Physical Remodeling of Connective Tissues

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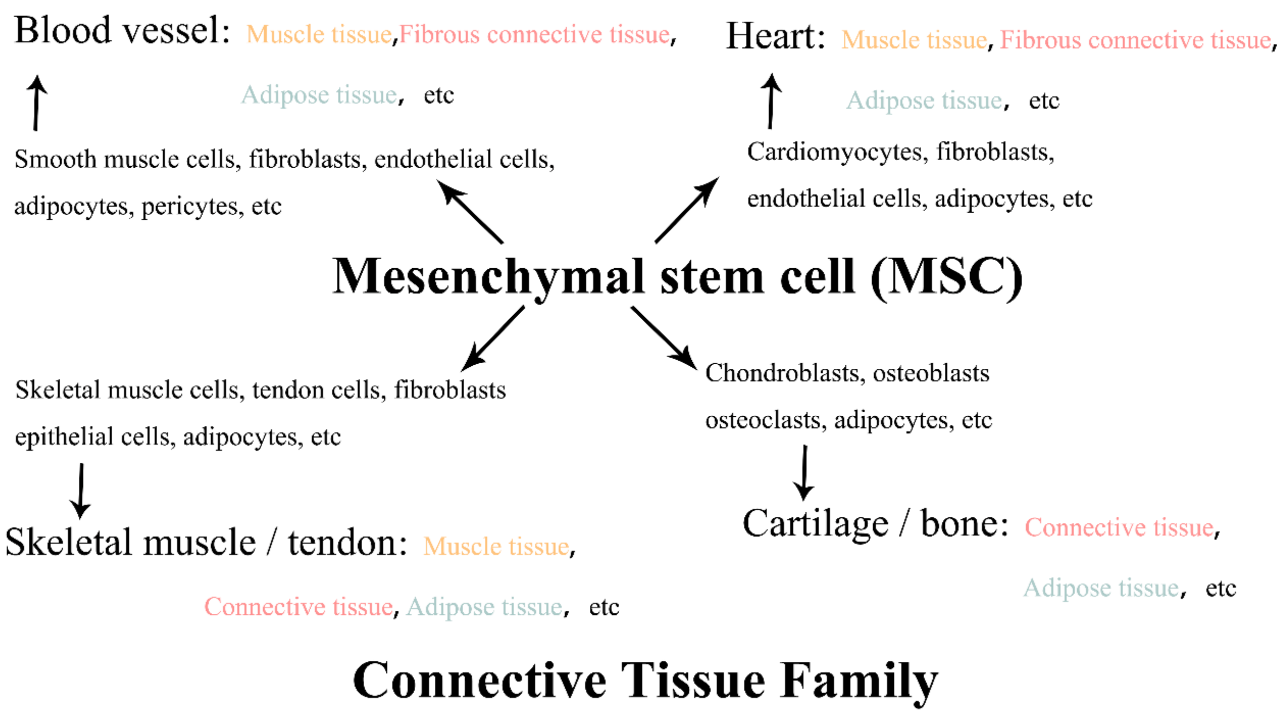

Figure 1. Connective Tissue Family

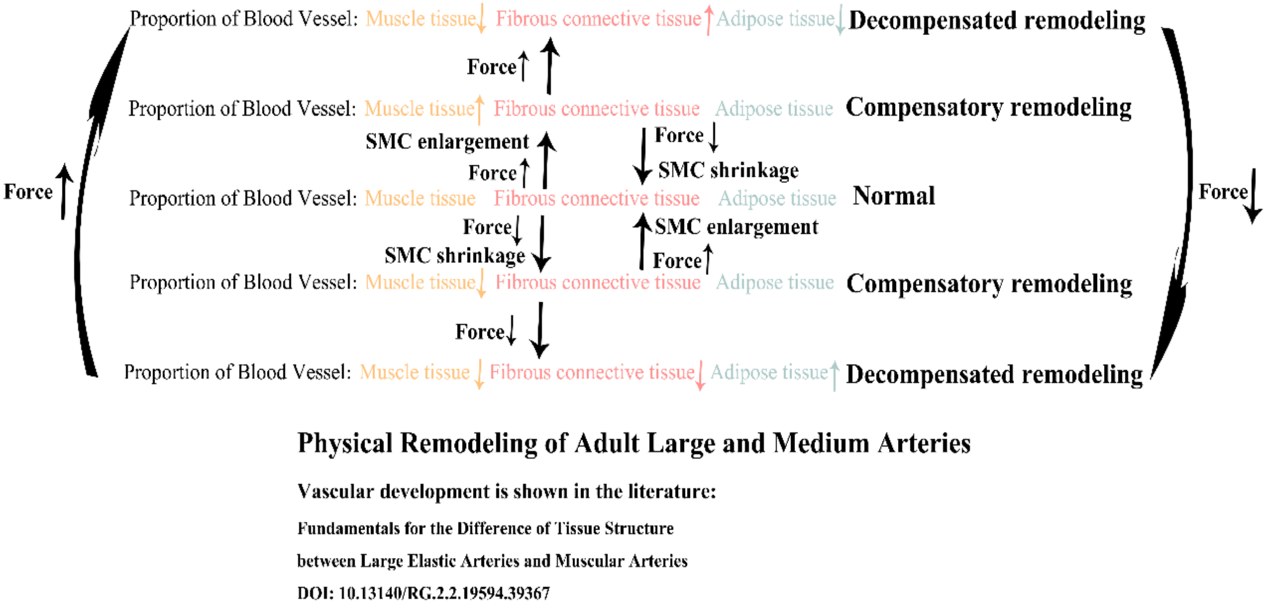

Figure 2. Physical Remodeling of Adult Large and Medium Arteries

Vascular development is shown in the literature: Fundamentals for the Difference of Tissue Structure between Large Elastic Arteries and Muscular Arteries.

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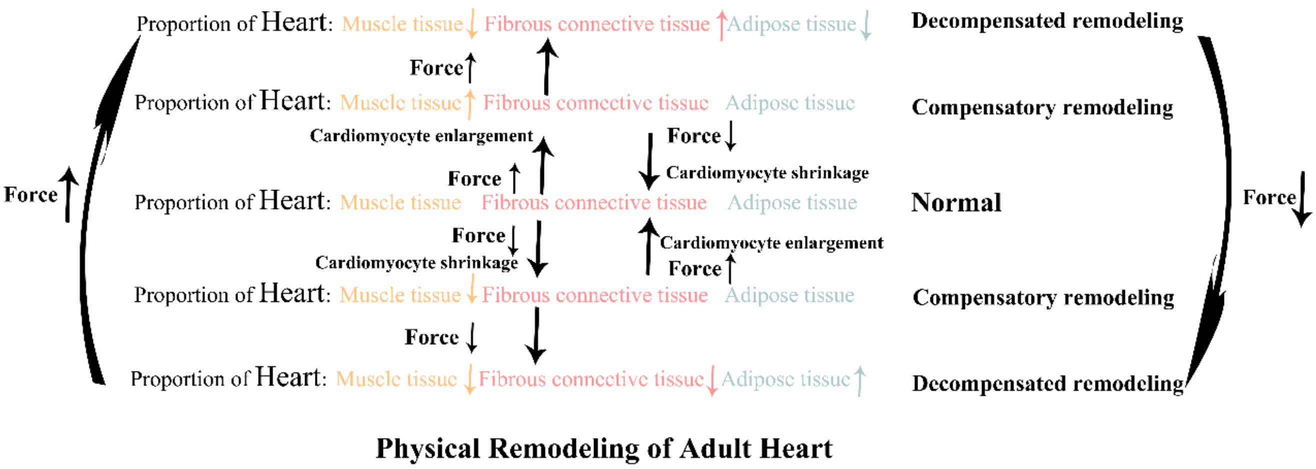

Figure 3. Physical Remodeling of Adult Heart

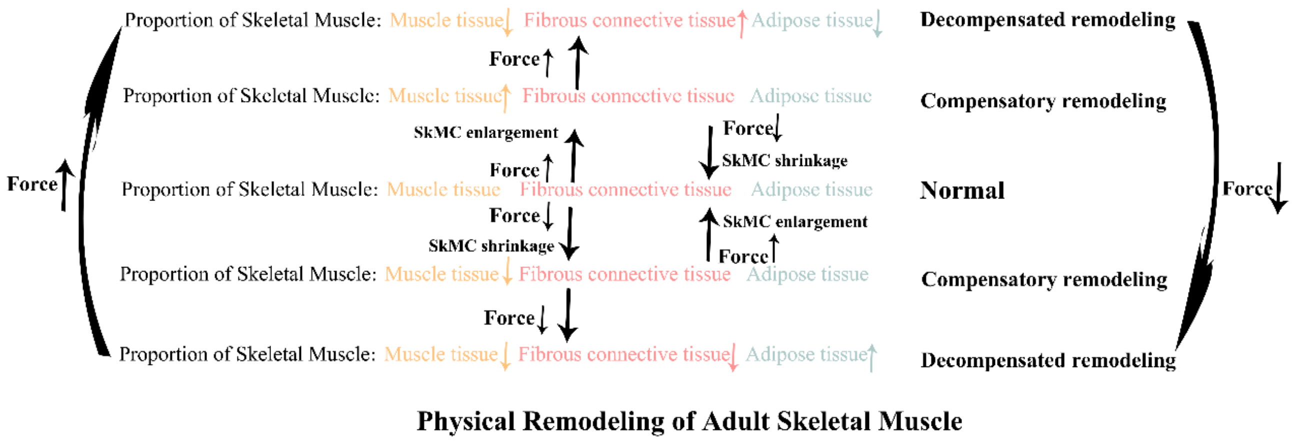

Figure 4. Physical Remodeling of Adult Skeletal Muscle

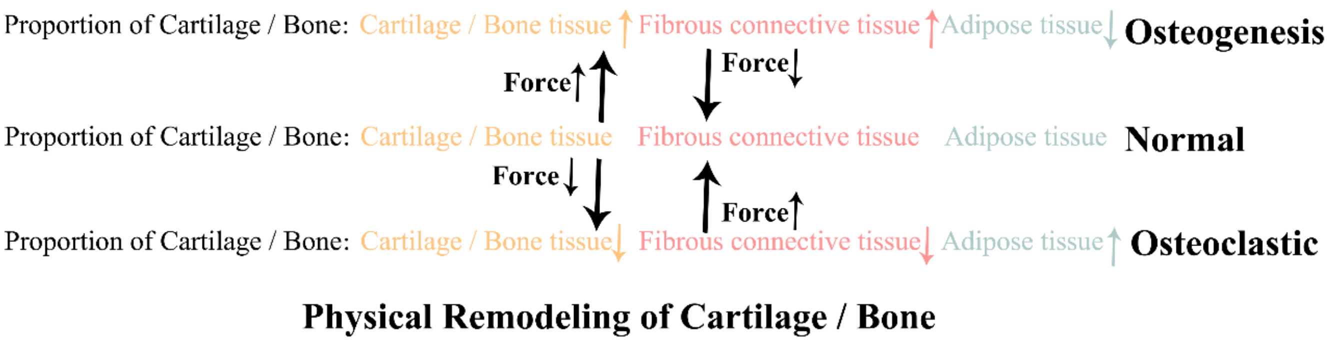

Figure 5. Physical Remodeling of Adult Cartilage and Bone

Main text

Previous reports have demonstrated the fundamentals of the development, remodeling or degradation of blood vessels, etc. [1-21]. These papers explained common human vascular phenomena that cannot be explained by the traditional hypotheses: (1). The formation principle of three-layer structure of blood vessels[12]; (2). The formation mechanism of perivascular adipose tissue (vascular "Kuiper belt")[7,11-14]; (3). Vascular development, remodeling or degeneration[6,7,11,12]; (4). The formation mechanism of atherosclerosis, stiffening, hemangioma or dissection[3,9,12,18]; (5). The occurrence characteristics of human atherosclerosis, prone sites or non-prone sites[4,9]; (6). Pathogenesis of vascular chronic total occlusion (CTO)[11]; (7). Formation principle of vascular ligament[7]; (8). Fundamentals of transformation among muscle tissue, fibrous connective tissue and adipose tissue[8]; (9). Mechanism of cardiovascular calcification[5]; (10). Causes of neonatal atherosclerosis[12,18], etc. In these processes, the transformation among muscle tissue, fibrous connective tissue and adipose tissue is closely related to the changes of force (energy) borne by cells / tissues[8]. Force (energy) increase could promote adipose tissue transformation into fibrous connective tissue[12], and it could also enhance the remodeling of fibrous connective tissue[6,11,12]. Force (energy) decrease could lead to desertification of muscle tissue / fibrous connective tissue (Muscle tissue transformation into fibrous connective tissue / adipose tissue, fibrous connective tissue transformation into adipose tissue)[7,11,12]. These processes conform to the "central dogma" of tissues[8].

Blood vessels, heart, bone, cartilage, muscle, tendon, ligament, adipose tissue, etc. are members of connective tissue family, which are directly or indirectly derived from mesenchymal stem cells (Figure 1) [22], which is the basis for easier mutual transformation among them (Figure 2, Figure 3, Figure 4, Figure 5). Based on the "central dogma" of tissues, this paper would propose the fundamentals of force (energy) remodeling of connective tissue family (Figure 2, Figure 3, Figure 4, Figure 5). It is expected to provide a theoretical basis for the etiological treatment / physical rehabilitation of diseases of connective tissues, such as cardiovascular diseases, musculoskeletal diseases and tumors.

The matter and energy in the universe comply with the "least action principle", and human organs, tissues and cells are no exception. They also comply with the "least action principle", that is, the principle of material and energy optimization. The remodeling of organs / tissues is in line with the fundamentals of strengthening when used and retreating when not used. The mechanism is the remodeling of force (energy). When the development of tissues / organs to a certain size / thickness, due to the limitations of hormones, blood supply or nutrient diffusion distance[6], etc., the size / thickness of normal tissues / organs (except tumor tissues) is limited[6]. In order to adapt for force (energy) changes, tissues / organs must change their adaptability by changing the texture of tissues / organs, which is the mechanical principle of normal tissue / organ remodeling (Figure 2, Figure 3, Figure 4, Figure 5). The increase of force (energy) could make the tissue harder so that the tissue could bear bigger force (Adipose tissue into fibrous connective tissue, fibrous connective tissue into cartilage, cartilage into bone, etc.) (Figure 2, Figure 3, Figure 4, Figure 5). The decrease of force (energy) could soften the existing tissues (Muscle tissue / bone tissue / cartilage tissue into fibrous connective tissue, fibrous connective tissue into adipose tissue, etc.) (Figure 2, Figure 3, Figure 4, Figure 5).

This paper unifies the mechanical remodeling of connective tissues (Figure 2, Figure 3, Figure 4, Figure 5). Because the cardiovascular system and musculoskeletal system are members of the connective tissue family, cardiovascular diseases and musculoskeletal diseases should also be kinds of connective tissue diseases in essence. According to the tissue remodeling of force (energy), it can provide a theoretical basis for the physical rehabilitation treatment of cardiovascular diseases and musculoskeletal diseases. In the process of cells / tissue adapting to mechanical force (energy), it is not just a single molecule involved, but many molecules participated. Transforming growth factor-beta (TGF-β) superfamily should play an important role. Various connective tissue diseases, such as cardiovascular diseases, musculoskeletal diseases, tumors, etc. might be alleviated by regulating TGF- β superfamily molecules.

This paper is a summary of the unified law of physical remodeling of connective tissue family (Figure 2, Figure 3, Figure 4, Figure 5).

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