Research Review: The Impact of Resistance Training on Type 1 Diabetes

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Type 1 Diabetes (T1D) is an autoimmune disease which causes major challenges in glucose regulation, requiring individuals to maintain different strategies to keep metabolic health stable. Exercise, specifically resistance training, is an important factor in regulation for this disease, and although there is lots of research on type 2 diabetes, less is known about the effects of exercise on T1D. The question remains, how does resistance training impact glycemic control and insulin sensitivity on individuals with type 1 diabetes? Research shows that resistance training can help to promote metabolic stability and improve insulin function overall. In addition, resistance training builds muscle mass and can improve insulin signaling pathways, which helps with better glucose regulation. However, there is mixed research about the direct effect of resistance training on hbA1c levels, as well as long-term glucose control, especially when comparing to aerobic forms of exercise. Understanding the different adaptations is important for optimizing and prescribing exercise interventions for individuals with T1D. Exploring the essential role resistance training offers highlights the physiological mechanisms, effectiveness, and overall implications on glycemic control for T1D.

Literature Review

The following literature provided, offers insights into the effects of resistance training and glycemic control within individuals with type 1 diabetes. The research used includes a range of studies from meta-analysis to randomized controlled trials all with different participants and methodologies. It addressed the different methods resistance training can affect health outcomes for people with T1D using different variables. The review focuses on three primary themes, glycemic control and blood glucose regulation, insulin sensitivity and metabolic benefits, and long-term health benefits, including cardiovascular and body composition improvements.

Glycemic Control and Blood Glucose

Several studies have shown the effects of resistance training on glycemic control and blood glucose. Maintaining good glycemic control is vital in preventing both microvascular and macrovascular complications associated with diabetes. Hemoglobin A1c (HbA1c) is a widely used biomarker reflecting average blood glucose levels over two to three months. Several studies have investigated the influence of resistance training on HbA1c and daily blood glucose management in individuals with T1D.

A meta-analysis done in 2022, found that children and adolescents with T1D who performed a structured resistance training program had significant reduction in hbA1c levels after 12 weeks. This suggests that resistance training may be more beneficial for younger populations in improving glycemic control. However, a study conducted by Sigal et al. (2023) found that while resistance training improved strength and physical performance, it did not lead to significant reductions in HbA1c among adults with T1D. These different findings indicate that the effects of resistance training on glycemic control may be influenced by factors such as age, baseline fitness levels, adherence and length of training protocols.

Beyond just long-term data, acute glycemic responses to resistance training have also been investigated. Wróbel found that post-exercise glucose levels remained more stable following resistance training compared to aerobic exercise, which was associated with a higher risk of post-exercise hypoglycemia (Wróbel et al., 2018). This may suggest that resistance training can provide a safer alternative for individuals who are prone to exercise-induced glycemic variations.

Insulin Sensitivity and Metabolic Benefits

One of the key benefits of resistance training for individuals with T1D is its impact on insulin sensitivity. Insulin sensitivity refers to the body's ability to respond to insulin effectively, enabling glucose uptake by muscle cells. Improved insulin sensitivity allows for better glucose uptake by skeletal muscle, reducing the overall insulin requirement and minimizing glycemic fluctuation. Gharani et al. (2022) conducted a 24-week intervention study and found that individuals with T1D who engage in progressive resistance training exhibit improved insulin sensitivity, as measured by the homeostatic model assessment of insulin resistance (HOMA-IR). These findings are consistent with previous studies that indicate resistance training enhances glucose transporter type 4 (GLUT4) expression in skeletal muscle, which plays a vital role in facilitating glucose uptake independent of insulin action (Irvine et al., 2020).

Furthermore, the metabolic benefits of resistance training extend beyond glucose uptake. A study by Baldi et al. (2019) found that individuals with T1D who participated in resistance training had reduced fasting insulin levels and improved lipid profiles, including decreased LDL cholesterol and increased HDL cholesterol. These metabolic improvements highlight the potential of resistance training not only for glycemic control but also for reducing the risk of cardiovascular disease, which is a major concern for individuals with diabetes. Factors such as training status, dietary intake, and genetic predisposition may influence the extent to which insulin sensitivity improves. Future research should aim to identify the most effective training modalities and investigate the underlying physiological mechanisms.

Resistance training supports metabolic efficiency by stimulating the creation of new mitochondria within muscle cells. Enhanced mitochondrial density improves oxidative metabolism, allowing muscles to use glucose and fatty acids more efficiently for energy production. This reduces reliance on insulin and stabilizes energy supply during physical activity and rest. Resistance training also induces beneficial hormonal changes, including elevated levels of growth hormone and testosterone, which promote muscle protein synthesis, tissue repair, and further improvements in glucose homeostasis. By improving both the capacity and efficiency of muscle metabolism, resistance training directly addresses the fundamental metabolic impairments present in T1D (Ostman et al., 2018).

Long Term Health Benefits

While glycemic control and insulin sensitivity are primary concerns in T1D management, resistance training also provides additional long-term health benefits, including improved cardiovascular health, increased muscle mass, and enhanced functional capacity. Individuals with T1D have a higher risk of developing cardiovascular disease (CVD) due to chronic hyperglycemia, increased oxidative stress, and systemic inflammation. Resistance training has been shown to decrease some of these risk factors. Gharani et al. (2022) reported significant reductions in systolic and diastolic blood pressure among participants following a 24-week resistance training program, suggesting that resistance exercise may contribute to improved vascular health. Additionally, increased nitric oxide availability and improved endothelial function have been observed in individuals engaging in regular resistance training, further supporting its cardiovascular protective effects (Jabbour et al., 2021). Improved endothelial function is crucial for preventing atherosclerosis and maintaining healthy blood flow. These vascular adaptations show how resistance training as an important strategy for reducing cardiovascular disease risk in T1D populations (Jabbour et al., 2021).

Individuals with T1D are at risk of muscle wasting and decreased functional capacity, particularly if glycemic control is poor. Resistance training has been identified as a key intervention for preserving lean muscle mass and improving physical strength. A study by

Mitchell et al. (2021) found that T1D patients who followed a high-intensity resistance training program for six months experienced significant increases in lean muscle mass and improvements in maximal strength (as measured by one-repetition maximum testing). These adaptations are essential for maintaining overall health, mobility, and quality of life, particularly as individuals with T1D age.

Application and Discussion

Resistance training significantly influences physical performance by enhancing muscular strength, endurance, and coordination, which are essential for individuals with T1D. Strength improvements facilitate daily physical tasks, reduce the risk of musculoskeletal complications, and support metabolic efficiency. Strength gains improve the ability to perform daily activities, lessen musculoskeletal stress, and enhance metabolic flexibility. The resulting increase in muscle mass expands the body's capacity to store and use glucose, thereby smoothing out blood glucose fluctuation and contributing to better overall glycemic control. Research confirms that resistance training enhances neuromuscular function, leading to improved balance and reduced injury risk, particularly in individuals with chronic conditions like T1D (Jabbour et al., 2021).

In the context of individuals with physiological conditions such as diabetes, cardiovascular disease, and metabolic syndrome, resistance training has demonstrated broad health benefits. For individuals with T1D, exercise programs incorporating resistance training help mitigate the increased risk of cardiovascular complications by improving lipid profiles, reducing systemic inflammation, and promoting endothelial function (Gharani et al., 2022). Muscle hypertrophy induced by resistance training supports metabolic homeostasis, countering the muscle-wasting effects of poor glycemic control (Mitchell et al., 2021). While resistance training alone can be beneficial, future research should also explore the effects of combining resistance training with aerobic exercise to maximize cardiovascular and metabolic benefits. Studies found that such combined training approaches yielded better clinical outcomes in individuals with T1D compared to either modality alone, suggesting that a more well-rounded exercise prescription might be most effective (Ostman et al., 2018).

Human movement inherently drives physiological adaptations that improve health and performance. Through progressive overload and mechanical tension, resistance training stimulates muscle protein synthesis, enhances insulin receptor sensitivity, and promotes mitochondrial biogenesis. As noted by Holten et al. (2004), these adaptations play a vital role in metabolic efficiency, reducing the insulin dependency of individuals with T1D. Additionally, resistance training triggers favorable hormonal responses, such as increased growth hormone and testosterone levels, further supporting muscle maintenance and metabolic health. Future research should investigate individualized training approaches tailored to age, sex, and fitness levels to optimize long-term outcomes for individuals with T1D.

Conclusion

Resistance training has emerged as a promising intervention for individuals with Type 1 Diabetes, offering multiple health benefits beyond glycemic control. Evidence suggests that resistance training improves insulin sensitivity, stabilizes blood glucose levels, enhances cardiovascular health, and preserves muscle mass. However, variability in individual responses and a lack of standard exercise protocols show the need for further research. Healthcare professionals and exercise specialists should consider incorporating resistance training into diabetes management programs while tailoring interventions to individual needs.

Reflecting on the broader implications of this research, resistance training interventions can be adapted across a wide variety of populations. Minor adjustments to volume, intensity, and exercise selection can make resistance training accessible for older adults, beginners, or individuals with other chronic conditions. Given its versatility and various health benefits, resistance training should be a starting point of chronic disease management programs moving forward. Future research should continue refining optimal training prescriptions for different subgroups within the T1D population and explore long-term adherence strategies to maximize the sustainability and effectiveness of resistance-based interventions.

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