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HISTOLOGICAL CHANGES OF FASCICULUS INDUCED BY DIFFERENT SIZES OF THE PECTORALIS MUSCLE IN JAPANESE QUAILS WITH LARGE, NORMAL AND SMALL BODY SIZE

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Background:

Meat type animal and bird have been bred to make their body size and muscle mass increase for improving their meat production ability during domestication. Muscle size is determined by number and size of the fasciculus composed of myofibers with different histochemical properties. Ashmore et al. (1972) suggested that muscle makes its mass larger from the transformation of smaller α R fiber to larger α W. Swatland and Cassens (1972) observed hypertrophy of type II fibers in the vastus lateralis muscle increased its mass in rat. Rearrangement of fasciculus with age was also reported in human vastus lateralis muscle (Sjöström et al., 1992).

The iliofibularis muscle in the Japanese quails with different body sizes changed its mass by changing both dimension and number of the myofibers (Gotoh et al., 1998; Iwamoto et al., 1998). However, it has not been clarified what happened in the fasciculus of the pectoralis muscle by changing the muscle mass.

Objectives:

In this study, histological structure of the pectoralis muscle fasciculus was compared among 3 strains with large, normal and small body size in adult Japanese quails. Strain- and sex-differences of the fasciculus structure were observed using the fasciculus area size, its percentage area occupied by white myofibers, number of red or white myofiber per fasciculus and cross sectional area in each myofiber type.

Methods:

The Japanese quails bred by Okamoto (Saga University) to be getting large (LL strain), normal (RR) and small (SS) body sizes were used. In each sex, 5 birds of each strain were killed by bleeding under deep anaesthesia by intravenous injection of barbital sodium after weighing. Pectoralis muscle was dissected out and weighed without peripheral tendon and adipose tissue. Tissue destined for histological examination was taken from center of the ventral part with longer myofibers. Frozen section was cut and stained by the histochemical reaction for NADH dehydrogenase activity.

Image analysing was carried out on total 20 fasciculi from the 2nd layer to the 6th from the surface because of regional difference of fiber type composition in each bird. Cross sectional area (CSA) of fasciculus, its percentage area occupied by white myofibers and number of red and white myofibers, and average CSA of red and white myofibers were measured.

Results and Discussion:

Body weight and the pectoralis muscle weight were as follows: Male LL strain 282g and 22.6g, RR 114g and 8.6g, SS 61g and 4.0g, female LL 315g and 26.0g, RR 148g and 9.6g, SS 77g and 4.1g, respectively. In each sex, strain differences of both weights were significant at 1 % level (Table 1). CSA of fasciculus showed significant difference among the strains in each sex except for between female RR and SS ($P < 0.05$). Increasing or decreasing ratios of the CSA in LL or SS strains from RR were enough large or small to attain the proportional increase of the muscle dimensions. Percentage area of white myofibers in a fasciculus was significantly smaller in the male LL strain than the other and the female LL ($P < 0.05$). Although the average numbers in a fasciculus did not show any significant differences, myofibers of both types made their average CSA increase in the LL strain and decrease in the SS from the RR. Different responses between the myofiber types on the muscle weight change were recognized. In both sexes, red myofibers with smaller size had the average CSA increased more (male 2.21 folds, female 1.89) than white myofibers (male 1.80, female 1.61) to increase the pectoralis muscle mass in the LL strain, and conversely the larger

Table 1. Fasciculus CSA, its percentage area occupied by white myofiber, number of red or white myofibers in fasciculus, and cross sectional area of myofiber in each type in the pectoralis muscle.

Breed and strain	Fasciculus CSA $\times 10^5$ μ m^2	Percentage area of white fiber	No of myofiber		Myofiber size (μ m^2)	
			Red	White	Red	White
Male						
LL strain	4.28 ± 0.34^{ax}	49.4 ± 1.2^{ax}	197 ± 20^{ax}	57 ± 5^{ax}	1094 ± 131^{ax}	3526 ± 247^{ax}
RR strain	1.64 ± 0.09^{bx}	57.4 ± 2.7^{bx}	146 ± 16^{ax}	47 ± 3^{ax}	494 ± 39^{bx}	1964 ± 83^{bx}
SS strain	1.06 ± 0.13^{cx}	56.3 ± 0.4^{bx}	149 ± 13^{ax}	53 ± 5^{ax}	334 ± 60^{bx}	1163 ± 232^{cx}
Female						
LL strain	3.60 ± 0.20^{ax}	60.8 ± 4.7^{ay}	124 ± 17^{ay}	63 ± 5^{ax}	1185 ± 92^{ax}	3407 ± 218^{ax}
RR strain	1.85 ± 0.13^{bx}	59.8 ± 1.3^{ax}	117 ± 8^{ax}	52 ± 4^{ax}	645 ± 48^{by}	2110 ± 79^{bx}
SS strain	1.54 ± 0.04^{by}	53.3 ± 2.8^{ax}	137 ± 10^{ax}	50 ± 3^{ax}	542 ± 5^{by}	1632 ± 42^{cx}

Mean $\pm$ standard error n = 5

^{a,b,c} Means with the same superscript did not differed significantly between strains at 5% level.

^{x,y} Means with the same superscript did not differed significantly between sexes at 5% level.

white got the area decreased more (male 0.59, female 0.77) than the red (male 0.68, female 0.84) to decrease the muscle mass in the SS strain.

Although Ashmore et al. (1972) indicated transformation from small size red to large size white myofibers to get muscle mass increased, any evidences of the transformation were not obtained in the LL of both sexes in this study. In rat the hypertrophy of white myofiber was reported by Swatland and Cassens (1972). However, the red myofibers hypertrophied more than the white in the LL in this study. On the other hand, shrinkage of the pectoralis myofibers was larger in the white than the red in the SS. Gotoh et al. (1998) and Iwamoto et al. (1998) also showed the number of myofiber changes depending on the iliofibularis muscle size. In this study, the number of myofiber composed of fasciculus did not change and the fasciculus CSA was enough large or small to get the large or small muscle mass in the LL and SS strains.

Conclusions:

From these results, it was suggested that the most marked response of the fasciculus to changes of the pectoralis muscle weight was observed on its size with the myofiber hypertrophy or shrinkage. In the LL strain the hypertrophy was larger in red myofiber, and in the SS the shrinkage developed more in the white.

Pertinent literature:

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