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Brief review

Muscle characteristics of Japanese scooer players using NMR

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1 Introduction

This is a brief review on the muscle characteristic of elite soccer players in Japan. The information about the muscle characteristic of elite soccer players seems abundant but is, as a matter of fact, quite scare. This is because muscles are concealed and, therefore, can hardly be seen directly. The field of sports sciences witnessed the initiation of muscle biopsy in 1960's, enabling us to obtain the direct information about the muscle cell. The muscle biopsy is, however, not a practice athletes like to undergo as it is accompanied by an incision. It may be further difficult to inspect in-season changes of a muscle. These are the reasons for source data on elite athletes, and it has remained unknown within a black box how the muscles of such athletes are characterized and what changes take place due to training.

2 NMR

We have studied the muscle characteristic of Japanese top ranked soccer players using the MR equipment (Fig.1). This equipment enabled us to obtain the information about elite athletes as it allows morphological and biochemical information about muscles to be obtained *in vivo* through the irradiation of a living body with magnetism. At first, it is discussed that NMR data on a topic of the morphological characteristic of Japanese top-ranking soccer players' muscles as well as of the relationship between in-season training and muscle characteristic. Figure 2 shows an axial image of thigh obtained from MRI. It covers the section from the knee to the upper part of thigh. The muscles, bones, and fats are clearly depicted.

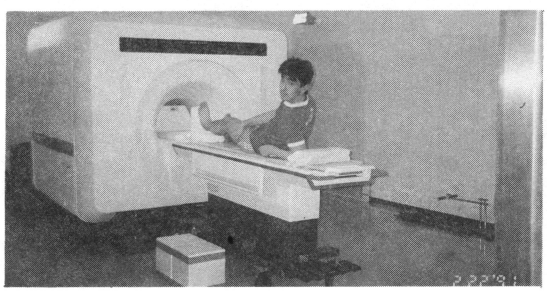

Figure 1 MR equipment.

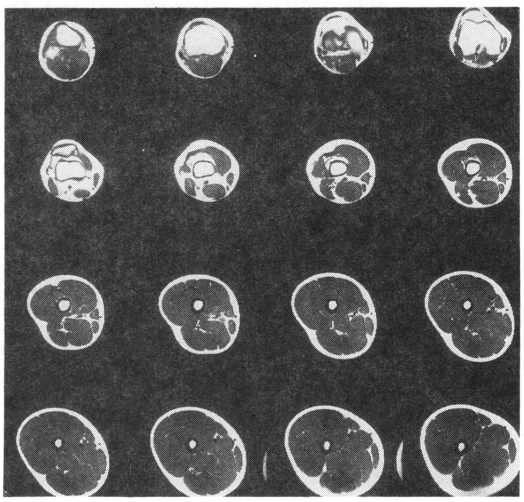

Figure 2 Axial image of thigh obtained from MRI.
It covers the section from knee side (top) to upper thigh (bottom).

Figure 3 shows a picture taken by a method called MRS to obtain muscle energy metabolic information. From left to right, inorganic phosphate, phosphocreatine, and ATP are shown. And, in this spectrum, the state at rest is shown up to the 4th streak from the bottom, that during exercise by the next 6, and the other of the streaks are recovery. When exercise is started, inorganic phosphate increases in its peak while phosphocreatine decreases. The use of ^{31}P MRS also permits us to determine an intracellular pH. Moreover, since the reduction in the intracellular pH has been found proportional to the amount of lactic acid accumulated within a muscle cell, ti can be inferred whether or not a glycolytic system has been mobilized if the value of intracellular pH is known.[3] Such information has so far been unable to be obtatined unless subjected to muscle biopsy.

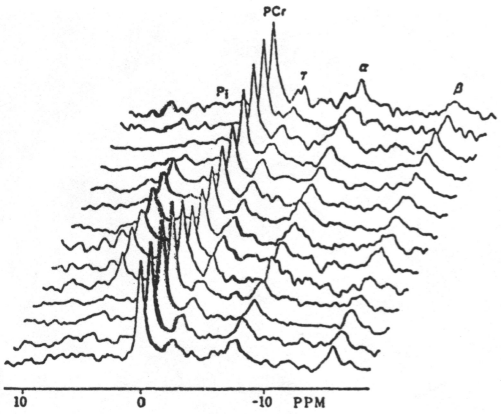

Figure 3 A series of ^{31}P MRS spectra *in vivo* at rest (lower 4 traces), during exercise (middle 6) and recovery (upper 4).[8)]
Pi, inorganic phosphate ; PCr, phosphocreatine ; α, β, γ, three phosphate groups of adenosine triphosphate (ATP)

3 Comparison between soccer players of muscle cross-sectional area andother sport's events

Figure 4-A is an axial image of the thigh depicted by MRI for a national soccer player as a member of the japanese delegation. The muscle quadriceps femoris and hamstring are among those well trained. Subcutaneous fat is also characteristically scarce. Figure 4-B shows that an MR imaging of a judo player who has won a world championship twice. It is particularly notable that the area of hamstring is larger than the soccer player's large one. That subject, though weighing 90 kg, has scarce subcutaneous fat, indicating a large composition ratio of muscles. Figure 4-C shows that the MR imaging of a male volleyball player of the Japan national team. This player has most characteristically, highly developed M. rectus femoris. It is generally well that M. rectus femoris plays an important role in jumping motion. This picture indicates that the development of this muscle is still ever important for volleyball players who repeat such a motion during a game. Figure 4-D shows an example of those players observed to have the highest developed muscles with very little subcutaneous fat among the elite athetes contained. He was an athletic pole jumper and had held a Japanese record until recently. Figure 4-E shows an untrained male's axial image. This subject, unlike an athlete, has characteristically less developed muscles and abundant subcutaneous fat. Figure 5 shows cross-sectional areas of various muscle groups calculated from each image of the thighsobtained by MRI.[4)] The topside of a picture corresponds with the upper part of thigh and the lower part covers the section around upper part of the knee. From left to right, each column gives the area of hamstring, M. vastus medialis and M. vastus intermedius combined, M. vastus lateralis, and M. rectus femoris, respectively.

This figure may, therefore, be considered as a morphological aspect of thigh muscles. They are, from left to right, the muscles of a track and field athlete, judoist, speed skater, soccer player, vollyball player and the untrained. A group of athletes used consisted of those who, represented each of all-Japan teams and who were ranked 10th or higher in each event in Japan. The above comparison clarifies different characteristics in the morphological aspect of thigh muscles for different sport events.

Figure 6 shows a comparison between a soccer player and sprinter. Quite characteristically, there is no significant difference observed in the cross-sectional area of upper-thigh, but in the lower part of thigh, the soccer player definitely exhibits a larger cross-sectional area of muscle. It is considered that this might be partly due to the fact that a coccer player not simply runs in a straight direction but also repeats the most important mode of kicking motion in his performance. At present, however, this cannot be explained to a full extent but is considered as an interesting fact. It also indicates the necessity