Resistance Exercise in the Context of Type 1 Diabetes

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About the Author

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Introduction

Exercise and physical activity are associated with many benefits for individuals with type 1 diabetes (T1D), including increased longevity and a decrease in the incidence/severity of diabetes-related complications.[1,2] Unfortunately, these activities (and aerobic exercise in particular) also increase the risk of hypoglycemia and glycemic variability, both of which act as barriers to being more active in this population.[3] Resistance exercise is an often-overlooked activity, as historically it has been seen in training reserved for elite athletes. For individuals with T1D, it is associated with a multitude of benefits including a reduced risk of hypoglycemia during activity.[4,5] With improved insulin formulations and rapid increases in technology to manage T1D, people with this condition are living longer, healthier lives. This article describes the many reasons why resistance exercise should be a part of this longevity.

Benefits of Longer-Term Resistance Training

Resistance exercise is generally described as using muscular contraction against an external force. This force can be provided by body weight, resistance bands, weight-lifting machines or free weights. The benefits of resistance exercise in people without diabetes include increases in skeletal muscle mass, strength and endurance, improvements in insulin sensitivity, decreases in visceral fat, an enhancement of cardiovascular health (in particular through reductions in blood pressure), increases in bone mineral density, and an ameliorated lipid profile.[6] Most of these benefits are also seen in people with T1D, although recent evidence may suggest that performing resistance exercise may not lead to improvements in average blood glucose levels as measured by HbA1c.[4,7]

Acute Glycemic Effects of Resistance Exercise

Due to its reliance on blood glucose as a fuel source, aerobic exercise (activities involving repeated contractions of large muscle groups over extended periods of time, e.g. walking, swimming, cycling, etc.) relies on lipids and blood glucose to fuel activity. This selection of fuels produces large declines in blood glucose during aerobic activity in individuals with T1D, leading to a greater risk of hypoglycemia during activity. In contrast, higher intensity (anaerobic) activities, have a greater reliance on hepatic and muscular glycogen stores.[5] As a result, there is a tendency for smaller blood glucose declines during anaerobic activity, albeit with the potential for more post-exercise hypoglycemia.[5,8]

The acute glycemic effects of resistance exercise in people with T1D have only recently been examined.

In 2013, using a repeated measures design, Yardley et al showed that late afternoon resistance exercise produced a smaller decline in blood glucose levels than a comparable duration of moderate aerobic exercise performed at the same time of day in physically active individuals with T1D.[5] To the extent possible, the authors controlled for food intake (self-selected but repeated over three days of monitoring for each exercise session), insulin adjustments (self-reported) and background physical activity (measured by pedometer). While blood glucose decreased less during exercise, post-exercise continuous glucose monitoring revealed a greater amount of hypoglycemia overnight after resistance exercise, likely due to the replenishment of glycogen stores.[5]

Not long after this initial publication, Turner et al found an increase in blood glucose levels in individuals with T1D performing a similar resistance exercise protocol.[9] It has recently been shown that this difference can be attributed to the fact that participants in the Turner study were exercising after an overnight fast. Using a repeated measures design, Toghi-Eshghi and Yardley (2019) compared the response of a group of participants with T1D to an identical resistance exercise protocol performed once in the fed state (around 5 p.m.) and once in the fasted state (around 7 a.m.) to replicate the scenarios from the previous studies.[10] They found that intra-individual blood glucose was more likely to increase during fasted morning resistance exercise, while it decreased when the same protocol was performed later in the day.[10] As such, performing resistance exercise while fasted can be advised for individuals with T1D for whom the fear of hypoglycemia is a major barrier to being active. The physiology behind these blood glucose responses to fasted exercise are described in detail elsewhere.[11]

An additional glycemic benefit to performing resistance exercise is that it may slow or prevent large blood glucose declines during subsequent aerobic exercise. In a crossover study of afternoon exercise (protocols performed at 5 p.m.), participants with T1D experienced a delayed, and slower, decline in blood glucose levels during 45 minutes of aerobic exercise when it was performed after 45 minutes of resistance exercise.[12] Conversely, large blood glucose declines were immediately evident when aerobic exercise was performed first. As a result, if individuals with T1D approach a combined exercise session with blood glucose levels in a higher than desired range, performing aerobic exercise first may be beneficial. Conversely, if blood glucose levels are lower and there is a concern that hypoglycemia may occur, performing resistance exercise first may be the safest option.

It is also important to note that there may be sex-related differences in blood glucose responses to resistance exercise in people with T1D. A secondary analysis by Brockman et al showed that male participants had both a greater blood glucose decline during resistance exercise, and developed more hypoglycemia in the six hours following exercise.[16] However, the authors note that these differences may be due simply to differences in body composition (males tend to have more muscle mass than females) and the amount of work performed (males lifted more weight than females, even if it was of similar intensity relative to the participants' maximum lifting ability). A recent cross-sectional study also indicated that gender-related (behavioural) differences in glycemic management strategies around exercise are likely to exist for those with T1D and, as such, it is possible that the differences in blood glucose responses (in particular post-exercise), may be the result of different management strategies in women and men.[14]

Frailty Prevention

Due to recent improvements in insulin agents and diabetes technology, people with T1D are living longer, healthier lives. However, recent studies show that as they age, individuals with T1D lose muscle mass and quality faster than matched controls without diabetes.[15] There is also evidence to indicate that bone strength (whether due to bone density or bone quality) also decreases faster, thereby increasing the risk of fractures.[16] These two factors combined elevate the risk of frailty in older individuals with T1D. As such, it is essential for individuals with T1D to perform weight-bearing and resistance exercise throughout their lifespan to offset diabetes-related declines in strength, bone health and functional mobility.

While data from individuals with T1D are currently lacking, early adoption of these activities in those without diabetes, even in small doses, can lead to higher peak muscle strength/mass and higher bone density/quality, from which the eventual age-related declines will occur.[17,18] In people without diabetes, those who perform resistance exercise and high-impact activities tend to have a slower loss of muscle and bone with aging.[18] Studies of older adults show that it is still possible to gain strength by performing resistance exercise.[19] Further research is necessary to determine if these benefits are as pronounced in individuals with T1D.

Gaps in the Research

It is important to note that the research to date on the acute glycemic effects of resistance exercise in people with T1D has involved only one type of resistance exercise protocol—one that is designed to build muscle mass (performing 3 sets of 8 repetitions). Several types of resistance exercise protocols exist, each stimulating different physiological adaptations. High-volume, low-resistance protocols are designed to increase muscular endurance and are likely to have a greater contribution of aerobic metabolism. As such, they may be associated with greater blood glucose declines, but less post-exercise hypoglycemia. Very low-volume, high-resistance protocols favour neurological adaptations to produce more powerful muscular contractions. These activities may, therefore, be reliant to an even greater degree on glycogen as a fuel source. At this stage, however, potential glycemic responses are purely speculative.

There is also very little known about how differences in age, sex and physical fitness may affect blood glucose responses to resistance exercise. Research in individuals without T1D show that these physiological factors can affect fuel selection during different types of exercise.[20] Whether or not their effect is potent enough to influence blood glucose responses to resistance exercise in T1D (where synthetic insulin also plays a very dominant role) has not been fully elucidated.

Conclusion

Resistance exercise is associated with many health benefits for people with and without diabetes. With more predictable and smaller blood glucose changes during exercise, there is often less need for insulin adjustments prior to exercise and a lower need for carbohydrate supplementation when it is being practiced by those with T1D. The former is important for overcoming a barrier to exercise in those with unpredictable schedules, while the latter is important to those who are exercising for the purpose of weight maintenance or weight loss. Overall, for individuals with T1D, performing regular resistance exercise should be seen as a means to maintain overall health and physical function, thereby creating a higher quality of life with aging.

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