Distribution of muscle fibers in skeletal muscles of the African elephant (Loxodonta africana africana)

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The African elephant (Loxodonta africana africana) is the largest land animal on the earth, today. The structure and motion of the elephant are unusual compared with those of other animals. The most significant characteristic regarding the frame of the elephant is the legs, shaped like columns or pillars. The elephant supports its bulk with its straight legs and padded feet. It could be considered that the elephant needs less power to support the body. The elephant walks and swims, but cannot run (Gambaryan 1974; Hutchinson et al. 2006; Ren et al. 2008; Genin et al. 2010). Elephant moves with straighter limbs, and has limited speed and gait. The elephant cannot perform locomotion with an aerial phase. However, elephant has been reported to reach speeds of up to 40 km/h using a fast walk (Hutchinson et al. 2006). The elephant performs fast walking mainly by increasing the stride frequency (Biewener 2003; Hutchinson et al. 2006). The movements are produced by activation of the muscles. To understand movements during the locomotion of animals, studies of muscles are indispensable. In the elephant, the placement, origin, and insertion of skeletal muscles throughout the body have been performed by many researchers (Shindo and Mori 1956a, 1956b, 1956c; Gambaryan 1974; Mariappa 1986). However, to understand the function of skeletal muscles, we must studied the force and action produced by muscle. The skeletal muscles contain different types of muscle fiber (Burke 1981). Muscle fibers can be classified into Types I, IIa, IIb, and IIx by staining with monoclonal antibody for each myosin heavy chain (MHC) isoform and metabolic enzyme activities (Pette and Staron 1993, 1997). Type I is a muscle fiber with a high metabolic cost of maintenance and a small force output, Type IIa is a muscle fiber with a high metabolic cost of maintenance and larger force output, and Type IIb is a muscle fiber with a low metabolic cost for maintenance and the largest force output. Type IIX has intermediate characteristics between Types IIa and IIb. A single motor neuron and the muscle fibers that it innervates comprise a motor unit. The motoneuron properties are exquisite-ly matched to properties of the motor units supplying the muscles and properties of the muscles themselves (Burke 1981). There are systematic differences in the size, excitability, and corresponding variation of speed, power, and endurance in different types of motor unit. Motor units are classified into S, FR, FI, and FF types (Burke 1981). The muscle fibers in S, FR, FI, and FF types correspond to Types I, IIa, IIX, and IIb, respectively. Henneman (1981) showed the existence of a recruitment order among different types of motor unit on the activation of muscle. The recruitment of motor units is very important for motor performance. Studies on muscle fiber compositions are limited to humans and experimental or domestic animals: rat (Ariano et al. 1973; Hintz et al. 1980), cat (Ariano et al. 1973; Reichmann and Pette 1982), dog (Tonilo et al. 2007), horse (Van den Hoven et al. 1985; Kawai et al. 2009), and human (Johnson et al. 1973; Essen et al. 1975). In our previous study, we showed the muscle fiber composition in skeletal muscles from the body of the cheetah, domestic cat, and beagle dog (Goto et al. 2012). Our results indicate that the distribution of different types of muscle fiber reflects the kinematic characteristics of each animal, and studies of muscle fiber distribution are very important to understand animal locomotion. The most important point for studies of muscle fiber composition is the condition of muscles. We had a chance to sample muscles from the African elephant within 24 hours after death.

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