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Effect of Aerobic and Resistance Exercise on TGF- β 1/Smad3 Signal Pathway and Collagen in Skeletal Muscle of Aging Mice

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Objective

The purpose of this study was to investigate the effects of TGF- β 1/Smad3 signaling pathway and its downstream factor CTGF in collagen deposition and its molecular mechanism. And then it explored further the effect of exercise on the TGF- β 1/Smad3 signaling pathway and collagen deposition in skeletal muscle. Therefore, it is expected to provide alternative exercise intervention approaches for skeletal muscle diseases, which are caused by age-related changes of collagen, and to provide new research perspectives for skeletal muscle satellite cell activation and skeletal muscle regeneration.

Methods 21 male BALB/c mice were normally raised from 4 weeks to 36 weeks under standard conditions. The mice was divided randomly into three groups, including: group C, the quiet control group; Group A, the aerobics training group, received nine weeks of treadmill training without loading; And the group R, the resistance training group, received nine weeks of climbing training with loading. The body weight and limb grip of the mice were measured on regularly during the experiment. After 24 hours of the last intervention experiment, the mice were weighed and then executed by dislocating the cervical spine. The quadriceps were taken. Real-time PCR technology was used to detect the mRNA levels of TGF- β 1, T β R I, Smad 3, CTGF, Pax7, COL1 and COL3. Western blotting technique was used to detect the protein levels of TGF- β 1, Smad3, P-Smad3, CTGF, COL1, COL3, Pax7 and MyoD. The deposition of collagen in the quadriceps muscle tissue of mice was detected by Sirius red staining. And the localization and expressions of COL1 and Pax7 in the quadriceps of mice were demonstrated by immunohistochemistry and immunofluorescence technology respectively.

Results (1) Compared with group C, the weight of mice in group A was significantly increased ($P < 0.05$), and the ratio of the wet weight of the quadriceps and the body weight of the mice increased significantly ($P < 0.05$), while there was no significant change on the limbs relative grip strength. Compared with group C, the body weight of mice in group R showed a certain degree of increase but no significant difference, the ratio between the wet weight of the quadriceps and the body weight of the mice was significantly increased ($P < 0.01$), and the limbs relative grip strength was significantly increased ($P < 0.05$).

(2) Compared with group C, there was no significant difference in the mRNA and protein expression of COL1 and COL3 in the quadriceps of mice in group A, and there was no significant change in collagen volume fraction. Compared with group C, the mRNA and protein expression of COL1 and COL3 of the quadriceps in group R were significantly decreased ($P < 0.05$), and collagen volume fraction significantly reduced ($P < 0.05$), and collagen deposition decreased.

(3) Compared with group C, the mRNA level of CTGF and the protein level of TGF- β 1 and CTGF in quadriceps tissues of mice in group A were significantly decreased ($P < 0.05$). While the protein levels of Smad3 and p-Smad3 and the ratio of Smad3 and p-Smad3 had no significant change. Group R is compared with group C, the mRNA level of TGF- β 1, T β R I and CTGF in quadriceps were significantly decreased ($P < 0.05$); the mRNA levels of Smad3 and the protein levels of TGF- β 1 and p-Smad3 were significantly decreased ($P < 0.01$); and the protein levels of Smad3 and CTGF and the ratio of Smad3 and p-Smad3 were also significantly decreased ($P < 0.05$).

(4) Compared with group C, the mRNA and protein expression of Pax7, and the protein expression of MyoD in the quadriceps of group A showed no significant difference. But group R is compared to

group C, the expression of Pax7 mRNA in the quadriceps was significantly increased ($P<0.01$), and the expression of Pax7 protein was also significantly increased ($P<0.05$), while the protein expression of MyoD did not change significantly. Compared with group A, the mRNA levels of Pax7 in the quadriceps of the R group was significantly increased ($P<0.05$), but the protein expression of Pax7 and MyoD showed no significant change.

Conclusions

- (1) Through 9 week resistance or aerobic exercise training, skeletal muscle mass index in mice increased significantly; and the resistance exercise training can improve the limbs relative grip strength to prevent sarcopenia.
- (2) 9 week resistance exercise training can inhibit TGF- β 1/Smad3 signaling pathway, affect the gene expression of COL1 and COL3, inhibit collagen synthesis, and improve collagen deposition.
- (3) 9 weeks of resistance exercise training can effectively promote Pax7 gene expression, activate skeletal muscle satellite cells and promote its proliferation.
- (4) The effect of 9 week of resistance exercise training on the improvement of skeletal muscle mass, strength, collagen deposition and the activation of satellite cells was significantly better than that of aerobic exercise.