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The relationship among physical activity, disease status and medical expenditure of adolescents: A Systematic Review

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Abstract: Objective: problems such as physical decline and diseases caused by insufficient physical activity of adolescents have become a global public health problem. The relationship between physical activity, disease status, and medical expenditure of adolescents is analyzed to provide information for the health promotion of adolescents. Methods: Using PubMed, Web of Science, CNKI, and dimensional spectrum, search for research papers from 2005 to April 2023 by using keywords such as physical activity, physical fitness, medical expenses, disease status, health promotion, and economic value. The PEDro scale was used to check the quality of the literature. **Results:** a total of 27 papers were included in the review. Regular physical activity can improve the important indicators of health promotion, such as cardiopulmonary fitness and muscle fitness, and delay or reduce the occurrence of obesity, respiratory disease, cardiovascular disease, and mental disease, to improve the health status of teenagers. From the perspective of the economic value of national fitness, regular and appropriate physical activity is an effective way to reduce the use of medical resources and medical expenses. **Conclusions:** it is suggested to increase the amount of physical activity of adolescents through the following paths to promote the healthy development of adolescents. Create a multidimensional health promotion mode of physical intervention, psychological counseling, and nutritional diet. Form health management and exercise prescription design based on modern medical technology. Establish the linkage development mechanism of school, family, and community.

Keywords: Physical activity; Nursing measures; Physical fitness; Disease status; Health promotion; Economic value

Introduction

With the advent of the high-tech and information age, people's lifestyles tend to be static, reducing people's physical participation in life and work. This has made screen behavior, sedentary behavior, and fast-food culture the norm of life, followed by 'rich diseases,' 'civilized diseases,' as well as the stresses of science and technology, and hard work. All of these not only enable us to enjoy a rich material life but also bring many bitter consequences. The World Health Organization report shows that about 80% of teenagers in the world fail to reach the recommended amount of exercise for daily physical activity[1]. As the future of the motherland, the healthy growth of adolescents is directly related to the development of the future society and the country. The topic of adolescent health promotion has been widely concerned and actively explored. In 2021, the State Council issued the national fitness plan, comprehensively promoting the national fitness strategy, effectively carrying out the youth physical exercise promotion plan, implementing the health package project, and playing its important role in improving health and promoting development[2]. In addition, the idea that exercise is a good doctor has been re-recognized. People have gradually separated health promotion from disease prevention and placed it in the same position, gradually moving from passive health to active health, and began to actively take physical exercise, cultivate health awareness, and other behaviors to develop a healthier lifestyle[3]. Therefore, under the guidance of policy and the cultivation of health awareness, national fitness activities are an effective way to promote the diversified development of teenagers.

Health fitness is directly related to the comprehensive ability of an individual's body to adapt to life and environment and reflects the individual's health level through body composition, cardiovascular function, and musculoskeletal system function (such as muscle endurance, strength, and flexibility)[4].

Physical activity can be understood as the physical action of energy consumption generated by skeletal muscle contraction higher than the level of quiet metabolism[5], and its types include aerobic exercise, resistance exercise, multi-component exercise, etch[6]. Different physical activity intensities, duration, type, and so on lead to adaptive changes in the body. Common obesity, asthma, mental disorders and other diseases of teenagers are highly related to the level of healthy physical fitness. Lower physical fitness levels can also lead to higher physical risk factors[5]. But these can be reversed by increasing physical activity. Regular physical activity can promote the physical and mental health development of teenagers[7]. How do you think you can improve unhealthy eating behavior? Enhance physical health, and reduce the risk of disease. In addition, physical activity is also an effective means to promote the healthy development of the brain and academic performance, which can effectively help the all-round development of teenagers[8]. However, physical activity or moderate to high-intensity exercise can increase healthy physical fitness, including cardiopulmonary fitness and muscle fitness[9], and good physical fitness can improve the degree of participation in future physical activities. Thus, physical activity-mediated fitness can play an important role in many aspects of health promotion and can be used as an important indicator to evaluate the effectiveness of health promotion.

In the context of national fitness and national health, active health, integration of sports and medicine, and integration of sports and health all interpret that sports are good medicine. At present, China's national health level is worrying, and the pressure on medical security is huge. It is estimated that by 2034, the total annual medical expenditure in China will exceed 22.2 trillion[10]. From the perspective of economic value, sports are a more economical intervention method for health promotion and disease prevention than health care. In adolescence, physical activities of active health are used to intervene, block lifestyle diseases, and reduce medical expenses. However, it is still unclear whether the health promotion, disease status, and economic issues of adolescents are related to whether the physical fitness benefits mediated by physical activities are related to the incidence of diseases in adolescents in the future. Is the difference in physical fitness related to medical expenditure? There are few such studies. Based on this, this paper reviews the domestic and foreign literature on physical activity, physical fitness, disease cure, medical expenses, and so on, and discusses the relationship between physical activity, disease status, and medical expenses from the perspective of the economic value of national fitness, to provide theoretical guidance for the health promotion of teenagers.

1. Data and methods

Data sources

Using PubMed, Web of Science, China National Knowledge Infrastructure (CNKI), and Dimensional Spectrum, search for research papers published in relevant journals at home and abroad from 2005 to April 2023 by using keywords such as physical activity, physical fitness, medical expenses, disease status, health promotion, and economic value.

Selection criteria

1) The research subjects are composed of adolescents. 2) The experimental group has a strict exercise prescription design.

3) The exercise prescription for the experimental group must be based on physical activity, while the control group can prescribe other exercises or not intervene. 4) The prescription design follows the standards of the American School of Sports Medicine (ACSM). 5)The evaluation indexes mainly include Disease status, medical expenses, physical activity, and physical fitness.

Literature Exclusion Criteria

1) Excluding non-English or non-Chinese literature. 2) Exclude repetitive and nonexperimental studies. 3) Exclude literature unrelated to physical activity.

Data Intake Quality Assessment

1) The shortlisted literature is read in three stages. In the first stage, researchers search the database, browse titles and abstracts, and preliminarily screen the literature they have retrieved. In the second stage, another researcher sorted out the literature and excluded duplicate ones. In the third stage, two researchers read all the literature to determine whether it meets the inclusion criteria. If there is no consensus on any literature, it will be decided whether to include it after discussion.

2) Literature quality and empirical level. The PEDro scale was used to check each document and evaluate its research quality. The higher the score, the better the research quality of this document. Each document was scored independently by two researchers. If there are different scoring items, a consensus was reached after discussion. Due to the characteristics of the included papers, the therapists are required to provide treatment intervention in the research process. The highest total score may be 9 for the items that cannot be single-blind for the therapists. Therefore, it is determined that those whose PEDro-scale score is greater than or equal to 5 are high-quality papers, and those whose score is less than or equal to 4 are low-quality papers.

The system search results are shown in Figure 1. A total of 2332 relevant articles were retrieved from four databases. Deleted 986 duplicate literature, and selected 1246 kinds of literature According to the title and abstract, full texts were obtained for further analysis, of which 315 were excluded because they did not meet the qualification criteria. Through the full-text analysis, 27 papers met the inclusion criteria and were included in this review.

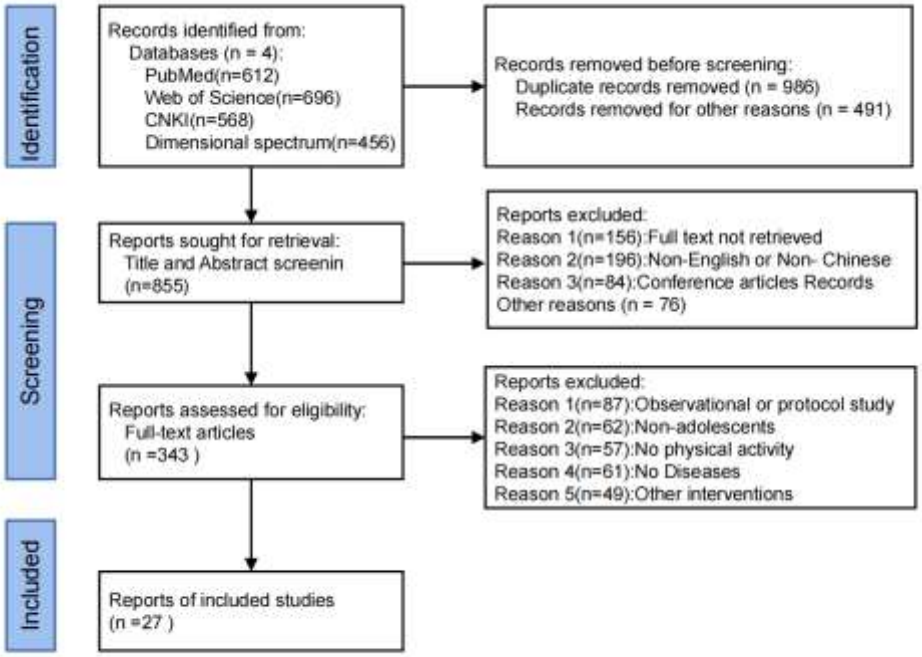

Figure 1. Flowchart regarding the selection process of the scientific studies.

2. Physical activity and health fitness

Childhood and adolescence are critical periods for adolescents to develop sports skills, and develop lifelong sports awareness and healthy behaviors, which are related to their lifelong health. The American Physical Activity Guide points out that preschool children should take physical exercise to promote growth and development[6]. The physical activity of teenagers is significantly positively correlated with their healthy physical fitness level. At the same time, it has the benefit of prolonging and also has a positive effect on the healthy physical fitness of adults in the future[11]. In addition, physical activity improves the healthy physical fitness of adolescents. Good physical fitness creates conditions for participating in moderate and high-intensity physical activities and also has an important correlation with the occurrence of disease resistance[12].

2.1 Physical activity and cardiopulmonary fitness

Cardiorespiratory fitness (CRF) refers to the ability of the circulatory system and respiratory system to provide oxygen for skeletal muscle mitochondria to produce the energy required for physical activity, including cardiorespiratory endurance, cardiovascular adaptability, aerobic capacity, and aerobic adaptability[13]. With the increase in adolescents' sedentary behavior, the rise in obesity rate, the decline in physical activity, and the change in social environment, the CRF level of adolescents in the world generally shows a downward trend. Studies have shown that a low level of cardiopulmonary fitness is closely related to the incidence of cardiovascular disease events, respiratory diseases, cancer, and all-cause mortality[14]. In addition, it also has positive benefits for mental diseases such as depression and anxiety.

Although cardiopulmonary fitness is affected by physiological heredity, age, gender, and lifestyle, physical activity with different intensities is an important factor affecting cardiopulmonary fitness.

Studies have shown that walking intervention lasting for 12 weeks can improve cardiopulmonary health and obesity-related cardiac metabolic risk by reducing resting heart rate, regulating blood lipid profile, and inducing changes in fat factors in obese adolescents[15]. Adolescents with normal BMI tend to show better cardiopulmonary fitness levels than obese and overweight children, and excessive sedentary behavior is bound to reduce physical activity[16]. Cardiopulmonary fitness is negatively correlated with BMI, body fat, and metabolic syndrome in the future, but the correlation between cardiopulmonary fitness and blood pressure, lipid metabolism, and glucose homeostasis is not strong[17].The improvement of body composition and reduction of visceral fat in obese adolescents will help reduce the risk of obesity and overweight in adolescence[18]. In short, reduce sedentary behavior and screen time, actively participate in physical activities, and develop a healthy lifestyle. In adolescence, keep cardiopulmonary fitness at a high value, effectively maintain good cardiovascular status, and reduce the risk of cardiovascular disease in adulthood.

The improvement of cardiopulmonary fitness also affects adolescents' mental health and brain intelligence. The study found that the improvement of cardiopulmonary fitness level has positive effects on adolescents' academic mood, self-efficacy, depression, self-confidence, and other mental health factors[19]. In addition, cardiopulmonary fitness also plays an important intermediary role between physical activity improving cognitive function and academic performance[20], increasing the level of neurotransmitters and regulating the changes of neurotrophic factors, inducing the improvement of brain regions related to cognition, especially executive function, and reflecting its positive benefits in high cognitive task situations such as working memory and inhibition control[21]. Thus, cardiopulmonary fitness plays an important regulatory role in the positive development and physical and mental health of adolescents.

2.2 Physical activity and muscle fitness

Muscle fitness refers to the ability of the body to exert maximum force on external resistance (muscle strength) or repeatedly exert maximum force under sub-maximum load (muscle endurance)[13]. Muscle fitness is one of the important indicators of teenagers' physical health, which is directly related to skeletal muscle health and affects their growth and development. At the same time, it shows significant differences in age, gender, and other characteristics. Generally, teenagers' muscle strength increases linearly with age, and the increase in strength between 12 and 18 years old is more obvious than that before 12 years old[22].

Besides cardiopulmonary fitness affecting cardiovascular health, muscle fitness is closely related to the cardiovascular health index. A cross-sectional study found that grip strength was negatively correlated with cardiovascular disease risk, revealing a positive correlation between grip strength and cardiac metabolism and skeletal muscle[23]. Buchan et al. found that muscle fitness is associated with reduced risk associated with obesity and clustered cardiac metabolic variables in adolescents. Low muscle fitness level is the starting point of many chronic diseases, such as hypertension and diabetes[24]. Due to the down-regulation of lipoprotein lipase and the impairment of mitochondrial function, fatty acid oxidation is reduced, which affects cell metabolism and energy consumption, and ultimately leads to the development of cardiovascular disease[25]. Adolescents are a special group of hypertensive patients. Adolescent hypertension seriously affects their physical and mental health.

Chronic inflammation, increased obesity, and impaired autonomic nervous regulation of heart rate led to hypertension. The development of muscle fitness can be used as a protective factor against hypertension[26]. In addition, the lower muscle fitness level is an independent risk factor for adults suffering from chronic diseases. The muscle fitness level in adolescence can predict the health level in adulthood and reduce the incidence of chronic diseases[27]. It can be seen that muscle fitness has a positive significance in improving the health status of adolescents and preventing the occurrence of chronic diseases in late adulthood. Adolescence is a critical period for the development of intelligence and values, and the improvement of physical health is conducive to the improvement of adolescents' academic performance and cognitive function[28]. Muscle fitness optimizes the performance of working memory, improves the processing speed and accuracy of working memory tasks, and then affects academic performance[29], which may be related to physical activity reducing insulin resistance and improving skeletal muscle health.

3. Relationship between physical activity and disease status of adolescents

A large number of studies have reported the positive effects of regular physical activity on healthy physical fitness and revealed that the health promotion of adolescents can be improved by physical fitness indicators such as cardiopulmonary fitness and muscle fitness. At present, relevant studies have reported the relationship between physical activity and common diseases. Based on the acute and chronic adaptation of individuals to physical activity, it can reduce the occurrence of specific diseases and improve disease symptoms[6]. Physical activity-mediated health fitness indicators can be used as key indicators for evaluating and preventing common diseases and can predict physical activity patterns, physical fitness, and chronic disease status in later adulthood[30]. In addition, adolescents have a lower incidence of chronic diseases than adults and the elderly but are prone to obesity, respiratory diseases, cardiovascular risk, depression, and other diseases, However, there is little literature about health fitness and adolescent disease status. Therefore, based on previous research evidence, this paper discusses the prevention and control of physical activity on common diseases in adolescents and reveals the relationship between physical activity and obesity, respiratory diseases, depression, and other diseases.

3.1 Effect of physical activity on adolescent obesity

The rate of overweight or obesity in children and adolescents is increasing. Overweight obesity in children and adolescents and its harm to health have become one of the major public health problems in the world[31]. Obesity has many negative effects on the health of the body. Obese patients are prone to suffer from metabolic syndromes such as hypertension and epidemically and may be secondary to a series of diseases, including several endocrine diseases (such as hypothyroidism, hypercorrection, and growth hormone deficiency), central nervous system injury (i.e., hypothalamus-pituitary injury caused by surgery or trauma) and post malignant tumors (such as acute leukemia)[32], The phenomenon of weight stigma is more prominent among teenagers.

Weight stigma refers to a person being belittled by society because of being overweight or obese, including negative stereotypes such as personal laziness and lack of willpower to improve health, which will increase teenagers' overeating behavior, reduce physical activity, and then lead to a vicious circle of obesity, seriously affecting the development of teenagers' physical and mental health[33]. Therefore, effective prevention strategies must be put forward to solve the growing obesity problem of teenagers.

Although obesity is the result of the interaction of many factors, external factors are more important than genetic factors. There is a considerable correlation between physical activity and obesity[32]. Physical activity is a good means to regulate sensitive indicators such as lipid metabolism and body composition in obese adolescents. Studies have shown that walking 8300-11400 per day can effectively achieve the optimal lipid reduction efficiency of obese adolescents. At the same time, it has been revealed that there is a nonlinear dose-effect relationship between the daily steps of obese adolescents and the lipid reduction effect[34]. Six weeks of aerobic exercise reduced the triglycerides, blood lipids, fasting insulin levels, and insulin resistance index of obese adolescents. At the same time, after the intervention, push-ups, 1000-meter running, balance ability, and other physical qualities were significantly improved, and the body shape was better reshaped[35]. Obesity leads to an abnormal increase in visceral fat volume in adolescents, which leads to interleukin-6 and tumor necrosis factor (TNF-α). The release of proinflammatory factors such as insulin resistance can induce the occurrence of cardiovascular disease risk related to insulin resistance[36]. Moderate-intensity continuous training and high-intensity intermittent training not only promote the reduction of visceral fat, but also have positive significance in improving the cardiopulmonary fitness level of adolescents[18], but high-intensity intermittent training improves bone mineral density, muscle volume, and strength, and promotes the healthy development of adolescents[37], revealing the effective strategy and long-term mechanism of short-term and explosive exercise mode for the management of obese adolescents. In addition, aerobic exercise combined with resistance exercise can help reduce the metabolic risk factors of obesity in adolescents, and reduce the volume of visceral ectopic fat and inflammatory markers. At the same time, resistance exercise can help avoid muscle loss in overweight adolescents[38,39]. The research evidence is shown in Table 1.

Table 1 Research evidence of physical activity improving obesity

Author	Country	sample	Age	Type of physical activity	Research results
Zekai Chen et al 2022 [34]	China	48	10-17	Lasting for 4 weeks, sports training course (mainly running and jumping) walking after class.	When the daily steps were 8300-11400, the fat consumption reached the best. For every 1000 steps increased daily, the lean weight increased by 0.58kg and the skeletal muscle mass increased by 0.29kg.

Liying Pan et al 2022 [35]	China	50	13-19	Lasting for 6 weeks, 5 times/week, 60 minutes/time, Aerobic exercise (jogging, badminton, basketball, etc.).	Aerobic exercise improves the body composition of adolescents with moderate and severe obesity, improves basic physiological function and glucose and lipid metabolism, and effectively promotes the development of physical quality.
Ju Lian et al 2022 [37]	France	60	12-16	Lasting 16 weeks, 4 times/week, 60 minutes/time, The experimental group received strength training, and the control group received a power bicycle.	In the two training groups, the body mass index and fat percentage decreased, but the bone mineral density and muscle strength of the strength group were better than those of the continuous training group.
Lee et al, 2019 [38]	Korea	118	12-17	Lasting for 24 weeks, 3 times/week, 60 minutes/time, Aerobic exercise resistance exercise.	After the intervention, aerobic exercise combined with resistance exercise effectively improved insulin sensitivity and visceral fat volume of adolescents.
Shu Li et al 2023 [18]	China	60	10-12	For 12 weeks, 3 times a week, high-intensity interval training medium intensity continuous training.	The visceral fat area of the HIIT group was less than that before the intervention, and the effect was better than that of the moderate-intensity continuous training group.
Bharath et al 2018 [39]	America	40	13-15	Lasting for 12 weeks, 5 times/week, 50 minutes/time. Aerobic exercise resistance exercise.	The aerobic combined resistance effect reduced the body fat rate, weight, and waist circumference of obese adolescents, and significantly improved blood insulin, glucose, and insulin resistance parameters.

3.2 Impact of physical activity on respiratory diseases in adolescents

At present, respiratory disease is one of the global public health problems, which has brought a huge economic burden to families and society. According to the Research Report of the Global Center for Disease, as of 2017, the number of patients with chronic respiratory diseases was 545 million, mainly caused by chronic obstructive pulmonary disease and asthma[40]. Most of the patients with chronic obstructive pulmonary disease were elderly patients, while asthma was a common respiratory disease in children and adolescents, accompanied by symptoms such as dyspnea, shortness of breath, wheezing, cough, and acute attack[41]. Exposure to worsening air pollution can easily lead to respiratory diseases, and adolescents are more vulnerable than adults [42]. Therefore, as the key exposure window of respiratory tract-related diseases, adolescents must be paid attention.

It has become a consensus that exercise is the cause of asthma, but with the relevant pathological studies at home and abroad, physical activity has a positive effect on lung function and the prevention and management of asthma[43]. Because of the fear that children with asthma will induce acute asthma attacks and be prevented from exercising, on the contrary, moderate breathing exercises and inspiratory muscle training can not only improve the strength of inspiratory muscles, relieve dyspnea, reduce the frequency of acute attacks, improve the quality of life, but also improve their lung function and physical condition[44]. Appropriate aerobic exercise is beneficial to the condition control and life learning of patients with asthma in remission, and will not aggravate the condition of patients with asthma[45]. In clinical practice, physical activity can be used as an auxiliary treatment for patients with respiratory diseases, and lung rehabilitation is one of the main aspects of medical rehabilitation[46]. Physical fitness mediated by physical activity has a strong correlation with lung function, especially cardiopulmonary fitness[47]. By reducing the level of pro-inflammatory factors and increasing the level of anti-inflammatory factors, it can promote airway remodeling and anti-inflammatory[41]. At the same time, it can regulate immune function, provide better asthma control, improve the quality of life, and finally prevent the deterioration of asthma[48]. A follow-up study found that healthy physical fitness in childhood may have a beneficial impact on the reduction of the risk of respiratory diseases in adulthood. Adolescents who lack physical activity have a lower level of lung function and a higher risk of asthma[49]. During physical activities, strong inhalation and exhalation will strengthen respiratory muscles, increase lung perfusion and surfactant release, and then improve lung capacity, thereby improving cardiopulmonary fitness and preventing asthma as much as possible[50]. The lack of physical activity leads to the decline of exercise ability of children with asthma, which seriously affects their growth and development, recovery treatment, and quality of life, moderate-intensity aerobic exercise is a good means to improve such problems in clinical non-drug treatment[51]. In addition, Winn and other scholars jointly conducted high-intensity intermittent training for healthy adolescents and adolescents with asthma[52]. During the six-month intervention cycle, they had good tolerance and compliance to high-intensity intermittent training, regardless of whether they had a history of asthma, which is the key to maintaining good health and fitness in adolescents and improving asthma. However, some studies believe that it is not clear whether physical activity can effectively reduce the incidence of acute respiratory tract infection[53].

But on the whole, physical activity not only promotes physical health but also has a positive effect on improving chronic respiratory diseases such as asthma. The research evidence is shown in Table 2.

Table 2 Research evidence of physical activity improving respiratory diseases

Author	Country	sample	Age	Type of physical activity	Research results
Liao PC et al 2019 [48]	China	57	6-12 years old	Lasting for 12 weeks, twice a week, 60 minutes a time, Taijiquan.	12 weeks of TCC training can improve lung function, regulate immune function, provide better asthma control, improve the quality of life, and ultimately prevent the deterioration of asthma.
Mensink et al 2022 [50]	Netherlands	4854	13 years old	Daily physical activities.	The lower level of cardiopulmonary health and physical activity in adolescents indicates lower lung function and a higher risk of asthma.
Yongqiang Tan et al 2019 [45]	China	63	6-11 years old	Lasting for 48 weeks, 3 times/week, 30 minutes/time. Small and medium intensity aerobic exercise.	The days of absenteeism and the number of recurrences of infection in the exercise group were significantly less than those in the nonexercise group.
Qiong Chen et al 2020 [51]	China	40	8-14 years old	Lasting for 12 weeks, 2 times/week, 30 minutes/time, Moderate-intensity aerobic exercise.	The exercise ability and quality of life index of the exercise group were higher than those of the control group, which improved the exercise ability and quality of life of asthmatic children.
Winn et al 2019 [52]	Britain	616	11-14 years old	Lasting for 24 weeks, 3 times/week, 30 minutes/time. High-intensity interval training (push-ups,	High-intensity interval training can improve the aerobic fitness of teenagers and maintain BMI. Asthma patients are well-tolerated and show

				Bobbie jumps, variable speed running)	similar aerobic fitness to healthy peers.

3.3 Effect of physical activity on cardiovascular disease in adolescents

Individual cardiovascular disease may be caused by the long-term disorder of the regulatory system, which has become one of the main causes of adult disease and death in the world. Although it often occurs in the late stage of adulthood, the incidence of cardiovascular disease in adolescents is on the rise year by year. It is a chronic noncommunicable disease caused by a variety of causes, and its disease types mainly include hypertension, hyperlipidemia, atherosclerosis, coronary heart disease, ischemic heart disease, chronic rheumatic heart disease, etc., which are mainly affected by obesity, blood lipids, blood pressure, bad lifestyle, genetics and other related factors[54]. It is worth noting that the risk factors of cardiovascular disease begin in adolescence and slowly progress to disease. The frequent occurrence of hypertension and high weight development in adolescence will predict the risk of secondary cardiovascular disease in adulthood[55].

Research shows that obesity caused by bad living habits is an important factor for adolescents to cause hypertension, and a reasonable diet combined with aerobic exercise is an effective means to improve blood pressure and body mass index of obese adolescents, which reduces the incidence of cardiovascular disease to a certain extent[56]. In addition, changes in arterial stiffness are directly associated with an increased risk of atherosclerosis and heart disease. Aerobic combined resistance exercise can enhance endothelial function by improving the angiotensin aldosterone system, oxidative stress, and inflammatory response[57]. Physical exercise program can reduce blood pressure, arterial stiffness, and abdominal fat, increase cardiopulmonary health, and delay arterial wall remodeling in pre-adolescent obese children[58]. In addition, the reduction of plasma glucose, insulin, adiponectin and leptin levels is the positive effect of aerobic combined resistance exercise in alleviating arteriosclerosis[39], thereby reducing the risk of cardiovascular disease in adolescents. After rope skipping exercise, the active substances such as nitric oxide and endothelin-1 (ET-1) in blood vessels are fully utilized to regulate the internal resistance of blood vessels, thereby reducing hypertension and arterial stiffness[59]. The research evidence is shown in Table 3.

Table 3 Research evidence of physical activity improving cardiovascular disease

Author	Country	sample	Age	Type of physical activity	Research results
Guoliang Zhaoet al 2016 [56]	China	93	15 years old	Lasting for 4 weeks, 5 times a week, 60 minutes/time. Aerobic exercise (walking, jogging, aerobics, etc.).	Under the condition of a reasonable diet combined with aerobic exercise, the blood pressure and body mass index of obese adolescents with hypertension will be significantly improved,

					and their blood pressure and body mass index will be controlled.
Donghui Tang et al 2017 [57]	China	32	10-15 years old	Lasting for 6 weeks, 5 times/week, 80 minutes/time. Aerobic combined resistance exercise.	Serum MDA, 8-isoprostane, CRP, and TNF in adolescents after intervention- α The level was significantly reduced, the antioxidant stress and anti-inflammatory disease were improved, and the vascular endothelial function was improved.
Bharath et al 2018 [39]	America	40	13-15 years old	Lasting for 12 weeks, 5 times/week, 50 minutes/time. Aerobic exercise+resistance exercise.	Aerobic combined anti-resistance effect reduces the body fat rate, blood insulin, glucose, and insulin resistance levels of obese adolescents, thereby improving metabolic health and cardiovascular health.
Sung KD et al 2019 [59]	Korea	40	14-16 years old	Lasting for 12 weeks, 5 times/week, 50 minutes/time. rope skipping	After the intervention, the levels of nitrate and nitrite in the rope-skipping group were significantly increased compared with those in the control group. The vascular function was improved by improving the bioavailability of vascular activity in pre-hypertensive adolescents,
Farpour et al 2009 [58]	Switzerland	44	6-11 years old	Lasting for 12 weeks, 5 times/week, 60 minutes/time. Aerobic exercise (fast walking, running, ball games)	Aerobic exercise can significantly reduce systemic blood pressure, BMI score, overall obesity, and abdominal obesity, and increase fat-free weight and cardiopulmonary health

					of obese pre-adolescent children.

3.4 Impact of physical activity on adolescent mental illness

Health not only refers to being strong and healthy without illness but also needs to be in a good state in terms of psychological status and social adaptation. However, mental illness is an important factor affecting the healthy growth of teenagers, including depression, autism, and other diseases[60]. Patients often show negative emotions such as pessimism, pessimism, self-isolation, and even self-mutilation or suicide[61], As a critical period of high incidence of mental illness in children and adolescents, early prevention and intervention is particularly important.

In addition to common drug therapy, psychological intervention, and other therapies, nondrug therapy such as exercise intervention is considered a potential treatment for various mental diseases and has a positive impact on mental health. Depression is a common mental and psychological disorder, especially an emotional state. Jaworska and other scholars recruited 12 adolescent patients with depression who had not yet taken medicine for 12 weeks of aerobic exercise intervention and found that the subjects not only increased the maximum oxygen uptake but also effectively improved the depressive symptoms[62]. In addition, based on the lack of exercise motivation of patients with severe depression, vibration training is introduced into conventional treatment to conduct passive whole-body muscle stimulation. Vibration training intervention four times a week seems to be sufficient to achieve an antidepressant effect, improve their pessimism, and promote positive progress[63]. It is worth noting that there are differences and continuity in the effect of different intensities of exercise on the improvement of depression. Hughes found that the depression relief effect of high-intensity aerobic exercise was more obvious and efficient than that of low-intensity stretching exercise, but the effect of the two intervention methods was not different after 12 weeks and continued to 56 weeks[64]. It can be seen that physical activity based on aerobic exercise is an effective treatment to improve the symptoms of depression in adolescents. In daily life, it is natural to interact and communicate with people. However, interaction and communication are some of the problems that need to be improved for people with autism, including difficulties in social interaction, abnormal communication, narrow interests, and slow development of motor skills[65]. Motor development is an important evaluation index for the development of early motor function in children. Motor dysfunction in patients with autism is closely related to self-confidence, social development, and health promotion[60]. Research shows that the 10-week exercise intervention has effectively developed the basic motor skills of autistic children, obtained more opportunities for social interaction in sports activities, and then improved their core symptoms such as self-confidence, self-control, and social communication defects[66]. Shang Jian and other scholars intervened in single-person or group sports with multiple people at different recovery stages of patients with autism, involving functions such as game activities, treatment intervention, and attention guidance. They found that stage recovery training improved the exercise ability, cognitive ability, self-care ability, and social ability of patients with autism[67]. In addition, it is also found in the regular movement of people and horses that equestrian sports not only play a role in alleviating autism but also improve the balance ability, flexibility, strength, and other qualities of teenagers, which is of great significance to the health promotion and growth and development of patients with autism[68].

On the whole, physical activities promote the development of physical and mental health of adolescents and help reduce the risk of mental illness. The research evidence is shown in Table 4.

Table 4 Research evidence of physical activity improving mental illness

Author	Country	sample	Age	Type of physical activity	Research results
Jaworska et al 2019 [62]	Canada	12	10-15	Lasting for 12 weeks, 3 times/week,45 minutes/time. Aerobic exercise.	After the intervention, the maximum oxygen uptake increased, while the depression score decreased, and the exercise compliance and satisfaction were very high.
Wunram et al 2018 [63]	Germany	32	12-18	Lasting for 6 weeks, 4 times/week, 30 minutes/time. Vibration training.	Vibration training can improve cardiovascular function and depression in patients with severe depression, but it can not explain the correlation effect between them.
Hughes et al 2013 [64]	America	40	12-18	Lasting for 24 weeks, 7 times/week, 40 minutes/time. Aerobic exercise.	After exercise intervention, compared with the early antidepressant control trial, aerobic exercise and stretching exercise significantly reduced the symptoms of depression, with higher clinical response and remission rate.
Liangshan Dong et al 2021 [66]	China	40	14-16	Lasting for 12 weeks, 3 times/week, 60 minutes/time. Aerobic exercise (situational substitution).	After the intervention training, the basic motor skills of patients with autism have been significantly improved, and the social communication ability has been significantly improved in the classroom.
Jian Shang et al 2009 [67]	China	59	5-10	Lasting for 12 weeks, 5 times/week, 60 minutes/time. Aerobic exercise (running, jumping, games, etc.)	After the intervention, the overall autism score of the patients decreased, indicating that stage recovery training can effectively alleviate the overall symptoms of children with autism spectrum disorders.

Yaofang Zhang et al 2022 [68]	China	2	5	Lasting for 10 weeks, 5 times/week, 60 minutes/time. Equestrian sport.	After the intervention of equestrian exercise, autistic children's balance, strength, and flexibility were significantly improved compared with those before the intervention.

4. Impact of physical activity on medical expenditure

Scientific and technological life has relatively reduced the opportunities for the public to engage in physical activities, and most people live statically, resulting in a serious lack of physical activity, which leads to many diseases. Not only does the government bear a lot of pressure on medical resources every year, but patients and their families incur a large amount of medical expenses due to diseases. As a result, the medical expenses caused by diseases are a huge burden on families and society[69].

The study found that when people participated in low, medium, and high physical activity intensity, the total medical expenditure decreased by 22.4%, 40.4%, and 62.5% respectively, revealing that physical activity intensity was negatively correlated with medical expenditure[69]. Among the 5140 overweight and obese patients with diabetes, the medical care and prescription drug use rate of the exercise group was lower than that of the nonexercised group, and the medical expenses of the exercise group were 5651 dollars lower than that of the nonexercised group. After controlling the socio-economic and health-related variables, regular exercise reduced the total medical care costs by 22.1% and the possibility of hospitalization by 28% [70]. Wang et al. (2016) found that the medical expenses of patients with cardiovascular disease were higher, and the total medical expenses of patients with cardiovascular disease were 1.5 billion yuan, of which 300million yuan (41.3%) was related to inactivity[71]. Patients with hypertension or cardiovascular disease regularly participate in moderate intensity physical activity. It is found that moderate physical activity can significantly reduce medical expenditure by about 20% (14-28%) compared with those without enough exercise. At the same time, it can reduce the use of medical resources such as hospitalization, emergency, outpatient, and the purchase of prescription drugs[72]. Carlson et al. Also pointed out that about 12.5% of medical expenditure in the United States is related to insufficient physical activity. After calculating the expenditure of health care, it was found that people who do not exercise spend $1437 more than those who have enough physical activity, and those who have insufficient physical activity spend $713 more than those who have enough physical activity[73]. In addition, the annual overall healthcare costs and heart disease-related healthcare costs of the elderly with good cardiopulmonary function were significantly lower than those with poor cardiopulmonary function, with a difference of about 50% and 53% respectively[74]. It can be seen that a moderate increase in exercise or participation in physical fitness programs will not only have a positive impact on the recovery of the disease but also greatly reduce the huge proportion of medical expenditure.

However, most of the above studies are about the research evidence of adults' physical activity and medical expenses, and there are few research data related to teenagers.

At present, there are many researches on Teenagers research evidence focusing on disease status, health fitness, health promotion, and so on, and increasing physical activity, and a few studies have discussed whether establishing exercise habits and regular exercise can reduce the medical burden. Oosterhoff based on the sports activities and lifestyle investment of the school, discussed the lifelong cost-effectiveness for teenagers, including the expenses caused by overweight or obesity-related chronic diseases, quality of life, medical care, etc., and found that the basic standard of 2000 euros invested in school was far lower than the medical expenses caused by diseases, and a healthy lifestyle was a cost-effective and fair strategy for teenagers[75]. Physical activity is a more economical intervention method than medication and psychotherapy. School sports activities help teenagers control weight, reduce the incidence of obesity in teenagers, and in the long run, reduce obesity complications and medical care expenditure[76]. Therefore, it is suggested that we should combine increasing physical activity with health promotion, and take exercise prescription as a potential medical treatment, to effectively alleviate the high medical costs of diseases. The research evidence is shown in Table 5.

Table 5 Research evidence of physical activity reducing medical expenditure

Author	Country	sample	Research object	Type of physical activity	Research results
Wu et al 2019 [70]	America	5140	Diabetic obese patients	Moderate-intensity aerobic exercise.	Among the 5140 overweight and obese adults with diabetes, the use rate of medical care and prescription drugs in the regular exercise group was lower than that in the nonexercised group ($p<0.001$), and the total unadjusted medical expenses in the exercise group were $5651 lower than that in the nonexercised group ($p<0.001$).
Valero et al 2016 [72]	America	26239	Patients with cardiovascular disease	Moderate-intensity aerobic exercise.	Moderate-intensity physical activity is associated with significantly reduced health care expenditure, which has a positive effect on reducing health care expenditure regardless of whether the individual has cardiovascular disease.
Carlson et al 2015 [73]	America	57987	youngsters	Physical activities of different intensities.	11.1% of the total expenditure on health care was related to physical activity deficiency, and 8.7% of the total expenditure on health care was related to physical activity deficiency. If Daiyu exercises for at least 150 minutes a week, it can effectively reduce the overall medical expenses by about 10%, including medical care expenses for emergency, outpatient,

					hospitalization, and receiving prescription drugs.
Oosterhoff et al 2020[75]	Netherlands	3352	youngsters	Games, aerobics, etc.	From a social point of view, compared with the control school, the benefit of school intervention is 19734 euros, the possibility of cost-effectiveness is 50%, and has a beneficial equity impact, thereby reducing the medical expenses of adult diseases.
Veugelers et al 2005[76]	Britain	5200	Obese adolescents	Mainly aerobic exercise.	School sports activities are effective in preventing obesity in children, which will reduce the incidence of obesity in children and adolescents, and reduce complications and medical care expenditure.

5. Conclusions and Suggestions

5.1 Conclusion

The transformation from the treatment of the disease to the treatment of the disease before it is the thinking of facing risks and challenges in the process of modernization. At the same time, it is also the fundamental reflection of people's recognition of sports value and their own needs. Therefore, from the perspective of the value of physical activity, regular physical activity can improve the important indicators of health promotion, such as cardiopulmonary fitness and muscle fitness, and delay or reduce the occurrence of obesity, respiratory disease, cardiovascular disease, and psychological disease, to improve the health status of teenagers. From the perspective of the economic value of national fitness, regular and appropriate physical activity is an effective way to reduce the use of medical resources and medical expenses. However, there are few studies on adolescent physical activity and medical expenses, and such issues will be discussed sustainably in the future.

5.2 Suggestions

Moderate physical activity can improve the level of health and physical fitness, and significantly reduce medical expenditure and resource use. In addition, moderate physical activity can still reduce health care expenditure even with disease. Therefore, it is suggested that when clinicians or school-related personnel think about the effective use of health insurance or long-term care plans, they should incorporate the strategy of regular and appropriate physical activities into the health management of teenagers.

1）Create a multidimensional health promotion mode of physical intervention, psychological counseling, and nutritional diet. The health problems of teenagers involves many aspects. The risk factors of diseases are closely related to physical activity, environmental support, and nutritional health care. Therefore, according to the characteristics of teenagers' physical and mental development, we should actively carry out sports intervention, nutritional diet regulation, and mental health counseling to promote the positive development of teenagers in many ways.

2）Form exercise prescription design and health management based on modern medical technology. According to the concept of exercise is beneficial, under the guidance of doctors and the control of exercise intensity and physical condition by relying on various wearable devices, physical activities are included as part of the treatment for patients with special adolescent diseases , to guide patients to develop regular exercise, gradually improve their physical fitness, and improve disease conditions. At the same time, healthy teenagers also need to actively exercise to enhance their physique, take protective measures to prevent diseases, and reduce the risk factors of diseases.

3）Establish the linkage development mechanism of school, family, and community. School physical education is the main front for the health promotion of teenagers in China. Schools can carry out rich sports activities to improve students' physical health, and implement health promotion measures such as physical activity evaluation, physical fitness, and disease risk assessment. Family sports companionship is an important part of teenagers' interest in sports, and increasing family participation in leisure sports activities also requires family.

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Author Contributions

This article is written by Yi Yang and Jiong Luo, Luo Jiong is the manager of the project and has approved the author and corresponding author of this study. All authors have readand agreed with the published versionof the manuscript.

Authorship declaration

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Data Availability Statement

The data presented in this study is available upon request from the corresponding author.

Conflict of interest

The authors deny any conflict of interest

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