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Electrolytes in Normal and Dystrophic Chickens as Influenced by Dietary Potassium (40600)

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A type of muscular dystrophy was described in New Hampshire chickens by Asmundson *et al.* (1) in which the affected chickens had difficulty in righting themselves when placed on their backs, due principally to an abnormality in the pectoralis muscle. The importance of potassium in muscle disease has been demonstrated by the effect of potassium administration in familial periodic paralysis, by the profound muscle weakness associated with potassium depletion in severe diabetic coma, and by the severe depression of body potassium concentration in patients with muscular dystrophy (2) Blahd *et al.* (3) have proposed that intracellular potassium deficiency is a primary factor in the dystrophy process.

In the present study, two different levels of potassium were fed to normal and dystrophic chickens and a study was made of the tissue electrolytes to determine whether abnormal electrolyte balance is associated with the dystrophic condition.

Materials and methods. A factorial design experiment was conducted with two lines of male chickens and two levels of dietary potassium. Normal New Hampshire chicks (line 200) were a control for dystrophic chicks (line 307) described by Asmundson *et al.* (1). The chicks were raised in electrically heated batteries with raised wire floors. They were fed a practical chick starting ration for 1 week before being fed the purified diet (4) which contained either 0.5 or 1% of supplemental potassium. At the end of the 4 weeks, samples of blood, the left pectoralis major muscle, left gastrocnemius leg muscle, and entire heart were collected from 7 chicks on each treatment. Dry matter, fat, and ash content were determined on each sample before the analysis of sodium, potassium, magnesium, and calcium content by atomic absorption spectrophotometry. Statistical analyses were carried out by the t test and the analysis of variance.

Results. Body weight (Table I) was similar for the normal chicks fed both the 0.5 and 1% level of potassium. Gain of the dystrophic chicks was also similar to the normal chicks when fed 0.5% potassium, but was significantly reduced at the 1% potassium level. The body weight gains for the normal and dystrophic chicks fed the lower level of potassium were comparable to those which have been previously reported (1).

Blood plasma from the normal chicks contained the following levels of electrolytes: sodium, 128.5; potassium, 6.05; magnesium, 1.52; and calcium, 5.07 meq/liter. Comparable values for the dystrophic chicks were sodium, 126.3; potassium, 5.81; magnesium, 1.49; and calcium, 4.90 meq/liter. The only electrolyte which was significantly different between the normal and dystrophic lines was calcium, which was slightly higher in the normal strain ($P < 0.025$). There were no significant differences between the blood plasma electrolytes of chicks fed 0.5 and 1% potassium.

As indicated in Table II, dystrophic chickens had pectoral muscles significantly smaller than normal at 5 weeks of age. The dietary potassium levels studied did not significantly affect pectoral muscle weight, regardless of the chicken line. The dry matter content in the muscle of the dystrophic chicks was significantly reduced in comparison to normal chick muscle, and was unaffected by the dietary level of potassium. In the normal chicks, the pectoral muscle did not change in dry matter content when the dietary level was increased from 0.5 to 1%. Since the dystrophic line was originally selected for high fat content of the pectoralis muscle (1), it is not surprising that male chicks from this line contain almost five times as much fat as the

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TABLE I. BODY WEIGHT GAIN (g) FROM FIRST TO FIFTH WEEK OF AGE IN NORMAL AND DYSTROPHIC CHICKS FED TWO DIFFERENT LEVELS OF POTASSIUM

	Potassium supplemented (%)[a]	
Line	0.5	1.0
Normal	353.6 ± 16.6[1]	357.8 ± 19.1[1]
Dystrophic	341.9 ± 14.7[1]	323.2 ± 8.5[2]

[a] Mean ± SEM; seven chicks per group. Different superscripts indicate significant differences at $P < 0.05$.

pectoral muscle from the normal chicks. The fat content was unaffected by dietary potassium. The ash content of the pectoral muscle in both lines of chicks was not statistically different, regardless of line, and the ash content was significantly increased when the dietary potassium was increased from 0.5 to 1%.

The pectoral muscle of dystrophic chicks contained a significantly higher concentration of sodium on a fat-free, dry matter basis than (Table II) that of normal chicks. This higher sodium concentration in the dystrophic chicks was unaffected by the dietary potassium level, however in normal chicks, the sodium content was significantly reduced with an increase in dietary potassium. There was no significant difference in the potassium content of the pectoral muscle between normal and dystrophic chicks when all groups were compared, but the normal chicks showed a significant increase in potassium content with increased dietary potassium. At the 0.5% level of dietary potassium the dystrophic chicks had a significantly greater level of potassium than the normal chicks. The magnesium content was similar in both lines of chicks and did not vary with the dietary potassium level. The pectoral muscle from dystrophic chicks showed a significantly higher level of calcium than that from normal chicks, which was not significantly modified by potassium level.

Differences in gross composition between the normal and dystrophic lines for the gastrocnemius muscle are very small or insignificant. For this reason it is valid to make comparisons between the electrolyte levels based upon dry matter weight instead of fat-free dry matter. The sodium level (Table III) in normal chick gastrocnemius muscle was unaffected by potassium level. The sodium content of dystrophic muscle was signifi-

TABLE II. COMPOSITION OF SUPERFICIAL PECTORAL MUSCLE OF NORMAL AND DYSTROPHIC CHICKS FED TWO DIFFERENT DIETARY POTASSIUM LEVELS

Line	K added	N^a	Muscle wt[b] (g)	Dry matter (%)	Fat[c] (%)	Ash[c] (%)	Concentration meq/100 g fat-free dry matter: Sodium	Potassium	Magnesium	Calcium
Normal	0.5%	7	12.18 ± 0.37a[d]	26.49 ± 0.31a	5.26 ± 0.87a	4.03 ± 0.10b	18.07 ± 1.03a	28.06 ± 0.61b	10.46 ± 0.34a	0.90 ± 0.17a
						$P < 0.005$[e]	$P < 0.05$	$P < 0.001$		
	1.0%	6	12.89 ± 0.25a	25.95 ± 0.25a	5.33 ± 0.86a	4.71 ± 0.04a	15.33 ± 0.86b	36.75 ± 0.60a	10.69 ± 0.18a	0.77 ± 0.06a
(Combined)		13	12.54 ± 0.53A	26.24 ± 0.21A	5.29 ± 0.59B	4.35 ± 0.11A	16.81 ± 0.76B	32.03 ± 1.30A	10.57 ± 0.19A	0.81 ± 0.05B
Dystrophic	0.5%	7	6.63 ± 0.73a	24.42 ± 0.55a	25.53 ± 1.84a	4.01 ± 0.13b	42.08 ± 2.43a	33.13 ± 1.63a	9.96 ± 0.89a	2.56 ± 0.26a
						$P < 0.005$				
	1.0%	7	6.78 ± 0.73a	23.05 ± 0.55a	23.39 ± 1.51a	4.71 ± 0.11a	42.13 ± 2.31a	36.03 ± 2.16a	10.15 ± 0.41a	2.17 ± 0.21a
(Combined)		14	6.71 ± 0.50B	23.74 ± 1.58B	24.46 ± 1.18A	4.36 ± 0.13A	42.10 ± 1.61A	34.58 ± 1.36A	10.06 ± 0.28A	2.35 ± 0.17A
			$P < 0.001$	$P < 0.001$	$P < 0.001$	NS	$P < 0.001$	NS	NS	$P < 0.01$

[a] Number of chicks sampled.
[b] Fresh weight.
[c] On dry matter basis.
[d] Mean ± SEM.
[e] Level of significance.

TABLE III. ELECTROLYTE CONTENT OF GASTROCNEMIUS MUSCLE OF NORMAL AND DYSTROPHIC CHICKENS FED TWO DIFFERENT LEVELS OF POTASSIUM

		Concentration meq/100 g dry matter			
Line	K added	Sodium	Potassium	Magnesium	Calcium
Normal	0.5	17.70 ± 0.19	35.91 ± 0.41	9.96 ± 0.19	1.49 ± 0.16
Normal	1.0	17.22 ± 0.86	33.29 ± 1.76	9.75 ± 0.15	1.53 ± 0.23
Dystrophic	0.5	25.22 ± 2.32[a]	36.34 ± 1.10	9.18 ± 0.13[b]	1.32 ± 0.09
Dystrophic	1.10	21.01 ± 0.43[c]	32.76 ± 0.93	8.58 ± 0.58[b]	1.54 ± 0.15

[a] Significantly different from normal ($P < 0.005$).
[b] Significantly different from normal ($P < 0.01$).
[c] Significantly different from normal ($P < 0.025$).

cantly greater than that of normal muscle, but again was unaffected by the level of dietary potassium. The level of potassium in normal chicks was unaffected by potassium level, and there was no difference between the dystrophic and normal levels of potassium at equivalent dietary potassium levels. However, the dystrophic chicks fed the higher level of potassium had a significantly lower level of potassium in their muscle. The magnesium level in the gastrocnemius muscle were unaffected by dietary potassium level, however, the levels in the dystrophic chicks were significantly lower than those in the normal chicks. There were no differences in the calcium content of the gastrocnemius muscles of any of the chicks.

There appeared to be some differences in the electrolyte content between normal and dystrophic heart tissue, however, it was found that the fat content of the hearts from normal chicks was significantly greater than those from the dystrophic line, and that there were no significant differences in the electrolyte content between normal and dystrophic chicks when expressed as electrolyte per fat-free dry matter.

Discussion. Since the plasma electrolyte levels showed little difference with the addition of potassium, it is possible that the growth depression is due to some other metabolic change occasioned by the addition of potassium rather than the level of potassium itself. Studies on lysine–arginine antagonism by O'Dell and Savage (5) have shown that growth of chicks fed an excess of lysine can be improved by the supplementation of the diet with arginine or potassium. Arginine metabolism was not specifically influenced by potassium (6), but lysine anabolism appeared to be promoted by the supplement (7). Scott and Austic (8), on the other hand, found that the addition of 1.8% potassium to a high lysine diet increased lysine catabolism and that this, coupled with increased food intake, may explain the alleviating effect of potassium on an excess of lysine. Kratzer and Earl (9) found that the growth of dystrophic chicks was exacerbated less by an increase in dietary lysine than was the growth of normal chicks. In the present study the pectoral muscle of dystrophic chicks was found to contain a higher level of potassium which might explain their greater tolerance to excess lysine.

The extremely high level of fat in the superficial pectoral muscle of the dystrophic chicks was consistent with the results reported earlier (1) and represent the further result of selection for a strain with this high fat level. There was little difference in the gross composition of the gastrocnemius muscle. The heart showed a different trend in that the fat content of the dystrophic chicks was lower than the fat content of the controls.

The superficial pectoral muscle of the dystrophic chicks was significantly elevated in sodium and calcium content. This was not in agreement with studies of Blahd *et al.* (3) in which they reported that potassium depletion is the major factor in the dystrophic process. Baker *et al.* (10) reported that mice with muscular dystrophy have a lower potassium and a higher sodium concentration in the leg muscle compared to normal mice. The dystrophic chicks did not show altered sodium and potassium levels in the superficial pectoral muscle with the addition of 1% potassium, while the normal chicks had an increased potassium and a lowered sodium level.

The gastrocnemius muscle, which is affected very little in the dystrophic chick, showed no change in potassium and calcium content but sodium was increased and magnesium slightly decreased in the dystrophic condition. There was no change in the electrolyte composition of the heart.

The genetically muscular dystrophic chicken has been tested previously and exhibited a differential response to dietary changes in comparison to normal chickens (9, 11, 12). The results of this nutritional experiment represent another example of the effect of nongenetic variables on the various parameters that differentiate the genetically dystrophic from the normal chick.

Summary. Normal and genetically dystrophic chickens showed different responses in electrolyte balance when fed two different levels of potassium. Dystrophic chickens had significantly higher levels of sodium, potassium, and calcium in their pectoral muscle, significantly higher sodium and lower magnesium levels in their gastrocnemius muscle, and no significant differences in the electrolyte levels of their cardiac muscle compared with normal chicks. Electrolyte composition was greatly affected in the pectoral muscle, less affected in the gastrocnemius muscle, and unaffected in the cardiac muscle in the normal chicks when potassium was increased from 0.5 to 1%. In dystrophic chicks, however, only the gastrocnemius muscle was affected by an increase in dietary potassium.

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