2023; Bosch-Sierra et al., 2024); Exercise intervention (such as aerobic and strength training) can reduce TNF-α and CRP, increase IL-10 expression, and has anti-inflammatory effects even without significant changes in body weight (Yousefabadi et al., 2020; Rahimi et al., 2021).

Dietary intervention is also very important. Adopting a Mediterranean diet or a plant-based diet can reduce inflammation and improve metabolism (Onu et al., 2025; Suarez et al., 2025). In addition, drugs such as GLP-1 receptor agonists can reduce abdominal fat and inflammation and lower the severity of the disease (Sandsdal et al., 2023). In conclusion, lifestyle intervention combined with drug treatment is an effective strategy for improving the prognosis of metabolic syndrome.

8 Interventions and Outlook

In recent years, the treatment of metabolic syndrome has increasingly focused on inflammatory pathways in the brain, especially the IL-1-related pathway, the NF-κB/JNK signaling axis and the NLRP3 inflammasome. The NLRP3 inflammasome plays a key regulatory role in the production of pro-inflammatory factors. Inhibiting it can alleviate metabolic problems such as obesity and insulin resistance. The NF-κB and JNK pathways are at the core of chronic inflammation and metabolic disorders, and their continuous activation is closely related to insulin resistance and adipose tissue inflammation. In addition, the regulation of glial cell activity has also drawn attention. The neuroinflammation it triggers can damage hypothalamic function and lead to systemic metabolic disorders. These targets provide potential directions for the development of anti-inflammatory drugs.

In addition to drug treatment, comprehensive lifestyle management is still the fundamental way to reduce the burden of inflammation. Regular exercise (especially moderate-intensity) can reduce pro-inflammatory factors such as IL-1β and TNF-α and increase anti-inflammatory substances such as IL-10, which is effective even with little change in weight. The Mediterranean diet and plant-based diets can reduce systemic inflammation, improve metabolism, and the effect is even better when combined with exercise. In addition, regulating sleep and circadian rhythms is also crucial. Regular diet helps regulate inflammatory pathways and improve metabolism.

Future research should further clarify the causal relationship between central inflammatory factors and the progression of metabolic syndrome, and determine the best intervention timing. Given the individual differences in metabolic syndrome, there is an urgent need to develop reliable biomarkers for the early identification of high-risk populations, stratification of patients and evaluation of therapeutic effects. Multi-omics technology provides a new tool for analyzing individual inflammatory and metabolic characteristics. Mechanism research combined with biomarker strategies is a key direction for promoting anti-inflammatory intervention towards precise individualized treatment.

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Conflict of Interest Disclosure

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