Changes in Skeletal Muscle Composition in Response to Swimming Training for Young Horses

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ABSTRACT. To investigate muscular adaptation to swimming training in young horses, 18 two-year-old Thoroughbred horses were trained in a program which included both running and swimming, and the changes in skeletal muscle composition during the training period were evaluated histochemically. The horses were divided into the following three groups: Group A, trained by running only; Group B, trained by running plus a gradual increase in swimming; Group C, trained by running plus constant swimming. In Groups B and C, fast twitch-low oxidative (FT) fibers tended to decrease, while fast twitch-high oxidative (FTH) fibers to increase with the training progressed. The tendency was more remarkable in Group B. Therefore, in these two groups, it was suggested that the horses' aerobic capacity at the muscular level was improved significantly.—KEY WORDS: equine, muscle, swimming.


To reduce the incidence of injuries during training, racehorses have been trained using high-intensity exercise with low shock loading of the horses' legs against impact with the racing surface. Since young horses also suffer frequently from exercise-related diseases, it seems necessary to introduce new training methods. Therefore, we have studied the effects of swimming training as a new exercise method for young horses. Our results revealed that a training program with swimming is potentially useful for improvement of performance capacity, since it can reduce the incidence of locomotor injury and allow smooth progress of future training [6]. In this study, muscular adaptation to swimming training in young horses was evaluated histochemically to investigate further the improvement in horses' performance capacity.

Eighteen out of 24 two-year-old Thoroughbred horses, the same as those used in our previous study [6], were used for this experiment. After becoming familiarized with swimming, the horses were divided into the following three groups, for the 5 month training schedule shown in Table 1.

Group A: subjected only to training on a track — trained by running only (4 horses). Group B: subjected to swimming training, which was increased in proportion to the progress in running training — trained by running plus a 300 m swimming every day during the first 2 months, and a 500 m swimming every day during the last 3 months (7 horses).

Group C: subjected to constant swimming training in addition to running training — trained by running plus a 300 m swimming every day for 5 months (7 horses).

Muscle biopsies were carried out every month during the first 3 months of the training period, and the samples obtained were analyzed histochemically. The biopsies were taken from a part of the left gluteus medius muscle, 15 cm dorso-caudally away from the tuber coxae, as reported by Lindholm and Piel [3]. After careful shaving of the hair in a 2 cm square and disinfection, 1 cm incision was made with a scalpel, including both skin and fascia. A biopsy needle with an external diameter 6 mm was used, and the muscle samples were obtained at 10 cm depth. The samples were collected at four different corners of the shaved square every month as follows: before the training, top left corner; after 1 month of the training, bottom right; after 2 months of the training, bottom left; after 3 months of training, top right. After sampling, there was no infection or hematoma, although the incision was only disinfected with iodine and compressed with the fingers without suturing.

Just after sampling, the specimens obtained from each horse were placed in an aluminum vessel filled with O.C.T. Compound (Tissue-Tek, Miles Inc., U.S.A.) and immediately freeze-dried in liquid nitrogen. These samples were stored at -196°C until analyzed histochemically.

Serial cross-sections were cut in a cryostat at -20°C and mounted on glass slides for histochemical staining for succinate dehydrogenase. Muscle fibers were classified as slow twitch (ST), fast twitch-low oxidative (FT) and fast twitch-high oxidative (FTH), according to their characteristic succinate dehydrogenase staining patterns (Fig. 1). After the numbers of each muscle fiber type contained in a given area were counted from photographs of stained sections, the percentages of each of the fiber types were calculated. The data were presented as mean ± standard deviation (SD), and analysed using analysis of variance (ANOVA).

The changes in muscle fiber composition during the 3 months of the training period are presented in Table 2 and Fig. 2. The percentages of each of the fiber types before training showed no significant differences among the 3 groups.

In Group A, there were no significant changes during the 3 months after the start of training. In Groups B and C, the percentages of FT fibers decreased, whereas those of FTH fibers increased as the training progressed. The changes observed in Group B were more marked than those in Group C, and the decrease in FT fibers after 3 months of training and the increase in FTH fibers after 2 and 3 months of training in Group B were significantly different (p<0.05) in comparison with the pre-training values.

Previous studies showed that the fiber composition of the gluteus medius muscle in 1–2 year old horses has a high
Table 1. Training schedule for young horses

<table>
<thead>
<tr>
<th>Month</th>
<th>Running training (6 days/week)</th>
<th>Swimming training Protocol (1) (4 days/week)</th>
<th>Swimming training Protocol (2) (4 days/week)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 month</td>
<td>Walk 1,000 m, Trot 1,200 m, Canter 1,200 m</td>
<td>100 m * 3/day</td>
<td></td>
</tr>
<tr>
<td>1st month</td>
<td>Walk 800 m, Trot 1,800 m, Canter 2,400 m</td>
<td>100 m * 3/day</td>
<td></td>
</tr>
<tr>
<td>2nd month</td>
<td>Walk 800 m, Trot 1,800 m, Canter 2,400 m</td>
<td>100 m * 5/day</td>
<td></td>
</tr>
<tr>
<td>3rd month</td>
<td>Walk 800 m, Trot 1,200 m, Canter 3,000 m, Gallop 400 m</td>
<td>100 m * 3/day</td>
<td></td>
</tr>
<tr>
<td>4th month</td>
<td>Walk 800 m, Trot 1,200 m, Canter 3,000 m, Gallop 800 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5th month</td>
<td>Walk 800 m, Trot 1,200 m, Canter 3,000 m, Gallop 1,200 m</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Group A: running training  
Group B: running training + swimming training protocol (1)  
Group C: running training + swimming training protocol (2)

Table 2. Changes of FTH/FT ratio throughout the training period

<table>
<thead>
<tr>
<th>Month</th>
<th>FTH/FT ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group A</td>
</tr>
<tr>
<td>0</td>
<td>1.5 ± 0.29</td>
</tr>
<tr>
<td>1</td>
<td>1.7 ± 0.12</td>
</tr>
<tr>
<td>2</td>
<td>1.6 ± 0.47</td>
</tr>
<tr>
<td>3</td>
<td>1.7 ± 0.30</td>
</tr>
</tbody>
</table>

*: P<0.05 vs. pre-training value.

Fig. 1. A section of equine M. gluteus medius (× 100). The succinate dehydrogenase staining demonstrates three fiber categories can be classified as slow twitch (ST), fast twitch-high oxidative (FTH) and fast twitch-low oxidative (FT) fibers.

variance, the reported values being as follows: ST fibers, approximately 20%; FT fibers, 30-50%; FTH fibers, 30-50% [1, 2, 4, 7]. The percentages of each fiber type obtained in this study were approximately 20% for ST, 30-40% for FT and 40-50% for FTH, in agreement with the data reported by Essén et al. [1]. Since the distribution of each fiber type varied little throughout the experimental period, it appeared that the 4 biopsy sites were fixed, and that the present data are not an obstacle to understanding the changes in muscle fiber composition as the training progressed.

The muscle fiber composition in Group A did not change significantly. Groups B and C showed a decrease of FT fibers and an increase of FTH fibers as the training
progressed, and a significant increase in the FTH/FT ratio occurred after 3 months of training. Earlier studies on changes in skeletal muscle in response to training demonstrated that improvements in the oxidative capacity of skeletal muscle result only from intensive endurance training in horses [4, 8], and result in an increase of the FTH/FT fiber ratio and oxidative enzyme activities in muscle [4, 5, 9]. Therefore, the significant increases in the FTH/FT ratio in Groups B and C would imply an improvement in the oxidative capacity of the muscle. The significant increase after 3 months of the training may be related to the training program, in which higher-intensity endurance work was included after 2 months. The most remarkable decrease in FT fibers and the increase in FTH fibers in Group B were thought to correspond to our previous findings [6], which indicated a favorable increase of aerobic energy yield only in Group B, as determined using a standardized exercise test.

REFERENCES