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Resistance Training and Homeostasis: Benefits, Risks and Diseases

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Abstract. Resistance training is inextricably linked with homeostasis. Resistance training will lead to disorders and reconstruction of homeostasis, and the muscle density of the reconstructed muscle system will increase while the muscle fibers will change. Furthermore, excessive resistance training may lead to disorders of sodium and potassium ions in the body, which lead to dehydration as well as ligament, muscle, and other injuries. This paper mainly studies the effect of steady-state imbalance on the adaptation process of resistance training and explores the specific changes and micro-regulation of resistance training on the steady-state of the internal environment. Resistance training can improve homeostasis to a higher level by improving and improving the ability and level of the body's buffer system, cardiovascular system, hormone secretion and glycogen reserve. Moreover, it can also regulate insulin sensitivity, blood glucose homeostasis, bone strength, etc., so that it also has a certain auxiliary role in the treatment of chronic diseases, fracture treatment and other fields. This paper will focus on the significance of resistance training to the body's steady-state balance and the significance of long-term resistance training in the treatment of chronic diseases and fractures such as diabetes and kidney disease.

Keywords: Homeostasis, disorders of homeostasis, resistance training, rehabilitation training

1. Introduction

Physical exercise occupies an expanding position in modern public health management, among which resistance training has gained rising popularity across diverse population groups. Resistance training is characterized by very intimate and reciprocal links with systemic homeostasis. Altered homeostasis of the muscular system can be viewed as a physiological signal that responds to the stimuli of resistance training; however, if this type of training is too intense, then pathological symptoms like strain of muscles and fascia may occur. On the other hand, self-induced homeostatic disruption, e.g., altered intracellular ratio of potassium and sodium ions, hinders training adaptations.

Foreign studies have revealed many pieces of information about exercise mediated disease interventions and fracture healing. Endurance based exercise keeps the heart health and enhances myocardial adaptation capacity [1]. Resistance exercise intervention may help to increase the lumbar bone mineral density of those who suffer from low bone mineral density [2]. In fracture healing protocol, resistance exercise helps tissue healing and functional recovery. In metabolic disorders,

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exercise regulates insulin resistance and glucose homeostasis for designing the exercise prescription for type 2 diabetes [3]. Resistance training is capable to develop some special cell adaptations in skeletal muscle, brain, liver, and other organs that help to balance the homeostasis [4]. Domestic studies have shown that Low Volume High Intensity Interval Training (LV HIIT) is helpful to improve cardiovascular markers, regulate blood glucose and lipid profile, and optimize body composition [5].

However, existing literature seems to be more generalized concerning the connections between exercise, homeostasis, disease, and rehabilitation with relatively wide scope of investigation. There is a need for research specifically dealing with mechanisms through which resistance training helps to maintain homeostasis and provides disease prevention. Existing evidence related to resistance training and homeostasis regulation is partially obtained using animal models, while clinical trials of high quality, proving the existence of the causal connection between resistance training and homeostasis, are relatively scarce. The current study aims to elucidate homeostatic regulation mechanisms triggered by resistance training and discuss adaptive effects as well as pathologic effects resulting from disrupted homeostasis.

2. Mutual interaction between resistance training and homeostasis

2.1. Homeostatic perturbation and adaptive reconstruction induced by resistance training

Resistance exercise constitutes an organized, long-term physical activity stimulated by external loading. The neuromuscular system produces muscular contraction against external resistance that causes enlargement of muscle fiber size and changes in muscle fiber phenotypes [6]. In the process of resistance exercise performance, anaerobic glycolysis produces large amounts of lactic acid and hydrogen ions, thus causing reduction in pH level of body and disruption of acid-base balance within the body [7]. Simultaneous contraction of muscles causes increase in intracellular calcium levels while the concentration of adrenaline and cortisol increases.

Molecularly, mechanical force arising from eccentric and concentric contraction stimulates PI3K-Akt-mTOR signaling pathway, which is the master control mechanism controlling protein synthesis. The mTOR phosphorylates p70S6 kinase and 4E binding protein 1, which leads to increased ribosome synthesis and translation initiation, respectively. In addition, resistance exercise inhibits the ubiquitin-proteasome proteolytic pathway and muscle ring finger protein 1 as well as muscle atrophy F box (atrogin 1), which results in net protein anabolism. Satellite cells, which exist under the basal lamina of muscle fibers, get activated due to the micro damage caused to muscle fibers, and then they undergo proliferation and differentiation before fusing with muscle fibers and contributing their nucleus to myofiber hypertrophy.

Post-training physiological changes facilitate the transformation of the internal environment from that of disturbance into reconstruction. This process is not a mere process of going back to pre-training physiological state. Biological processes like damaged muscle fiber repair, increased hormone levels, and increased muscle glycogen level take place together. Through multiple rounds of perturbation-reconstruction cycle, the volume of myofibrils increases, the muscle fibers become larger and longer, and the body acquires a new higher level of homeostasis. Under the new homeostasis, the body's ability to tolerate lactic acid becomes better.

In addition, resistance exercise promotes the process of phenotypic switching of fiber types. The fast glycolytic fibers of type IIx gradually transform into oxidative and fatigue-resistant fibers of type IIa under chronic exposure to mechanical stress, resulting in higher mitochondria content, increased activity of citrate synthase and better capillary supply of trained muscles. Such a

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transformation of fiber type directly affects the regulation of substrate utilization, promoting oxidative phosphorylation and minimizing the contribution of anaerobic glycolysis in the process of exercise. Therefore, lactate accumulation in muscles is decreased, shifting the lactate threshold towards higher workload intensities.

Additionally, muscular contraction during resistance training acutely raises peripheral vascular resistance; repetitive stimulation promotes vasodilation and improves vascular elasticity. To counteract elevated peripheral resistance, the left ventricle executes intensified contraction, which stimulates myocardial cell hypertrophy and increases ventricular wall thickness. This physiological cardiac adaptation is accompanied by enhanced endothelial nitric oxide synthase (eNOS) expression, increased nitric oxide bioavailability and improved flow mediated vasodilation. The resulting improvement in vascular compliance reduces afterload at rest and during submaximal exercise, contributing to a new cardiovascular homeostatic set point characterized by lower resting blood pressure, reduced heart rate response to standardized workload and improved cardiac efficiency.

2.2. Homeostatic imbalance caused by excessive resistance training and corresponding pathological risks

Resistance training does not follow the simplistic principle that greater volume yields superior benefits; distinct dose effect relationships separate its adaptive gains and pathological risks. When training volume, frequency or single session load surpasses individual bodily tolerance, the rate of internal microenvironment perturbation outpaces tissue repair reconstruction capacity, producing severe homeostatic breakdown. This imbalance manifests as cumulative micro structural damage: repeated overload traction generates ligament fiber micro tears. Without adequate recovery intervals, such micro injuries progress into chronic ligament strain or even complete ligament rupture. Continuous high mechanical stress upon bone without sufficient rest raises stress fracture susceptibility.

Delayed onset muscle soreness (DOMS) represents an early clinical marker of excessive homeostatic perturbation. Eccentric contraction-induced sarcomere disruption triggers infiltration of neutrophils and macrophages into damaged tissue, releasing pro inflammatory cytokines including tumor necrosis factor alpha (TNF-α), interleukin-1-beta (IL-1-β), and interleukin 6 (IL-6). While moderate inflammatory signaling is essential for satellite cell activation and tissue repair, exaggerated and prolonged inflammation disrupts regenerative homeostasis, perpetuates muscle soreness and impairs force production for several days post exercise. Reactive oxygen species (ROS) generated during intense contraction further exacerbate oxidative damage to sarcolemma lipids and proteins, overwhelming endogenous antioxidant defenses including superoxide dismutase, catalase and glutathione peroxidase. This oxidative inflammatory cascade constitutes a key mechanistic bridge between excessive training load and sustained homeostatic dysfunction.

In more severe scenarios, overtraining induces rhabdomyolysis. Excessive mechanical load provokes massive skeletal muscle cell disintegration; intracellular myoglobin, creatine kinase and other biomolecules pour into systemic circulation. High molecular weight myoglobin readily occludes renal tubules, further inducing acute tubular necrosis and potentially irreversible acute renal failure. Typical clinical manifestations include soy sauce colored urine, oliguria or anuria; delayed intervention leads to permanent renal impairment. The pathophysiological sequence involves myoglobin induced ferrihemate formation within acidic tubular urine, direct cytotoxic injury to renal tubular epithelial cells, renal vasoconstriction mediated by endothelin and reduced nitric oxide availability, and intratubular cast formation. Electrolyte disturbances including hyperkaliemia, hypocalcemia and hyperphosphatasemia frequently accompany rhabdomyolysis,

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reflecting massive release of intracellular electrolytes and further disrupting systemic ionic homeostasis. Severe hyperkalaemia may precipitate life threatening cardiac arrhythmias, underscoring that muscular system homeostatic breakdown can rapidly propagate to cardiovascular and renal systems.

Furthermore, high intensity resistance training imposes notable cardiovascular stress. Sustained muscular tonic contraction elevates peripheral vascular resistance sharply, triggering systolic blood pressure surges and increased cardiac output, hence raising acute stroke and myocardial infarction risk. The Valsalva maneuver commonly employed during heavy lifting produces abrupt intrathoracic and intra-abdominal pressure elevation, transiently reducing venous return and cardiac output while simultaneously increasing arterial blood pressure. Upon maneuver release, a compensatory hyperemic response occurs, generating rapid hemodynamic fluctuations that impose excessive shear stress upon atherosclerotic arterial walls. In individuals with preexisting carotid or coronary plaque, these pressure oscillations may precipitate plaque rupture, thrombus formation and acute vascular occlusion. Additionally, abrupt cessation of intense resistance exercise can induce post exercise hypotension due to accumulated skeletal muscle vasodilation and reduced sympathetic outflow, potentially causing syncope in susceptible individuals.

It deserves emphasis that patients suffering from hypertension, cardiovascular diseases, diabetes and obesity maintain inferior baseline homeostatic status. Their vascular elasticity, renal filtration performance and metabolic buffer reserve are inferior to healthy populations. Therefore, blood pressure fluctuation, metabolite accumulation and acid base disturbance triggered by resistance training exert stronger physiological impacts on these subgroups. Such populations ought to implement resistance interventions under professional medical supervision to avoid disease exacerbation.

2.3. Bidirectional relationship between homeostasis maintenance and resistance training performance

Homeostasis is essential as preconditions to successful resistance training practice. The molecular mechanism of excitation contraction coupling involving calcium ions, as well as sodium-potassium transmembrane exchange that causes action potentials, is responsible for muscular contraction. Glycogen storage and turnover in muscle tissues, regular ATP production to provide energy for muscular contraction, hydrogen ion neutralization using bicarbonates to prevent muscular fatigue, as well as hormonal adaptations and blood vessels' reorganization, are all prerequisites to successful resistance training practice. Homeostasis and resistance training influence each other mutually: stable state of homeostasis provides necessary physiological conditions for the execution of training, and resistance training influences homeostasis in such way as to increase the stable level of homeostasis.

Intracellular pH is responsible for having considerable effects on the stability of homeostasis. Lactic acid and hydrogen ions produced by the resistance training have an effect of stress on the body buffer and regulation systems and cause the rise of systemic bicarbonate levels. Regular resistance training increases the absorption of hydrogen and bicarbonate ions as well as compensating capacity of respiration system for the release of carbon dioxide, hence enhancing the efficiency of systemic buffers, kidney regulation and respiration adaptation. Heart failure, myocardial infarction and diabetes are some of the conditions that can lead to metabolic acidosis [7]. Resistance training can help prevent clinical metabolic acidosis; however, prior training medical advice is necessary to prevent complications arising from overtraining. Increased myocardial contractility and improved vascular function from resistance training aid in rehabilitation of heart

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failure patients [8]. Resistance exercise training enhances myocardial function more specifically. It enhances vasodilator function and vascular elasticity by increasing peripheral vascular resistance, which prevents systemic vascular stiffness and regulates blood flow, and results in normal physiological myocardial hypertrophy without any abnormal collagen accumulation. Although resistance exercise was considered unsuitable for heart disease patients, moderate resistance exercise helps improve cardiac biomarker levels and cardiovascular function for the rehabilitation of chronic heart failure. However, those who suffer from chronic heart failure should first seek medical advice before doing resistance exercise because of chest tightness and tiredness due to overtraining.

Resistance exercises regulate insulin sensitivity and glucose homeostasis and a combination of resistance exercise along with aerobic exercises provides an enhanced regulation [3]. Resistance exercises increase the body's insulin sensitivity and help in managing body weight for helping people with glucose intolerance in controlling their diseases and decreasing chances of developing diabetes. LV-HIIT exercises have been used in several chronic disease scenarios such as diabetes, cardiovascular diseases, obesity and cancers. As compared to conventional HIIT exercises, LV-HIIT exercises offer lower intensity, decreased duration of exercise session and improved safety along with increased insulin sensitivity, cardiopulmonary endurance and immunity [5]. Chronic disease patients can use LV-HIIT for improving their fitness and dealing with their complications. Patients with diabetes should check their glucose levels after performing exercises.

Additionally, Youth-oriented glucose regulation mechanism goes further than preventing diabetes. Resistance training improves the function of insulin release and increases the capability of the β cells in mice, and it is also a preventative measure for Type 1 diabetes [9]. Resistance training improves the mass of the skeletal muscles and glycogen storage capacity of muscles, thus increasing the effectiveness of glucose buffering mechanism. Participation in resistance training by non-diabetic youth optimizes the body's intrinsic glucose buffering mechanisms.

Resistance training offers unique advantages for the well-being of senior adult and adolescent populations. Exercise is a good tool to combat the effects of aging through sarcopenia [10]. Sarcopenia causes weakness in physical strength and balance abilities, increasing the chance of falls resulting in bone fractures and extended bed rest. Resistance training helps maintain bone mineral density through mechanical loading that encourages osteoblast function. This also leads to neuromuscular adaptation, which improves strength in the legs and balance of senior adults, preventing fractures and improving their quality of life. On the other hand, for adolescents in the period of bone formation, correct mechanical loading through resistance training results in healthy mechanical strain on bones and remodeling, leading to peak bone mass formation. This will help in reducing the risk of developing osteoporosis in the future, increase athletic power in adolescents, and reduce their vulnerability to sports-related injuries. Exercise science-based resistance exercise makes adolescents interested in strength sports, instills exercise habits, and encourages the practice of physical activities. These behaviors that have been developed at an early age usually stick in the individual even when they become adults. Together, resistance exercises are a viable solution to address age-related decline in functionality and literacy of sports in older people.

Resistance training-induced mechanical stress creates adaptive stimuli for bone tissues. Appropriate resistance training has positive effects on bone mineral density in persons with fractures or suffering from osteoporosis. Tensile forces created by muscular contraction pass through tendons to bone tissue. Adequate level of resistance training triggers bone tissue remodeling procedures and increases activity of osteoblasts. Osteoblasts gather in the zones of mechanical stress and create bone collagen matrix and accelerate calcium-phosphorus accumulation, which increases bone mineral density and bone tissue hardness. Thus, in the case of fracture rehabilitation or osteoporosis,

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appropriate resistance training increases the work of osteoblasts and calcium deposition and helps in development of muscle strength while reducing risk of refractures. As compared to total immobility or sedentary state, resistance training promotes bone healing process and increases regional bone and muscle strength. Total fracture immobilization leads to decrease in bone mineral density in the region of fracture and adjacent muscle strength. Resistance training promotes bone remodeling processes and decreases disuse-induced muscular atrophy. Nevertheless, people with fractures and osteoporosis should control their resistance training intensity and frequency appropriately.

3. Conclusion

Resistance training results in the disruption and correction of homeostasis; likewise, the disturbance in homeostasis also has adverse effects on resistance training. Homeostasis is the premise of resistance training. The supply of muscle glycogen, normal ATP synthesis and energy supply, timely buffering of hydrogen ions and lactic acid produced by exercise to delay muscle fatigue, as well as the secretion of different hormones and the supply of the cardiovascular system are the premises of resistance training. Resistance training can lead to muscle fiber hypertrophy, reduce the hardness of blood vessels and improve vascular elasticity, improve cardiac efficiency, improve the whole-body buffer system and regulatory system, to have certain preventive and rehabilitation significance for chronic diseases such as clinical diabetes, kidney disease and heart failure. Furthermore, the stimulation of muscle and bone has certain significance in promoting the increase of muscle mass and the decrease of bone mineral density by resistance training. It has certain significance for the treatment of fractures and osteoporosis and the prevention of falling fractures caused by the decrease of bone mineral density in the elderly. Resistance training for adolescents can help them reach the peak bone mass level and support their bone development. When doing resistance training, it is important to pay attention to the intensity and frequency of training to prevent stress fracture susceptibility, DOMS, rhabdomyolysis and other diseases caused by excessive training. People with chronic diseases should pay more attention to the intensity of resistance training during rehabilitation. This paper explores the interaction between homeostasis and resistance training and provides reasonable resistance training suggestions for people of different ages and different diseases. However, most of the current research is about aerobic exercise and disease rehabilitation, and some resistance training experiments remain in animal studies. The content of articles on resistance training and disease rehabilitation is limited.

References

[1] Wang, L., Wang, J., Yu, P., Feng, J., Xu, G. E., Zhao, X., ... & Xiao, J. (2022). METTL15 is required for exercise-induced cardiac hypertrophy and protects against myocardial ischemia-reperfusion injury. *Nature Communications, 13*(1), 6762.

[2] Giangregorio, L. M., Bleakney, R. R., Brien, S., Butcher, S. J., Chan, B. C., Chilibeck, P. D., ... & Cheung, A. M. (2023). Finding the optimal resistance training intensity for your bones: protocol for a randomized controlled trial. *Physical Therapy, 103*(10), pzad120.

[3] Collins, K. A., Ross, L. M., Slentz, C. A., Huffman, K. M., & Kraus, W. E. (2022). Differential effects of amount, intensity, and mode of exercise training on insulin sensitivity and glucose homeostasis: a narrative review. *Sports Medicine-Open, 8*(1), 90.

[4] Leuchtmann, A. B., Adak, V., Dilbaz, S., & Handschin, C. (2021). The role of the skeletal muscle secretome in mediating endurance and resistance training adaptations. *Frontiers in Physiology, 12*, 709807.

[5] Tao, Z., Cheng, Y., Xing, S., Wang, X., Zhang, L., Wang, S., … & Gao, X. (2026). Research progress on the application of low-volume high-intensity interval training in patients with chronic diseases. *Journal of Nursing Science, 41*(15), 108-112+119.

DOI: 10.54254/2753-8818/2027.MB37862

[6] Lohmann, L. H., Afonso, J., Behm, D. G., Siegel, S. D., Keiner, M., Wirth, K., ... & Warneke, K. (2026). What is resistance exercise? A review of current uses and potential ways forward. *European Journal of Applied Physiology, 1*-11.

[7] Shaul, D., Lev-Cohain, N., Sapir, G., Sosna, J., Gomori, J. M., Joskowicz, L., & Katz-Brull, R. (2023). Real-time influence of intracellular acidification and Na+/H+ exchanger inhibition on in-cell pyruvate metabolism in the perfused mouse heart: A 31P-NMR and hyperpolarized 13C-NMR study. *NMR in Biomedicine, 36*(10), e4993.

[8] Jiang, Y., Zhang, J., & Wang, K. (2026). Effect of resistance training combined with comfort nursing on exercise endurance and cardiopulmonary function in patients with chronic heart failure. *Harbin Medicine, 46*(4), 136-138.

[9] Bronczek, G. A., Soares, G. M., Marmentini, C., Boschero, A. C., & Costa-Júnior, J. M. (2022). Resistance training improves beta cell glucose sensing and survival in diabetic models. *International Journal of Molecular Sciences, 23*(16), 9427.

[10] Szablics, P. (2021). *Effects of physical activity on the aging process-with non-invasive follow-up and invasive cross-sectional researches* (Doctoral dissertation, University of Szeged (Hungary)).