Muscle fiber development in humans and other mammals

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Introduction. Mammalian and human muscle fibers can theoretically grow in two ways: by multiplication, or by thickening. It is logical for muscle growth by multiplication to predominate in young ontogenetic stages, but it would be interesting to discuss the process of muscle growth in the adult organism.

Muscle Growth in Adult Organisms. In adult humans (or adult mammals), muscle fiber growth primarily occurs through a process called hypertrophy, which involves the enlargement of individual muscle fibers rather than their division (multiplication) (Reggiani & Schiaffino 2020; Schiaffino et al 2021).

When an athlete engages in resistance training or strength exercises, he creates stress on his muscles. In response to this stress, the muscle fibers undergo a series of physiological changes. Specifically, the muscle fibers increase in size by adding more contractile proteins (actin and myosin), as well as other cellular components like mitochondria and sarcoplasmic reticulum, which are necessary for muscle contraction and energy production (Reggiani & Schiaffino 2020; Joanisse et al 2020; Schiaffino et al 2021).

This increase in protein content and cellular components leads to an enlargement of the muscle fiber, making it stronger and more capable of generating force. It is important to mention that, while the number of muscle fibers remains relatively constant in adulthood, the size of individual fibers can change significantly based on factors like training intensity, volume, and frequency (Reggiani & Schiaffino 2020; Joanisse et al 2020; Schiaffino et al 2021).

Additionally, in some cases, particularly during recovery from injury or in response to certain hormonal signals (see for instance MGF – Mechano Growth Factor), satellite cells (a type of muscle stem cell) can contribute to muscle growth by fusing with existing muscle fibers and providing additional nuclei, which can support the larger muscle fiber (Wei et al 2022; Koopmans et al 2022).

Hormonal Signals that Can Influence Muscle Growth and Development. Hormonal signals play a crucial role in regulating muscular development and growth. The following list presents some of the key hormones that influence muscle development.

Testosterone. Testosterone is an androgen hormone that plays a crucial role in muscle growth. It increases protein synthesis, which is important for muscle repair and growth. Higher levels of testosterone are associated with increased muscle mass and strength (Kraemer et al 2020).

Growth hormone (GH). The growth hormone, also known as somatotropin, is produced by the pituitary gland. It plays a role in regulating growth and metabolism, including the stimulation of protein synthesis. It can indirectly influence muscle growth by promoting overall tissue repair and growth (Kraemer et al 2020).

Insulin-like growth factor 1 (IGF-1). IGF-1 is a hormone structurally similar to insulin. It is stimulated by the growth hormone and plays a crucial role in cell growth and development. It can enhance muscle protein synthesis and contribute to muscle hypertrophy (Kraemer et al 2020).

Insulin. Insulin is a hormone produced by the pancreas that regulates blood sugar levels. It also has anabolic effects, as it promotes the uptake of nutrients (including glucose and amino acids) into cells, which can support muscle growth and repair (Mohammadabadi et al 2021).

Cortisol. While cortisol is primarily known for its catabolic (muscle-breaking-down) effects in response to stress, it also plays a role in regulating metabolism. Elevated levels of cortisol over extended periods can have a negative impact on muscle growth (Kraemer et al 2020).

Thyroid hormones (T3 and T4). Thyroid hormones play a role in regulating metabolism, including energy expenditure and protein synthesis. They can indirectly influence muscle growth by affecting the overall metabolic rate (De Stefano et al 2021).

Insulin-like growth factor binding proteins (IGFBPs). These proteins regulate the availability of IGF-1 in the body. They can modulate the effects of IGF-1 on muscle growth (Kraemer et al 2020).

Estrogen and progesterone. These are primary female sex hormones, but they are also present in males, albeit in smaller amounts. They influence muscle development and function, and their levels can affect muscle mass and strength (Alexander et al 2022).

Leptin and ghrelin. These hormones regulate appetite and energy balance. While they are not directly related to muscle growth, they play a role in overall metabolism and body composition, which can indirectly influence muscle development (Sun et al 2004; Mohammadabadi et al 2021).

Mechano growth factor (MGF). MGF is a splice variant of insulin-like growth factor 1 (IGF-1), and it is produced in response to mechanical stress or damage to muscle fibers. Specifically, MGF is released in response to resistance exercise, such as weightlifting or other forms of strength training. MGF plays a role in muscle repair and growth by promoting muscle cell proliferation and differentiation (Wei et al 2022; Koopmans et al 2022). It helps to activate satellite cells, which are a type of muscle stem cell, and encourage them to fuse with existing muscle fibers. This process leads to an increase in the number of nuclei within the muscle fiber, which supports protein synthesis and muscle growth.

Conclusions. Muscle growth in adult humans is primarily a result of hypertrophy, or the enlargement of existing muscle fibers, rather than cellular division (multiplication). MGF is one of the factors that contribute to muscle development, particularly in response to mechanical stress or resistance training. It helps facilitate the repair and growth of muscle tissue, ultimately leading to increased muscle mass and strength. While MGF is important, it is just one of many factors involved in the complex process of muscular development.

Conflict of Interest. The author declares that there is no conflict of interest.

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