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Diet and Exercise Together for Adolescent Insulin Resistance: A Review

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Abstract

Rising youth obesity rates closely link to insulin resistance, a key metabolic disorder that raises people's long-term chances of developing type-2 diabetes and cardiovascular illnesses. Lifestyle adjustment acts as the core non-drug method to help adolescents gain better insulin sensitivity. Even so, relying purely on diet adjustment or physical activity often brings modest outcomes, given insulin resistance's multiple contributing factors and teenagers' difficulty sticking to plans over time. This narrative review gathers available research to examine how combined diet-exercise schemes work for young people suffering from insulin resistance, alongside comparisons against single-mode intervention plans. Published research suggests schemes pairing nutritional adjustments with consistent moderate-to-vigorous exercise can bring more desirable changes to insulin sensitivity, body makeup and inflammatory markers than adopting diet or exercise separately. Such improvements come through several biological pathways: lowered energy intake and body fat percentage, enhanced glucose uptake within skeletal muscle tissues, as well as relief from persistent mild inflammation. Research data also points out that interventions running 12 weeks or longer, which pair frequent exercise with high-fiber meals low in added free sugars, can bring measurable metabolic gains for adolescents. Still, several gaps persist: intervention protocols differ widely between trials, long-term follow-up data stays scarce, and studies targeting Asian teenagers are still insufficient. Subsequent research ought to work out unified intervention frameworks, figure out solutions to sustain participant compliance, and build personalized lifestyle plans for better prevention and clinical handling of adolescent insulin resistance.

Keywords

lifestyle intervention, insulin resistance, adolescents, diet, exercise, HOMA

1. Introduction

Over the last twenty years, overweight and obesity cases among children and teenagers have grown rapidly across the globe. Such public-health pressure does not only appear within wealthy nations; emerging economies such as China are facing similar epidemiological trends. Domestic population monitoring reports show around 20 percent of Chinese children aged 6-17 are either overweight or obese [1]. Quite a number of these young individuals have excess body fat, and such metabolic stress is very likely to continue when they grow into adults.

Extra body fat accumulated during teenage years raises people's odds of developing several accompanying illnesses such as high blood pressure, lipid disorders and elevated blood sugar. Among these issues, insulin

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resistance draws particularly strong clinical attention. Insulin resistance describes weakened cellular response toward insulin, the hormone keeping blood-glucose levels stable. At early disease phases, pancreatic β-cells secrete extra insulin to offset poor insulin reaction in peripheral tissues, which results in compensatory hyperinsulinemia [2]. Under lasting metabolic pressure, β-cells gradually lose part of their secretion capacity. This pathological shift pushes individuals from prediabetes into full-blown type-2 diabetes [2]. Even without obvious high blood-glucose symptoms, insulin resistance itself can independently predict higher risks for cardiovascular problems [2].

Medications like metformin serve as one treatment choice for young patient groups. However, drug-based treatments may trigger side-effects including gastrointestinal discomfort. Their safety and suitability for diverse teenage groups are still not fully confirmed. For this reason, non-drug lifestyle adjustments are highly recommended whenever practical.

Even so, single-factor intervention plans meet noticeable real-life obstacles for adolescent groups. Teenagers struggle to stick to schedules due to heavy school assignments, packed daily routines, desire for independence, plus large amounts of screen-based sedentary time. Plans focusing only on diet or exercise can hardly reverse insulin resistance, which arises from multiple interacting causes. Simply adjusting eating habits cannot maximize muscle-tissue glucose consumption without enough physical movement. Meanwhile, exercise alone cannot produce ideal outcomes if teenagers keep consuming large quantities of free sugars and high-fat food.

Faced with these practical restrictions, more research projects turn to multi-part lifestyle programs combining nutritional adjustment and physical activity promotion. It carries clinical value to figure out whether combined interventions deliver more powerful and longer-lasting metabolic improvements compared to single-mode solutions. This narrative review centers on one key research question: can combined diet-and-exercise measures work better than diet-only or exercise-only plans to relieve insulin-resistance among teenagers? The paper sums up up-to-date clinical findings, explains mutually supportive biological mechanisms, and puts forward actionable suggestions intended for parents, school educators and clinical workers.

2. Prevalence, Causes, and Intervention Needs

2.1 Prevalence of Insulin Resistance Among Adolescents

Insulin resistance appears very commonly among overweight and obese teenagers. Overseas research indicates 30%-50% of obese adolescents show insulin resistance of different severity levels [3]. Similar epidemiological features can also be spotted among young Chinese populations [1].

Insulin resistance developed in adolescence often continues into adulthood. People showing insulin-resistance symptoms at age 15 have far higher chances of getting type-2 diabetes in their thirties or forties. Besides, insulin resistance itself counts as an independent cardiovascular risk factor, even for people without obvious hyperglycemia [2]. Hence, early detection and timely intervention hold great clinical meaning.

2.2 Causes of insulin Resistance in Adolescents

Several interlinked factors lead to insulin-resistance onset for teenagers. These include physiological changes of insulin sensitivity during puberty, inherited genetic tendency, sleep quality [14], social-environmental surroundings, alongside diet- and exercise-related variables [4].

For starters, poor eating habits represent one major contributing factor. Overconsumption of added sugars (drinks, fruit juice, candies) and refined-carb food (white bread, polished rice, baked pastries) causes sharp blood-sugar spikes after meals and subsequent hyperinsulinemia. Persistently high insulin levels in blood may damage insulin-receptor signal transmission within peripheral tissues. At the same time, most teenagers do not take in enough dietary fiber. This nutrient slows carbohydrate absorption and stabilizes blood-glucose readings; average fiber intake for teenagers reaches merely half of official recommended standards.

Next, insufficient physical movement acts as another major risk source. Many schools cut down physical-education class hours. After school, teenagers spend plenty of time doing homework, watching online

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content or operating mobile devices, which can create 8-10 hours of sedentary time each day. When muscle tissues take up little glucose, blood-glucose values stay high, forcing pancreatic β-cells to keep secreting larger amounts of insulin. Consistent physical exercise improves muscle insulin sensitivity; for that reason, lack of exercise counts as a changeable risk factor for insulin resistance.

Thirdly, surplus body fat triggers long-term mild inflammation. Adipose tissue, especially visceral belly fat, is more than just an organ storing energy. It releases pro-inflammatory cytokines such as TNF-α and IL-6. These inflammatory messengers break intracellular insulin-signal pathways and weaken insulin response in peripheral tissues. This creates a self-strengthening negative cycle: higher body fat fuels inflammation and insulin resistance, and these conditions cause further weight increase.

2.3 Limitations of Single-component Interventions

Given insulin-resistance comes from multiple sources in adolescent populations, interventions targeting just one risk factor often deliver unsatisfactory practical results [5]. For example, changing eating habits without matching physical activity may bring short-term weight loss but cannot fully maximize muscle insulin sensitivity. Likewise, exercise plans cannot fully ease inflammation originating from fat tissue if unhealthy eating patterns continue.

Teenagers also face unique obstacles that make single-mode plans hard to follow. Young people care a great deal about peer approval. When friends eat high-calorie food or take part in sedentary leisure activities, adolescents feel strong social pressure, which makes strict intervention compliance difficult. Plans that feel restrictive or punishing cannot be kept up well by teenage groups.

Additionally, most existing diet or exercise plans are designed by adults, with little opinion collected from adolescents themselves. Overly strict or boring schedules cannot be maintained for long stretches of time. Therefore, flexible multi-component intervention strategies are generally more suitable.

2.4 Rationale for Combined Interventions

Diet-only and exercise-only interventions work on separate pathological routes. Diet adjustment controls total energy intake and nutritional makeup, while physical activity raises energy consumption and directly improves muscle insulin reaction. The two approaches complement each other, and neither one can fully replace the other. Such theoretical mechanistic coordination may not always turn into statistically notable interaction effects in clinical trials [6]. Quick early-stage improvements, for instance lowered HOMA-IR values or moderate weight loss, can act as positive motivation to help teenagers keep participating.

On top of that, combined lifestyle interventions frequently contain behavioral and psychological supporting sections. These parts help teenagers handle food cravings, mental stress and peer-related social pressure — elements rarely seen within single-factor intervention plans. To sum up, breaking the self-strengthening loop linking body fat, inflammation and insulin resistance calls for simultaneous intervention on multiple fronts.

3. Effects of Single-Component Interventions

3.1 Effective Dietary Intervention Approaches

Within various dietary strategies, low-glycemic-index (low-GI) diets hold the most solid research backing for easing teenage insulin resistance. Low-GI eating chooses food that causes slow blood-glucose rises, for example whole grains, beans, vegetables and most kinds of fruit, which also contain abundant dietary fiber. One 12-week controlled research carried out on overweight Iranian adolescents proved plant-oriented eating patterns — cutting added-sugar intake while raising fiber consumption — can better insulin-resistance biomarkers [7]. Such metabolic benefits can be partially interpreted through short-chain-fatty-acid-driven AMPK and GLUT4 signal pathways [8].

Khorshidi and colleagues published a meta-analysis in 2025 that looked at 17 randomized controlled trials involving children and adolescents with overweight or obesity [5]. They found that low-carbohydrate modified diets, which often have a low GI, reduced HOMA-IR by an average of 0.43 (95% confidence interval: -0.83 to -0.03) [5].

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3.2 Benefits Brought by Physical-activity Intervention

Exercise is just as important as diet. Liu and colleagues did a network meta-analysis in 2026 that compared four types of exercise: aerobic exercise (like running and swimming), resistance training (like weight lifting and elastic band exercises), high-intensity interval training (HIIT, like sprinting and jumping rope), and combined training (a mix of aerobic and resistance) [8]. They included 63 studies with a total of 3,286 participants, all of whom were children and adolescents with overweight or obesity [8].

The results were very clear. HIIT was the most effective at reducing fasting insulin (SMD = -0.80) and HOMA-IR (SMD = -1.21) [8]. Combined training was most effective in lowering fasting glucose (SMD = -0.41) [8]. Aerobic exercise improved all three markers, but not as much as HIIT or combined training [8]. Resistance training by itself showed no notable influence on these metabolic markers. Still, when paired with aerobic exercise, this combined approach produced better outcomes than aerobic exercise taken alone [8].

Current research findings offer practical references when designing exercise plans for adolescents. For teenagers with little workout background, moderate-intensity aerobic activities act as safe starting choices to build up physical fitness. For already-active adolescents, HIIT delivers desirable metabolic gains within shorter time spans. People may add resistance training into regular workouts to build muscle mass and boost glucose absorption.

4. Effects and Mechanisms of Combined Interventions

4.1 Outcomes of Combined Diet-and-Exercise Interventions

Diet and exercise generate synergistic effects via no fewer than three biological routes.

The first one relates to energy balance. Diet cuts calorie intake while physical activity lifts calorie consumption. Used together, they create a larger calorie deficit than either approach used separately. This brings more substantial fat reduction, particularly visceral abdominal fat. Losing belly-stored fat works best for lowering inflammation levels and boosting insulin sensitivity. Research indicates every one-kilogram drop in body weight corresponds to roughly a 0.2 fall in HOMA-IR value [9].

The second pathway concerns inflammatory responses. Diet and exercise both produce anti-inflammatory outcomes yet operate via separate biological mechanisms. Diet lowers intake of saturated fat and sugar substances that set off inflammatory reactions, while physical activity promotes synthesis of anti-inflammatory cytokines including IL-10. When applied together, inflammatory biomarkers including CRP, IL-6 and TNF-α fall more sharply compared to single-factor interventions [9,10]. Data from long-term multidisciplinary programs reveals after six-month interventions, endotoxin levels go down; protective hormone adiponectin rises; PAI-1 falls; and leptin returns to normal ranges [9,10]. According to available evidence, the optimal combined scheme is as follows: no fewer than 5 moderate-to-vigorous exercise sessions weekly (around 60 minutes each), sustained for 12 weeks minimum, paired with high-fiber, low-free-sugar meals with controlled total calorie intake [8,11]. Pooled analysis of controlled trials further confirms combined diet-exercise interventions achieve better metabolic results [15].

4.2 Real-world Examples

Two examples illustrate these findings well.

In 2025, Jiménez-Peláez and colleagues published a meta-analysis that combined data from 10 clinical trials [12]. They looked at interventions that included diet and physical activity, as well as psychological and behavioral support, such as goal-setting, problem-solving, and motivational interviews. They found that participants in these combined programs lost an average of 1.10 kilograms more than those in control groups, with a p-value of < 0.001 [12]. This shows that the non-diet, non-exercise components--like mental support and education--are also important for success [12].

The network meta-analysis by Liu et al. is another good example. It provided solid evidence that HIIT is the most effective exercise type for lowering HOMA-IR. This evidence is useful to doctors and trainers when writing exercise prescriptions for teenagers [8].

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5. Discussion

This review confirms that combining dietary changes with exercise training is more effective than using either one alone for improving insulin resistance in teenagers. The evidence we collected from 15 studies is consistent: the combined approach yields additional reductions in HOMA-IR, greater improvements in body composition, and larger reductions in inflammatory markers.

However, there are important limitations in the existing literature. The protocols vary a lot from one study to another. Some used very strict diets, others were more flexible. Some had supervised exercise, others gave only general advice. The duration of interventions ranged from 4 weeks to 12 months, and the follow-up periods were often short. Very few studies tracked participants for more than a year to see if the improvements were maintained. Also, most studies had small sample sizes. Finally, most studies were done in Western countries, so the findings may not directly apply to Asian populations with different dietary habits and body compositions [12]. Limited evidence from Asian cohorts, including Chinese samples, cannot fill this research gap.

For clinical practice, we suggest the "Three Cuts and Three Adds" rule: cut free sugars, refined carbohydrates, and saturated fats; add dietary fiber, high-quality protein, and micronutrients (like vitamins and minerals). For exercise, a combination of aerobic, HIIT, and resistance training seems best. We also recommend a hospital-school-family collaborative model with a closed-loop management system: Screening → Assessment → Intervention → Monitoring → Adjustment. This way, progress is tracked regularly, and the plan can be modified if needed.

6. Conclusion

Looking ahead, there are several promising areas. Precision nutrition, which tailors dietary recommendations based on genetic and epigenetic markers, could help identify which teenagers will respond best to specific diets. For example, some people have genetic variations that affect carbohydrate metabolism, and they might benefit more from low-GI diets than others.

Gut microbiota is another exciting frontier. The bacteria in our intestines affect how we digest food and how our bodies handle inflammation. Some studies have shown that certain probiotics or synbiotics can improve insulin sensitivity, but evidence in teenagers remains mixed [13]. More research is needed before these can be recommended as routine add-ons.

Technology is also making a big difference. Wearable devices like smartwatches and fitness trackers can monitor heart rate, step count, and even sleep quality. AI algorithms can provide real-time feedback and personalized coaching [15]. For example, if a teenager is sitting too long, the watch buzzes and suggests a short walk. Virtual reality exercise systems can make workouts feel like games, which might keep teenagers more engaged [15]. These tools could be integrated into traditional diet and exercise programs to form a smart management system that connects home, school, and hospital settings.

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Conflicts of Interest

The authors declare no conflict of interest.

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