EXERCISE AND DIABETES: EXERCISE TYPES AND DOSAGES IN PRESCRIPTION

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Around 80% of intake glucose stores as glycogen in skeletal muscle tissue as energy source for human to stay alive and do exercise [1], demonstrates the crucial role of skeletal muscle on glucose metabolism and blood glucose homeostasis. Insulin after meal and skeletal muscle contraction during exercise mobilize glucose transporter GLUT4 and regulate glucose uptake in skeletal muscle through distinct pathways[2], implies that contracting muscle during physical exercise will additively deliver glucose into skeletal muscle tissue beside insulin, and has the effect of lowering blood glucose and preventing high blood glucose.

Exercise-induced release of peptides, proteins and nucleic acids from skeletal muscle tissue, adipose tissues and other organs, so-called exerkines, have been confirmed involving in mediating acute physiological responses and chronic adaptations to exercise[3]. Exercise-induced exerkines such as interleukin-6 (IL-6), brain derived neurotrophic factor (BDNF), irisin, adiponectin, β-aminoisobutyric acid (BAIBA) , follistatin like-1 (FSTL1) and fibroblast growth factor 21 (FGF21) etc. have been also confirmed playing critical roles in beneficial metabolic adaptations include promoting hypertrophy and myogenesis, glucose uptake, glucose disposal, lipolysis, β-oxidation, angiogenesis, white fat tissue browning and revascularization[4], which potentially implicated in the prevention and treatment effects and mechanisms of exercise on obesity, type 2 diabetes mellitus and other metabolic diseases.

Systematic review and meta-analysis of epidemiological studies demonstrated that regular physical activity reduced the risk of type 2 diabetes mellitus (DM) in a linear dose response manner [5, 6]. A meta-analysis study also revealed that exercise significantly reduced the concentration of high sensitivity C-reactive protein, triglyceride, diastolic blood pressure, systolic blood pressure, HbA1c and homeostasis model assessment-insulin resistance and a pronounced increase of HDL-C in type 2 DM patients[7]. Regular exercise training has been proposed as an anti-diabetic polypill with pleiotropic effects of anti-hyperglycemia, anti-dyslipidemia, anti-oxidative stress, and anti-inflammation according to clinical trials and laboratory experiments[8]. Several meta-analysis studies evidenced that both aerobic exercise

training (AT) and resistance training (RT) or combination of AT and RT all effectively improve HbA1c, insulin sensitivity and other health benefits in type 2 DM patients, and a combination of AT and RT tends to be superior to AT or RT alone [9,10,11,12].

Mounting evidence derived from clinical trials demonstrated the low-volume, high-intensity interval training (HIIT), an exercise regime performed a short burst of high-intensity exercise followed by a brief low-intensity activity repeatedly according to designed frequency and duration, reduced hyperglycemia and increased muscle mitochondrial capacity[13], improved overall glycemic control and pancreatic β cell function[14], induced an improvement of endothelium-dependent flow mediated dilation (FMD) and significant outwards artery modeling[15, 16], increased peripheral but not hepatic insulin sensitivity[17], improved cardiac structure and function and reduces liver fat[18] in type 2 DM patients. A typical HIIT prescription usually involves 10×1 minute at ~90% maximal aerobic capacity separated by 1-minute rest or low intensity activity periods and lasts for ~20 minutes[19]. As a type of exercise with the focus of alternating high intensity with low intensity, HIIT can be performed on bike, treadmill, track, and some HIIT exercises even integrate with body weight training, a simple RT, into protocols. These evidences imply HIIT is potential to be safely implemented as a time-efficient and an easily accessible exercise option for reducing blood glucose levels and improving health in individuals with type 2 DM. In order to search more time-efficient regimes, even shorter durations of HIIT protocols are on the way of clinical trials.

Recently, the moderate-vigorous-intensity, but not mild-intensity, aerobic exercise protect against cardiovascular events, micro vascular complications such as stroke, infarction, retinopathy, nephropathy, and all-cause mortality in patients with type 2 DM and it does not matter whether vigorous intensity or combined aerobic and resistance training requires more or less energy expenditure have been proposed in a review paper[20]. Since the increased intensity of moderate-vigorous physical exercise requires recruitment of more skeletal muscle fibers and will signal adaptations in more skeletal muscle mass than mild-moderate-intensity, even when the exercise program matched for energy expenditure and subsequently produces greater benefits than mild-moderate intensity training, and these benefits will not be limited to the skeletal muscle and may occur in skin, peripheral nervous tissue, and other tissues engaged directly during exercise[20]. Also, that RT creates physiological stimuli, molecular signal, transduction pathways and adaptive response, and the subsequently multifactorial benefits induced by RT include increased key insulin signaling proteins, increased mitochondrial content, increased fatty acid oxidation capacity, increased GLUT4 protein

expression, increased muscle protein turnover etc. have been clearly elucidated, reflecting RT is a promising strategy to promote overall metabolic health in individuals with type 2 DM [21]. These review results revealed the importance of the exercise intensity of aerobics and RT on the metabolic benefits in DM patients.

By the year of 2014, international exercise prescription guidelines for type 2 DM agreed on followings: a weekly accumulation of a minimum of 150 min of aerobic exercise at moderate-to-vigorous intensity at least 3 days per week, resistance exercise for strengthening muscle is also recommended at least 2 days a week, flexibility exercises may complement other types of exercise, and individual exercise prescription should include detailed information on the exercise type, mode, duration, intensity and weekly frequency[22]. However, owing to the strong evidence on the beneficial effects of HIIT, the intensity of aerobic exercise and RT on DM, the intensity of aerobic exercise, HIIT and RT in exercise prescription for DM patients draw more attentions from clinical exercise physiology community. Therefore, in addition to aerobic exercise, resistance training and flexibility exercise, and the commonly accepted recommendations aforementioned, the latest formal recommendations for DM patients proposed that aerobic exercise may be done continuously or as high-intensity interval training (HIIT), and exercise frequency should be 3–7 days/week, with no more than 2 consecutive days without exercise, and also emphasize that vigorous-intensity aerobic exercise is not contraindicated by complications and both high-intensity interval and continuous exercise training are appropriate activities for the most individuals with diabetes. Moderate (e.g., 15 repetitions of an exercise that can be repeated no more than 15 times) to vigorous (e.g., 6–8 repetitions of an exercise that can be repeated no more than 6–8 times) also have been specified as well [23].

In summary, contracting skeletal muscle during exercise has a crucial role in regulating blood glucose. Exerkines released from organs during exercise may mediate the effects and mechanisms of glucose homeostasis. Exercise modes include AT, RT, combination of AT & RT and HIIT all have effects on HbA1c improvement and other health benefits in DM patients. Combination of moderate-vigorous intensity AT and RT should be superior to low-moderate AT or RT alone. Exercise prescription must be adapted for each individual patient based on comorbidities, contraindications and realistic personal goals and in exercise modality, intensity, duration, frequency and special care.

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