Dean&Francis
ISSN 2959-409X

The Mechanism and Intervention Strategies of Non-Alcoholic Fatty Liver Disease Caused by High-Fructose Beverages in Adolescents

Meixuan Lyu[1],

Huanxiao Jiu[2,*]

[1]Qingdao NO.2 Middle School of Shandong Province, Qingdao, China
[2]Tianjin Teda Maple Leaf School, Tianjin, China
*Corresponding author: jiuzkmail9@163.com

Abstract:

There is a common chronic liver disease among adolescents, called non-alcoholic fatty liver disease. It is common among teenagers all over the world. This kind of liver disease is difficult to detect in the early stage, and the symptoms are not obvious, but long-term development will lead to liver evolution. And this liver disease can lead to insulin resistance and metabolic complications. However, the current medical direction is mainly targeted at adults, and there is still a lack of research on the causes and prevention mechanisms of adolescents. In fact, the liver metabolism of adolescents is very active, which will also lead to the immaturity of intestinal flora, so the mechanism of liver disease in adolescents is worth studying. This paper systematically introduced the prevalence of nonalcoholic fatty liver disease in adolescents and the data of high fructose intake, explained the relationship between high fructose intake and the incidence of nonalcoholic fatty liver disease, proposed intervention strategies at different levels for different age groups, analyzed the implementation problems faced by implementing these measures in reality, and summarized the possible research directions and prevention prospects in the future.

Keywords: Non-alcoholic fatty liver disease, Adolescents, High-fructose beverages, Metabolic complications, Intervention strategies.

1. Introduction

This non-alcoholic fatty liver disease is a large amount of fat accumulation in liver cells, but there is no obvious drinking behavior. It is now the most common chronic liver disease among adolescents in the world [1]. The mechanism of this liver disease in adolescents is different from that in adults, and it is non-alcoholic fatty liver disease in adolescents. It is closer to the diet pattern. What we mainly mention

here is the large intake of high-fructose drinks, which contain a large amount of fructose, which is the key ingredient. The metabolic characteristics in the liver are very special. This fructose is not regulated by insulin, so it will lead to fat accumulation in the liver [2, 3].

With more and more teenagers suffering from non-alcoholic fatty liver, and the consumption of high-fructose drinks among adolescents is gradually increasing, we can find that high-fructose drinks are the potential important cause of the disease in adolescents, which can also help us make effective intervention strategies [4]. At present, the research on this non-alcoholic fatty liver disease is mainly for adult cases, and there is a lack of in-depth research on adolescent cases of liver disease caused by fat accumulation caused by high-fructose drink intake [5]. In addition, some intervention strategies for this kind of non-alcoholic fatty liver disease are often more targeted at the relatively common strategies of reducing beverage intake, and lack targeted methods. This paper summarizes the proportion of teenagers with non-alcoholic fatty liver, as well as the intake and purchase of high-fructose drinks at all ages. And we also introduced the relationship between high-fructose drink intake and the incidence of non-alcoholic fatty liver. In addition, we also focus on the actual living conditions of teenagers and formulate more targeted intervention strategies. In addition, this paper also analyzes some problems we will encounter in the process of practicing these strategies, and points out some future research directions that can help improve the health of teenagers and help them reduce the occurrence of cases of chronic liver disease.

This paper focuses on three aspects. First of all, it is to explain the intrinsic relationship between the intake of high-fructose drinks and the incidence of non-alcoholic fatty liver in adolescents. Secondly, we have put forward some more targeted strategies that can be used in the three different environments of personal family and school. Finally, we analyzed the challenges and problems that these targeted strategies will face in the process of implementation. And outline the possible research direction in the future.

2. Prevalence of Adolescent NAFLD and Consumption of High-Fructose Beverages

2.1 Global and Regional Prevalence of NAFLD

A major global public health problem, namely non-alcoholic fatty liver disease, now has a prevalence of about 25% in the general population. It is worth noting that the incidence is particularly high among adolescents and continues to rise. This reflects the impact of changes in the diet and life of teenagers on the disease [6]. There are some relevant surveys in China, so that we can find that the number of teenagers suffering from non-alcoholic fatty liver disease is increasing, and we can find that the intake of high-sugar drinks is one of the main causes of this disease. For example, there is a study in Hefei, from which we can find that nearly 90% of junior high school students drink high-fructose drinks every week. The high-intake group with high-fructose drinks had a nearly 55% higher risk of non-alcoholic fatty liver disease than the low-intake group [7]. This trend of onset makes us understand that targeted public health intervention strategies are very important at present.

2.2 Consumption Status of High-Fructose Beverages Among Adolescents

Carbonated drinks, juices, sugary tea, etc. are all called high-fructose drinks. They are very popular among teenagers. Through the relevant nutrition and health test reports we obtained, the data tells us that children and teenagers will drink this kind of sugary drink several times a week, and the frequency of drinking will increase with age. At this point, there are actually some obvious differences in the consumption level between urban and rural areas. In addition, we can find in a study in 2025 that adolescents who drink more than 250 grams of sugar-free drinks a day also have a 60% higher risk of non-alcoholic fatty liver disease. This data shows that not only high-fructose drinks, but also some sugar-free drinks also have the risk of non-alcoholic fatty liver disease [9]. This consumption pattern clearly reflects the normalization trend of high-fructose drink intake in the actual life of teenagers.

3. Core Mechanisms of High-Fructose Beverages Inducing NAFLD in Adolescents

3.1 Metabolic Characteristics of Fructose in the Liver

The liver is mainly responsible for the concentrated metabolism of fructose. It bypasses key regulatory steps, such as phosphor fructose kinase, which is different from glucose metabolism, and it is not regulated by insulin [10]. When teenagers consume a lot of high-fructose drinks, most of the fructose in the drinks will be transported to the liver and phosphorylated by it, promoting the formation of new fats and the synthesis of triglycerides. Compared with

ISSN 2959-409X

adults, this shows that the liver metabolism of adolescents tends to be more active, which also means that undeveloped livers can convert fructose into fat and triglycerides more effectively. This stronger metabolism actually leads to the deposition of triglycerides in hepatocytes, which is why non-alcoholic fatty liver disease can be quickly formed [5, 11].

3.2 Association with Hyperuricemia

In addition, when the liver metabolizes fructose, it will also accelerate the decomposition of adenosine triphosphate, that is, ATP. This is a by-product that occurs when purine is produced, and purine is the precursor of uric acid. At the same time, the intake of fructose will also interfere with the excretion of uric acid by the kidneys, which will lead to an increase in the level of uric acid in the blood, resulting in the occurrence of hyperuricemia [12]. Hyperuricemia is not only an inducing factor of gout, but also leads to kidney disease, endocrine disease and metabolic disorders, as well as cardiovascular disease. In adolescents, hyperuricemia and excessive intake of fructose exist at the same time. It will aggravate the damage to the liver through the synergistic effect of inflammation and oxidative stress. This will also promote the occurrence of non-alcoholic fatty liver disease [13].

3.3 Impact of Immature Intestinal Microbiota

As we mentioned earlier, the microbial flora in the intestines of adolescents is not fully mature, so the composition and function of these microbial flora are easily affected by dietary factors, such as the intake of a large amount of high-fructose drinks [5]. A large amount of fructose intake will change the structure of intestinal microbiota, reduce the content of beneficial bacteria, and increase the number of harmful bacteria. Similar flora disorders will greatly damage the barrier and immune function of the intestine, make the intestine more permeable, and cause endotoxins such as lipopolysaccharides to enter the portal vein circulation through the intestinal wall. Endotoxins will activate Toll-like receptors, causing systemic inflammation and liver inflammation. This will also promote fatty degeneration and damage in the liver [11]. However, the relationship and mechanism between fructose, intestinal microflora and adolescent non-alcoholic fatty liver disease, as well as specific regulatory methods, need to be further studied.

3.4 Daily Scenarios of High-Fructose Beverage Intake in Adolescents

The large consumption and intake of high-fructose drinks by teenagers is actually closely related to their daily life. For example, in schools, in order to be loved by more students in the canteen, vending machines and canteen, most of the drinks sold are high-fructose drinks. Students often use these drinks with meals, thus ingesting more sugar unconsciously. In the family environment, many families often use sugary drinks instead of water, making high-fructose drinks a very common drink in the daily life of teenagers. This family's diet pattern actually aggravates the frequency and amount of high fructose intake of teenagers, and sometimes even forms long-term habits that are difficult to change [8].

4. Intervention Strategies for NAFLD Induced by High-Fructose Beverages in Adolescents

4.1 Individual and Family-Level Interventions

The core of health intervention at the individual and family levels is to improve health awareness, change behavior habits, and create a supportive family environment.

It is suggested to adopt Visual Education Strategy to avoid abstraction. As shown in Fig. 1, 500ml of Cola contains about 14 cubes of sugar, which further transfer into liver fat. The Visualizing the process can help teenagers and parents more clearly understand the relevant health risks.

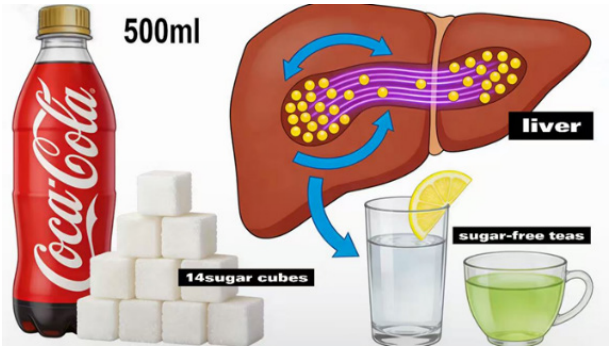

Fig 1. Sugar Content Visual (Picture credit: Original)

It is a fundamental strategy that is to only drink pure water. To ensure adequate water intake, we may carry a water cup every day. To enhance the attractiveness of drinking water, it is suggested to add lemon slices or cucumber slices to water, or choose sugar-free teas drinks (e.g., green tea and chrysanthemum tea) as health substitutes to gradually replace the intake of high fructose drinks [4].

4.2 Campus Environmental Interventions

Implementing environmental interventions in schools is crucial for regulating adolescents' beverage consumption and achieving a reduction in high-fructose intake.

The policy restriction is effective, and it should be advocated to completely prohibit the sales and promotion of sugary drinks in vending machines and canteens of schools. By installing drinking fountains in the corridors of teaching buildings and other areas, students can easily access free and clean drinking water, to support them to make healthier choices [9]. It is of great value to include nutrition knowledge and the risk of nonalcoholic fatty liver in school curriculum (e.g., biology and physical education). Inviting doctors or nutritionists to give special lectures helps to enhance teachers' and students' understanding of the hazards of high fructose beverages [13].

5. Current Challenges in Prevention and Control

5.1 Unavoidable Temptation from the External Environment

High fructose beverage marketing is pervasive in teenagers' life and social environment, which constitutes the main obstacle to reduce intake. High sugar drinks are sold in large quantities in shopping centers, cinemas and other entertainment places frequented by teenagers. In addition, targeted and high-frequency beverage advertising in takeout platforms and short video applications can effectively stimulate purchase desire [6]. Even if there are effective family and school control, it is still difficult to completely isolate teenagers from these external influences, which brings permanent challenges to the continuous change of behavior.

5.2 Difficulty in Translating Cognition into Action

Although education can improve adolescents' and parents' awareness of the hazards of high fructose beverages, maintaining sustained healthy behavior is still a challenge. For many teenagers, the sweet taste of high fructose drinks is inherently more attractive than boiled water, and they may pay more attention to immediate taste preference than long-term health considerations [3]. In addition, due to busy work and other factors, some parents are difficult to maintain a healthy eating environment at home for a long time, which may lead to oversight and significantly weaken the effect of sugar reduction interventions [8].

5.3 Urban-Rural Disparities in Prevention and Control Resources

The differences between urban and rural areas in beverage consumption are also reflected in the distribution of prevention and control resources. Schools in big cities usually have sufficient funds to carry out health education activities and organize regular health lectures; however, schools in poor rural areas are generally lack of health resources, local parents' health awareness is relatively weak, and access to professional guidance is also very limited [7]. This uneven distribution of resources hinders the balanced promotion and effective implementation of the prevention and control of nonalcoholic fatty liver in different regions.

6. Future Prospects

6.1 Disseminate Precise Scientific Education Through New Media

It is a promising direction to use the new media platform to disseminate health knowledge of high sugar drinks in a diversified and interactive way. Through the production of short videos, wechat public account articles and popular science cartoons, key information can be effectively transmitted. The use of intuitive data and vivid visual presentation helps to attract teenagers' attention. Cooperating with popular science experts who have influence in the youth audience can improve the coverage and influence of health education, and make relevant knowledge imperceptibly integrated into their daily media contact [12].

6.2 Promote Social-Level Collaborative Governance

The future prevention and control work needs to go beyond the scope of individual, family and campus, and build a common governance model for the whole society. The relevant departments should strengthen the supervision of the beverage industry, such as requiring the fructose content to be clearly marked on the commodity packaging and the health warning [9]. At the same time, it is also important to encourage the industry to invest in the research and development of truly healthier low sugar beverage alternatives. The community can set up health service stations to regularly provide dietary counseling

ISSN 2959-409X

and screening services for teenagers and parents, and help form a multi sectoral coordinated prevention and control network [4].

6.3 Strengthen Targeted Research and Optimize Intervention Plans

At present, there is still a significant gap in the study of nonalcoholic fatty liver disease in adolescents induced by high fructose drinks. Future studies should focus on the relationship between intestinal flora, metabolic characteristics and fructose intake in adolescents to clarify the specific pathological mechanism [5]. In addition, intervention strategies should be optimized according to the characteristics of adolescents in different regions and ages. For example, developing low-cost and easy to popularize customized educational materials for areas with limited resources (such as rural schools) is crucial to improving the adaptability and effectiveness of prevention projects.

7. Conclusion

Nonalcoholic fatty liver disease caused by high fructose beverage consumption has become a serious threat to the health of teenagers around the world. The high incidence of the disease in adolescents is closely related to the extensive intake of high fructose beverages. Its core mechanism involves liver specific fructose metabolism, hyperuricemia induction and the destruction of intestinal flora balance. Although intervention measures for individuals, families and schools have been proposed, they still face the challenges of ubiquitous marketing, unsustainable behavior and unequal resources between urban and rural areas. In order to effectively deal with this problem, we need to focus on using new media to carry out interactive education, promote cross sectoral collaboration to build a supportive environment, and carry out targeted research to optimize strategies in the future. Only through multi-level and multi-dimensional comprehensive prevention and control measures can we effectively reduce the intake of high fructose drinks, reduce the risk of non-alcoholic fatty liver disease and ensure their long-term health.

Authors Contribution

All the authors contributed equally and their names were listed in alphabetical order.

References

[1] Riazi K, et al. The prevalence and incidence of NAFLD worldwide: a systematic review and meta-analysis. The Lancet Gastroenterology & Hepatology, 2022, 7(9): 851-861.

[2] Stanhope K L, Havel P J. Fructose consumption: recent results and their potential implications. Annals of the New York Academy of Sciences, 2010, 1190(1): 15-24.

[3] DiStefano J K, Shaibi G Q. The relationship between excessive dietary fructose consumption and paediatric fatty liver disease. Pediatric Obesity, 2020, 16(6): e12759.

[4] Younossi Z M, et al. Lifestyle interventions in nonalcoholic fatty liver disease. Nature Reviews Gastroenterology & Hepatology, 2023, 20(11): 708-722.

[5] Eng J M, Estall J L. Diet-induced models of non-alcoholic fatty liver disease: food for thought on sugar, fat, and cholesterol. Cells, 2021, 10(7): 1805.

[6] Wang H, Gan Q, Zhang Q. Research updates of international strategies to control sugar-sweetened beverages consumption in children and adolescents. Chinese Journal of School Health, 2021, 42(3): 471-476.

[7] Miller E F. Nutrition management strategies for nonalcoholic fatty liver disease: treatment and prevention. Clinical Liver Disease, 2020, 15(4): 144-148.

[8] Ahmed I A, et al. Lifestyle interventions for non-alcoholic fatty liver disease. Saudi Journal of Biological Sciences, 2019, 26(7): 1519-1524.

[9] Cogorno L, et al. Non-alcoholic fatty liver disease: dietary and nutraceutical approaches. Liver Research, 2023, 7(3): 216-227.

[10] Lee Y, Kim H. Fructose metabolism and hepatic steatosis in adolescents: a review. Journal of Pediatric Gastroenterology and Nutrition, 2022, 75(4): 498-504.

[11] Zhang Y, et al. Gut microbiota dysbiosis and endotoxin/TLR4 pathway in adolescent NAFLD associated with high-fructose intake. Frontiers in Pediatrics, 2021, 9: 689234.

[12] Chen J, et al. Hyperuricemia as a mediator of fructose-induced NAFLD in adolescents. Pediatric Research, 2020, 88(3): 567-573.

[13] Liu X, et al. School-based interventions for reducing high-fructose beverage intake and preventing NAFLD in adolescents. Health Education Research, 2022, 37(2): 189-198.