The One-On-One Column provides scientifically supported, practical information for personal trainers who work with apparently healthy individuals or medically-cleared special populations.

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Exercise Programming for Insulin Resistance

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SUMMARY

INSULIN RESISTANCE (IR) POSES MANY CHALLENGES TO EXERCISE PROGRAMMING. EXERCISE PROFESSIONALS NEED TO BE KNOWLEDGEABLE OF THE COMPLICATIONS THAT IR PRESENTS AND STRATEGIES FOR EFFECTIVE EXERCISE PROGRAMMING. INSULIN RESISTANCE IS OFTEN ACCOMPANIED BY MANY COMORBIDITIES, WHICH MUST BE ADDRESSED. THIS COLUMN DISCUSSES APPROPRIATE EXERCISE INTERVENTIONS AND PRECAUTIONS FOR PERSONS WITH IR.

Insulin resistance (IR) and type 2 diabetes mellitus (T2D) are growing concerns worldwide (10). Exercise has been shown to reverse IR and prevent progression to T2D (3). The accompanying Special Populations column addresses the etiology of IR and mechanisms by which exercise positively modifies IR. This column will address exercise programming for persons with IR.

Exercise has been shown to improve insulin sensitivity and glucose uptake (3,6,7). Furthermore, exercise training, especially resistance training (RT), can increase muscle mass (further increasing glucose uptake). Insulin resistance is often associated with additional metabolic abnormalities (11). Therefore, it is appropriate to apply exercise guidelines for associated risk factors (i.e., obesity, hypertension, etc) with minor modifications for persons with IR.

AEROBIC TRAINING

Because of its substantial benefits on health and fitness and associated metabolic abnormalities, aerobic training (AT) should be the foundation of exercise programming for IR. For persons with IR, AT emphasis should be placed on daily and weekly accumulated volume. Current recommendations call for at least 2.5 hours of exercise per week to prevent progression to T2D (3) and 4–7 hours per week to achieve and maintain a healthy body weight (2). After exercise, glucose uptake by skeletal muscles can remain elevated for several hours (6). Therefore, breaking AT into multiple shorter sessions per day (10- to 20-minute bouts) may help maintain insulin sensitivity throughout the day. Aerobic intervals or intermittent exercise may also aid individuals in reaching their exercise goals, particularly among persons with little exercise experience because these individuals may be unable to tolerate prolonged exercise (1). Additionally, higher-intensity interval exercise has been shown to be an effective means of decreasing fasting insulin concentrations (14).

Initially, emphasis should be placed on moderate-intensity (40–60% $\dot{V}O_2$max) exercise (1,3). Intensity can gradually be increased as fitness improves. Recently, moderate-intensity exercise has been shown to perhaps be more effective than higher-intensity exercise (60–85% $\dot{V}O_2$max) in maintaining β-cell function (5,13). Persons with IR can progress according to similar guidelines as apparently healthy individuals. It is important to note that the rate of progression may depend more on comorbidities than on IR. Persons with IR beginning an exercise program should try to accumulate approximately 20 minutes of moderate-intensity (~40–60%$\dot{V}O_2$max) AT on 4–5 days per week. Persons can then progress to 30–60 minutes per session and accumulate approximately 4–7 hours per week of moderate- to vigorous-intensity AT over 5–7 days per week (2).

Because the majority of persons do not know their $\dot{V}O_2$max or maximal heart rate, it may be advantageous to perform an exercise test to determine or estimate

$\dot{V}O_2$max. Maximal exercise testing provides the most accurate results and can be a safe option for low-risk persons. However, because many persons with IR present with multiple risk factors, using a submaximal exercise test may be most appropriate. Two popular examples are the Astrand-Rhyming test and the Young Men's Christian Association bike test. If a client refuses an exercise test, or if proper equipment is unavailable, exercise prescription may be based on the Ratings of Perceived Exertion scale (recommended 11–15 effort; Table 1). Additionally, encouraging individuals to exercise at a "conversational" level may help establish the appropriate moderate intensity. Progression should not exceed a 20% increase in volume or intensity per week (1). Additionally, it is advised that individuals increase volume before increasing intensity. When intensity is increased, duration can be reduced if needed until the individual adapts to the increased workload. A sample aerobic exercise plan can be found in Table 2.

Table 1
Ratings of perceived exertion

Rating	Description
6	—
7	Very very light
8	—
9	Very light
10	—
11	Light
12	—
13	Somewhat heavy
14	—
15	Heavy
16	—
17	Very heavy
18	—
19	Very very heavy
20	—

Table 2
Sample aerobic exercise training program for persons with insulin resistance

Week	Intensity (% $\dot{V}O_2$max)/RPE	Duration (min)	Repetitions	Days per week
1	50–60/10–12	10	2–3	3
2	50–60/10–12	12	2–3	3
3	50–60/10–12	15	2	3–4
4	60–65/12–13	15	2	3–4
5	60–65/12–13	15	2–3	4
6	60–65/12–13	17	2	4
7	60–65/12–13	20	2	4–5
8	65–70/13–14	20	2	4–5
9	65–70/13–14	>40	1	5
10	70–75/14–15	>45	1	5

Emphasis during each week should be placed on accumulated time at designated intensity. It is recommended that training volume not increase by more than 20% between consecutive weeks. Care should be taken to not increase intensity and duration during the same week.

RPE = Ratings of Perceived Exertion.

RESISTANCE TRAINING

Resistance training can result in dramatic improvements in both insulin sensitivity and glucose uptake (3). In fact, RT may be equally as effective as AT with regards to glycemic control (12). Ideally, RT should be performed 3 times per week (3). Resistance training should focus on all the major muscle groups with an emphasis placed on multijoint exercises to improve insulin sensitivity of all major muscle groups. Because skeletal muscle accounts for 75–95% glucose uptake (4), increasing muscle mass can dramatically help maintain normal blood glucose (BG) levels. Initially, persons with IR should perform 1 set of 10–15 repetitions at approximately 40–60% of their 1 repetition maximum (1RM) (1).

Many exercise beginners do not know their 1RM for a given RT exercise. In this case, it is advisable to have the individual perform a 12RM test at a "fatiguing" effort (unable to complete 15 repetitions). This will help the exercise professional (EP) determine an appropriate resistance for each exercise. If practical, this test should be performed on all RT exercises included in the exercise prescription. As muscular strength increases, individuals can add additional sets. This can be followed by increasing resistance on successful completion of 15 repetitions for 2–3 sets at a given resistance. As muscular adaptation increases, it is recommended that resistance be increased until some sets consist of 8–10 "fatiguing" repetitions (3). Selectorized machines are advised for individuals with little RT experience and compared with free weights, which provide similar benefits for IR (3). Additionally, it is important to note that many persons with IR may need to modify RT exercises to accommodate additional comorbidities. For example, persons with IR and obesity may require modification of exercises to allow for comfortable body positioning or full range of motion. A sample RT program can be found in Table 3.

COMBINED AEROBIC AND RESISTANCE TRAINING

Aerobic training and RT are similarly effective for managing IR, but it seems

Table 3
Sample resistance training program for persons with insulin resistance

Exercise	Sets	Repetitions
Squat or leg press	2–3	10–12
Chest press	2–3	10–12
Pull-down	2–3	10–12
Leg extension	1	8–10
Leg curl	1	8–10
Shoulder press	2–3	10–12
Seated row	2–3	10–12
Lunge or step up	1–2	8–10
Bicep curl	1	8–10
Tricep extension	1	8–10
Calf raise	1–2	10–12
Back extension	1–2	12–15
Abdominal crunch	1–2	12–15

It is advisable to start with 1 set per exercise of 12–15 repetitions and progress to 2–3 sets of 8–10 repetitions.

that combined AT and RT is more effective than either alone with regard to glycemic control, when total exercise time is greater than either AT or RT alone (12). For exercise beginners, a circuit training program interspersing AT with RT can be an effective means of combining both forms of exercise. This allows longer recovery times for muscle groups while not adding unnecessary rest periods. Another strategy is to perform shorter duration AT on RT days and longer AT on days without RT.

SAFETY CONSIDERATIONS

As mentioned earlier, IR often occurs in the presence of additional comorbidities. It is not uncommon for these comorbidities (obesity, orthopedic injury, cardiovascular disease, etc) to limit exercise ability or tolerance. Therefore, it is important to modify exercise recommendations and/or techniques to accommodate these comorbidities. For instance, individuals with hypertension may require lower intensity for RT exercises to avoid hypertensive responses. Additionally, it is advised that frequent blood pressure monitoring be part of an exercise program for persons with hypertension.

Several safety measures can be used. First, the EP should establish good rapport and communication with all clients. The EP should be familiar with all the clients' medications. A copy of the medication list should be kept in the client's file in case of emergency or an unusual response to exercise and should be updated as medication changes occur. It is also recommended that persons with IR initially monitor BG before and after the exercise. Although hypoglycemia is not expected in IR, it is beneficial to monitor in case of a severe reaction to exercise (typical symptoms of these conditions can be found in Table 4). This is especially true for persons who are unfamiliar with exercise. In case of hypoglycemia, ingestion of 15 g of high–glycemic index carbohydrates (e.g., a cup of apple juice) is recommended. The EP should recheck BG approximately 15 minutes later to ensure BG is in normal range. Typically, persons presenting with hypoglycemia (BG values <70 mg/dL) should not be allowed to exercise until BG is increased to within the normal range. It is recommended to have 15 g carbohydrate snacks available if an individual presents with BG <100 mg/dL before exercise or in cases of prolonged and/or vigorous exercise (3).

CONCLUSIONS

While no single exercise prescription will appropriately address all individuals with IR, several considerations should be included.

- Persons should exercise 4–7 days per week (2)
- Insulin sensitivity is quickly reversed after exercise cessation (8,9). Therefore, to maintain insulin sensitivity between bouts, exercise sessions should not be separated by more than 48 hours (1,3)
- Moderate-intensity (40–60% $\dot{V}O_2$max) to vigorous-intensity (60–85% $\dot{V}O_2$max) aerobic exercise should be emphasized depending on fitness level of the client. These intensities have been shown to preserve β-cell function (5,13)
- Individuals should try to accumulate approximately 4–7 hours per week

Table 4
Typical symptoms of hypoglycemia and hyperglycemia

Hypoglycemia (BG < 70 mg/dL)	Hyperglycemia (BG > 300 mg/dL)
Faint feeling	Weakness
Hand tremors	Increased thirst
Excessive sweating	Dry mouth
Dizziness	Nausea
Fatigue	Vomiting
Unsteady gate/poor coordination	Acetone breath
Blurred vision	Kussmaul respirations
Loss of consciousness	
Inability to concentrate	
Slurred speech	

Kussmaul respiration refers to deep heavy breathing that is often a sign of ketoacidosis.

Adapted from American College of Sports Medicine (2).

of exercise to achieve or maintain a healthy body weight (2)
- A combination of AT and RT should be used for optimal glycemic control (12). However, the total volume of training should be additive (e.g., not decreased AT volume to allow time for RT or vice versa).

Insulin resistance can present numerous challenges to the EP. However, exercise is known to improve IR and can prevent progression to T2D (3). Familiarization with the etiology of IR, associated health complications, and mechanisms by which exercise improves IR can help the EP design a safe and effective exercise program.

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