767
P	> 0.30	< 0.001	< 0.001	> 0.20	> 0.30	> 0.50	< 0.001	> 0.05
Degrees of freedom $n_1 + n_2 - 2$ =	22	22	16	22	22	22	22	22

Table 2 — Significance of the differences between the means of the concentrations in M. tibialis anterior, deltiod and perctoralis major.

It should be noticed that the material studied by Lorenzi was obtained during surgery and not from cadavers. The comparison of the data obtained by him and by us shows that the results obtained in cadavers before 24 hours after death are fairly similar to those obtained from living specimens. Also, it may be — and further research should prove it — that in regard to the other elements investigated by us similar concentrations should be found in both conditions, as suggested by the data provided in the Geygi Documenta.

SUMMARY

The present paper aims to presents standard values for the contents of water, sodium, potassium, calcium, magnesium, phosphorus, copper and iron in muscles (tibialis anterior, deltoid and pectoralis major) in individuals without any neurological conditions. This study shall constitute the basis for the interpretation of other data, still being gathered, relating these normal values with those obtained for muscles under pathological conditions.

RESUMO

Os autores determinaram o conteúdo em água, sódio, potássio, cálcio, magnésio, fósforo, cobre e ferro em músculos estriados (tibial anterior, deltóide e grande peitoral) de indivíduos sem afecção neurológica. Êste estudo constitui base para estudos comparativos na composição química de afecções neuromusculares.

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