Overview of Research on Skeletal System And The Related Functional Structures Based on Evolutionary Medicine

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The combination of evolutionary medicine and biomedicine is a breakthrough development direction in the field of medical research in recent years, and the connection between the occurrence and development of diseases of the skeletal system and its related functional structures and biological evolution has been a topic of discussion and research. In this paper, we systematically summarize the relevant domestic and foreign literature in this field over the past few years, from the theory of Darwinian medicine, clarify the research ideas of domestic and foreign scholars on the combination of diseases of the skeletal system and evolutionary medicine, review the mechanisms of related diseases that have been revealed, clarify the unique ideas of the current research methods and theories of scholars in this field that are different from traditional science, and then propose relevant reference theories for the clinical diagnosis and treatment of diseases of the skeletal system. We will present the relevant referential theories for the clinical management of skeletal system diseases to provide reference for further research.

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Medicine is a product of the development of biology to a certain stage, and has gone through three stages: traditional medicine, laboratory medicine and modern systemic medicine. At the present stage, the incidence of diseases of the skeletal system has increased, the age span has increased, and the number of diseases has become more diverse, which has caused scholars at home and abroad to think about the causes of this situation. However, modern medicine does not reveal medical problems from the theory of biological evolution, but only proximate explanations of disease production, which leads to more and more microscopic studies and more mysteries and problems. Evolutionary medicine, on the other hand, has been exploring the emergence and evolution of diseases from the perspective of biological evolution by providing a final causal explanation for the emergence of diseases and complementing the proximate explanations of modern medicine. The purpose of this paper is to summarize the unique ideas of current research methods and theories different from those of traditional science that have been proposed by scholars at home and abroad in recent years under the guidance of evolutionary medicine, so as to explain the causes of the emergence and evolution of diseases of the skeletal system that are difficult to be explained by modern medicine, and then to provide reference for further in-depth research on diseases of the skeletal system in clinical practice and to propose relevant reference theories for diagnosis and treatment.

PROGRESS IN THE STUDY OF EVOLUTIONARY MEDICINE

1.1 Progress In The Study Of The Main Ideas Of Biological Evolution

On November 24, 1959, Darwin published his

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epoch-making work "On the Origin of Species", which put forward the theory of biological evolution and made the concept of "evolution" the basic idea of the whole natural science community, and announced the return of human beings to the natural world from the position of transcending it.process of evolutionary development under the combined effect of natural selection with heredity and mutation, resulting in the creation of species and the elimination of species. It is simply described as: survival of the fittest by natural selection. As stated by Nice & Williams[3], "any adaptation and benefit may come at a high price to health".

In recent years, along with the development of genetics and molecular biology, the doctrine of integrative evolution and the doctrine of neutral selection have been formed on the basis of evolutionary theory, both of which are powerful supplements to Darwinian evolutionary theory. The integrated evolutionary theory completes the shortcomings of Darwin's evolutionary theory from the point that the population is the main body of evolution, and the large number of individuals in the population can play the role of stable inheritance, while a small number of individuals does not guarantee the stable inheritance of traits. The neutral selection theory of molecular evolution suggests that the evolution of organisms is mainly the result of random "genetic drift" of neutral mutations in natural populations[4].

The Research Progress Of The Main Ideas Of Evolutionary Medicine

The museum tradition of evolution and the medical tradition of physiology are two long-standing separate traditions in the life sciences. In the general trend of combining proximate and ultimate cause biology, in 1991, they also slowly showed signs of mutual integration. A new concept of evolutionary medicine (EM), sometimes called Darwinian medicine (DM) came into being[5]. evolutionary medicine is a biomedical concept that has received more and more attention in recent years. It is the subject of some textbooks [6-7], and it is also a major scientific evolutionary medicine subject [8]. evolutionary medicine applies the concept of natural evolution to human morphology, and physiology. It uses the theory of evolution to explain diseases and medical problem evolutionary medicines from four-dimensional time and space (three-dimensional space + time factors), and to study the causes of human diseases and disease characteristics from an evolutionary perspective (genetics, environment, behavior, pathogens, etc.) . It also uses evolutionary principles to explain the response of pathogenic microorganisms to changes in the human body [9-13]. Researching diseases from the perspective of species rather than individuals can better understand the current human disease Etiology.

The theoretical basis of evolutionary medicine is the theory of biological evolution, with natural selection at its core. Evolutionary medicine develops the concept of natural selection and explores the ultimate causes of disease (evolutionary causes). It is because of the imperfect nature of natural, selection that disease will accompany the entire process of biological evolution and cannot be completely avoided. The new ideas of Darwinian medicine extend to all aspects of medicine, and we can roughly divide its research into four levels: (1) The origin and adaptive function of human physiological processes; (2) Hypothetical dysfunction diseases in which the adaptive use of human structure does not match modern lifestyles; (3) The evolutionary mechanism of modern host-pathogen interaction; (4)) Genetic dynamics of the population [14].

PROGRESS IN THE STUDY OF SKELETAL SYSTEM IN EVOLUTIONARY MEDICINE

The form, structure and function of the human body are determined by genetics and functional requirements. The theory of biological evolution considers the role of natural selection as the intrinsic motive force of evolution. As mentioned by Shouliang Chen [15], if a certain variation is beneficial to the survival of an organism, individuals with this favorable variant shape will have more chances of survival, and these favorable variations gradually accumulate in the offspring through heredity, allowing an original species to evolve into a new one.

Progress In The Study Of Human Evolutionary History

The key points of evolution are over breeding, struggle for survival, genetic mutation, natural selection, and the result is survival of the fittest. We look at how monkeys became human from the above key points. As some monkeys overpopulated, struggled for survival, genetic mutation, and evolved into human-like super monkeys through natural selection, they jumped down from trees and gradually stepped into the human journey by walking upright [16].

Some scholars have classified the origin of humans into five stages starting from vertebrates: vertebrates → mammals → primates → super family of apes → humans [17].

The evolution of bone and joints in biology: marine mollusks → exoskeletons → animals with both endoskeletons → emergence of skeletal muscles → vertebrates (later evolved synovial joints and limbs) → marine vertebrates on the continents 400 million years ago → terrestrial reptiles → higher mammals (e.g. dogs, horses, lions, etc.) → primates (various monkeys) → simian superfamilies (gibbons, orangutans, gorillas and humans) [18].

From the process of bone and joint generation and evolution in the biological world, we can observe that the evolution of organisms from lower to higher levels is first manifested in the emergence of bones, followed by the occurrence and development of joints. The important demarcation point for organisms to move from lower to higher levels is the emergence of the spine, which allows animals to move from passive feeding to active predation. The evolution of morphology, structure and function in higher mammals is marked by the differentiation of the lumbar and cervical vertebrae, followed by the evolution of the central nervous pathway. The complex and flexible living behavior and locomotion of animal bones and joints facilitated the rapid development of the brain and eventually the evolution of the upright walking human [19].

Research Progress On The Evolution Of Human Skeletal System

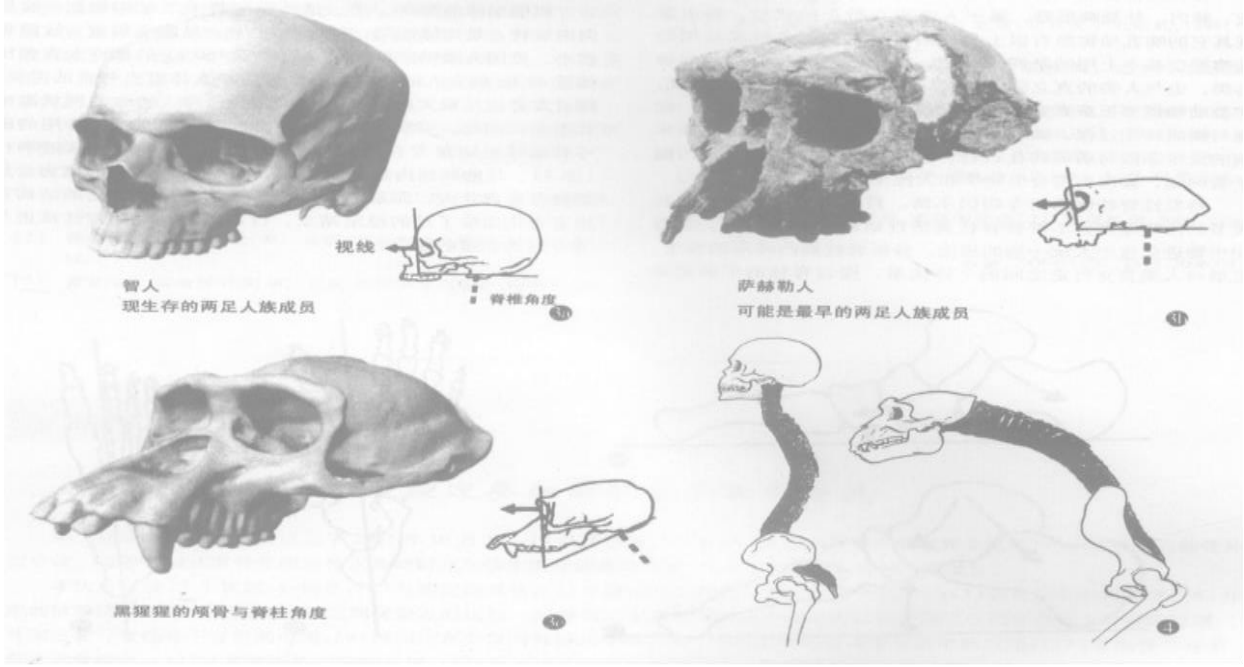
"Walking upright" is the mainstream view of human evolutionary process that distinguishes apes from humans, and the fundamental characteristic of humans, which facilitates the manufacture and use of tools and brings changes to human life behavior and locomotion [20]. The structural changes and functional upgrades in the organs of the skeletal system are based on the accumulation of generations of specific adaptations to the natural environment, with minor variations or mutations in individuals, which is the cumulative evolution of endogenous factors [21].

Because human arms no longer exercise functions such as climbing, humans are able to stand fully erect. The emergence of an upright walking posture of the spine in apes and monkeys in trees may have been a preparation for upright walking [22]. Upright walking had many benefits for human evolution, so in order to walk upright humans had to undergo corresponding changes in body form, structure and function [23]. In order to support the weight of the body, resist the earth's gravity, and cushion the impact stresses caused by walking upright, the total number of human muscles and joints increased to approximately 639 muscles, 282 joints, and numerous regularly distributed ligaments throughout the body. In addition, the vertebrae and joints of the limbs have become larger, and the feet have evolved arches, allowing the human body to reach the pinnacle of fine skeletal, balance and flexibility of higher animals [24].

Progress in the study of human spine evolution

In the history of evolution, the watershed between lower and higher organisms is the vertebrate, the birth of which laid the foundation for the emergence of humans. All mammals have seven cervical vertebrae, and the human lumbar vertebrae were reduced from six to seven in other mammals to five, and walking upright caused the human sacral vertebrae to fuse together. The spine acts as a weight-bearing column as a result of upright walking in humans. The spine evolved into an S-shaped curve to help support our heads, balance the weight above the hips and lower limbs, and maintain the body's balance and labor-saving bipedal movement. Each of the 33 bones that make up the human spine has another 6 joints, and rotation in 6 different directions can create 200 million permutations of different rotational directions, any of which may cause physical discomfort [24-26]. The cervical and lumbar curvatures, the formation of tower-shaped spinal vertebrae, the arrangement of vertebral epiphyseal rings and functional adaptations, and the arrangement of vertebral curvatures and intervertebral spaces are all mutually influential and complementary. From the point of view of biological evolution, the above is part of the human spinal structure is randomly formed by the development of energy. The remaining structures are related to both functional influences and genes [27] (Figure 1).

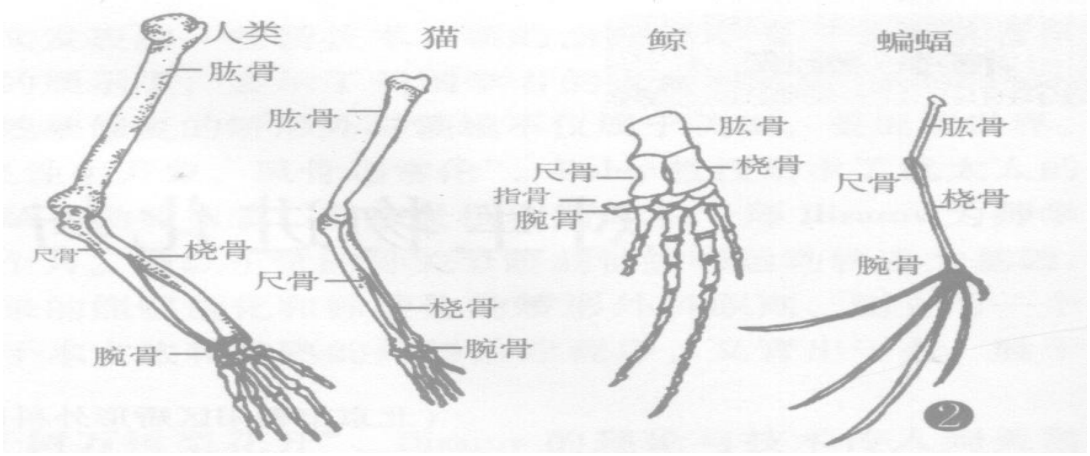
Figure 1. Comparison of cranial and spinal structures between humans and chimpanzees: The human spine is progressively stronger from the cervical to the lumbar spine, with an "S" curve in the sagittal position, while the chimpanzee spine is stronger in the cervical than in the lumbar spine, with an arch-shaped curve [24]



Progress of research on the evolution of human hands

The free movement and complete liberation of the two hands is the most unique difference between humans and other species in terms of life behavior and movement patterns. Of the more than 250 primate species currently living on Earth, gorillas and chimpanzees are the closest in blood to humans. The genetic similarity between humans and chimpanzees is 98.87%, much smaller than the genetic differences between chimpanzees and other primates [28]. However, the forepaws of human and chimpanzee are still very different. The evolution of the human hand can be demonstrated from the comparative anatomy of human forelimbs with different species of mammals. The evolution from primate forepaws to human hands may be due to the gradual changes in the morphology, structure and function of the upper limbs in the arboreal survival of primates such as climbing and picking, which facilitated the complex regulation and flexible movement of the corresponding nervous system. In order to better adapt to the changes in the natural environment to survive on the ground, apes have longer legs and shorter arms to support irregular semi-erect or fully erect walking. This freed up the forelimbs so that apes could feed with the assistance of the forelimbs and master warm behaviors such as petting, hugging, and carrying young children on their arms, all increasing the intrinsic motivational need for the forepaws to evolve into human hands (Figure 2) 24. The largest area occupied by the functional representative areas of the human cerebral cortex is the tongue and hand in. Brain science studies have found [28] that the hand prompts a significant increase in cerebral blood flow when performing fine movements such as playing the piano, which proves that language formation and hand movements prompt the development of the human brain and that human mental activity is necessarily linked to fine movements of the hand.

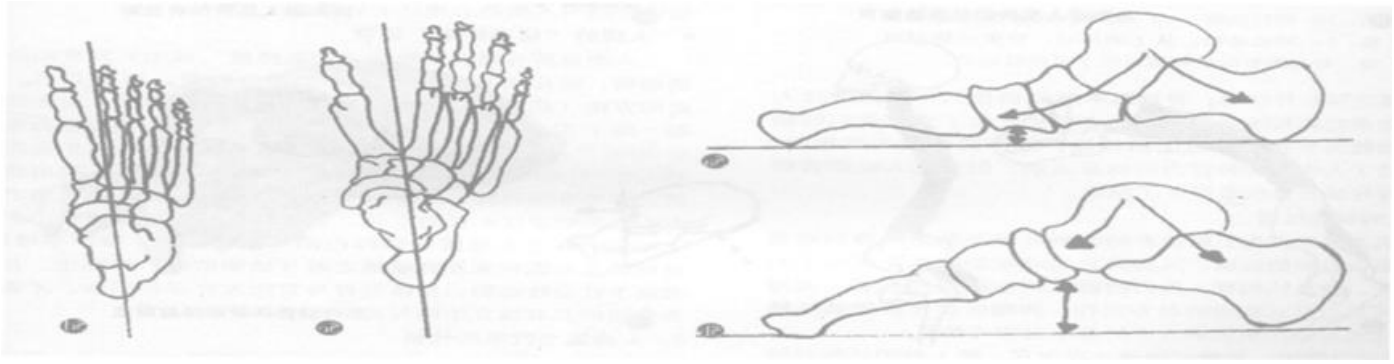
Figure 2. Comparison of the structure of the forelimbs of different species of mammals: the mammalian forelimbs have undergone changes due to selection and adaptation, and the homologous skeletal composition of humans, cats, whales, and bats have taken on the specific functions of their respective species, but all have five toe (finger) bones (from Ernst Mayr, What is Evolution, p. 25) [24]



Progress in the evolutionary study of the human foot

The arboreal-living monkeys that cannot walk upright have inwardly rotated forefeet, depressed inner foot edges and raised outer edges, non-weight-bearing heels, and small heel bones [29]. During the evolution of humans, the morphology and structure of the human foot changed to accommodate the function of standing, walking, running, and jumping in a stable manner in order to accommodate upright walking. Compared to monkeys, the human heel bone developed into the largest bone of the foot, and the cortical bone is thinner, and there are many loose reticular spongy bones, so that the heel bone can reduce the shock when landing on the ground. The dorsiflexion-extension muscle force of the foot is significantly smaller than the plantarflexion-inversion muscle force of the foot, and the intrinsic muscle of the foot atrophies and degenerates, while the ligaments of the foot evolve and become larger. Transverse and longitudinal arches with a spring effect are formed during the development of young children. The 1st toe is parallel to the 2nd toe close to parallel (Figure 3) [24].

Figure 3.Evolution of the human foot. 5a. Arboreal life with no longitudinal arch. 5b. Human walking upright, forming a well-developed heel of the foot arch. 5c. Arboreal life with the 1st metatarsal opening inwards. 5d. Human foot with 1st and 2nd metatarsals close together [24]



The Cost Of Human Skeletal System Evolution

The need for humans to walk upright to overcome their own unstable structures and the effects of the Earth's gravity has led to the fact that humans can suffer from evolutionary incompleteness diseases, which include skeletal dysfunction diseases, among others. Domestic and foreign scholars have analyzed human skeletal system diseases based on evolutionary medicine and medical environmental anomalies to explain human diseases due to evolutionary incompleteness, such as explaining why humans can develop low back pain, numerous human-specific diseases and potential problems in the hip, knee, ankle, and foot joints due to uprightness [30-32].

Professor Qin Sihe once proposed that humans must maintain body balance in order to complete all forms and postures of walking, but bipedal landing is not a particularly stable structure after all, which requires that all landing force parts of humans from head to foot must maintain a dynamic and relatively vertical line of gravity holding. A seemingly simple standing and walking movement requires the participation of numerous nerves, muscles, balance organs of the inner ear, and depth sensation. If any one of these components deviates, diseases related to skeletal dysfunction can arise. As the human neck has evolved to become thinner than that of other mammals of the same weight, this feature has also contributed to the vulnerability of humans to various types of cervical spondylosis and cervical muscle injury. The lumbar region became the weakest point after the evolution of spinal animals into humans, and it is also the hub of human movement. According to Professor Singh of Austin University [29], women with thin waists and fat hips exercise more flexibility and have higher fertility than women with thicker waists of the same age. The most attractive waist-to-hip ratio is between 0.16 and 0.17 [33]. An important indicator of the quality of life and health of the human individual is the movement that maintains the flexibility of the lumbar spine. These features of the evolution of the lumbar spine make chronic strain and acute sprains of the lumbar spine common, such as intervertebral disc disorders, unexplained lumbosacral pain, and lumbar muscle strain. Developmental hip dislocation, idiopathic scoliosis, internal and external knee deformities, and ischemic necrosis of the femoral head are among the skeletal dysfunctional diseases in humans, and no other mammal has been found to suffer from similar orthopedic diseases, so these diseases may be specifically the cost of the human evolutionary process. Because the structure of the human foot has not evolved perfectly to meet the needs of humans for long standing and high intensity walking, humans are more prone to foot and ankle disorders than other mammals [24].

There have been quite a few theories focusing on the role of mismatch in evolutionary medicine. Evolutionary mismatch refers to the disharmony between humans and the environment. Therefore, the theory believes that human genes and physiological structures have not had enough time To adapt to the modern lifestyle[33-35]. This incoordination may exacerbate many diseases. For example, modern diet is considered to be a common factor in increasing civilization diseases (such as cardiovascular disease, stroke, type 2 diabetes, high blood pressure, depression, cancer) [36]. Due to the reduction in chewing force during food processing, the size of the human jaw is reduced mechanically. Modern hunter-gatherers (especially those cultures with little exposure to Western lifestyles) maintain excellent and long-lasting insulin sensitivity, lower body mass index and fasting insulin plasma concentration than Westerners. In addition, humans are now exposed to a large amount of environmental pollution, and their sleep patterns have been changed due to the appearance of electric lights in the early 20th century, which is followed by interference with the physiological cycle[37].

Professor Chen Yusong mentioned that humans evolved to walk upright, which caused the body's hemodynamics and blood distribution to change, and the blood return to the lower extremities must be antagonized by gravity at the same time. When the force of this antagonism is relatively weak, the heart, brain, etc. then suffer from insufficient blood supply, while uprightness tends to lead to sympathetic nerve dysfunction in the human body, resulting in corresponding discomfort, i.e., "postural change" leads to the occurrence of upright intolerance [38-39].

3、The research progress of the Chinese medicine and evolutionary medicine

The traditional exercise methods in the Chinese medicine contain some ideas of evolutionary medicine, for example, the Five Animals imitates the movements and postures of five kinds of animals: tiger, deer, bear, ape and bird. For example, the ape's agility, the crane's ascent, the deer's return, the tiger's majesty, and the bear's mellowness. Although the activities and habits of these five animals are different, their athletic talents are consistent with the pursuit of physical fitness in humans [40]. Modern medical research has confirmed that imitating the various movement postures of the five animals makes up for the parts and joints that people cannot move in their daily lives and labor, improves the function of the body, and can make all joints and muscles of the whole body exercise, so as to achieve the purpose of unblocking meridians, harmonizing qi and blood, strengthening the body, and resisting external evil[41-42].

One scholar[42] conducted a 3-month study on the physical morphological indicators of middle-aged and elderly women who practiced the Five Animal Play. The study showed that after 3 months of Five Animal Play practice, the waist-to-hip ratio and waist circumference of the practitioners were significantly lower than before the exercise, blood pressure was decreased, grip strength and lung capacity were significantly improved, and root bone density tended to increase. The significant changes in several physical indicators of the practitioners suggest

that the Five Animal Play has a positive impact on the evolutionary incomplete diseases that developed during the evolution of man [43].

4、Problems in the study of evolutionary medicine

The imperfection of natural selection in evolutionary medicine is an important correction and complement to Darwin's doctrine, changing the view that natural selection brings organisms to perfection. The theoretical basis of evolutionary medicine is the eclectic nature of the functional or structural design of the evolutionary process, which is only a literary metaphor. At the same time this compromise is not causal, but merely phenomenal, and its theory of causality is yet another literary metaphor: evolution is a tinkerer (or blind watchmaker). The fragility of the foundations of Darwinian medical theory is undoubtedly a literary metaphor. Moreover, evolutionary medicine is clearly the result of the intersection of two disciplines: evolutionary biology and medicine, which also includes psychiatry, genetics, animal ecology, anatomy, and microbiology. Because of the emerging nature of evolutionary medicine, the theoretical foundations and technical aspects are still fragile. This, combined with the comprehensive nature of the content and the broadness of the objectives (to describe all aspects of medicine from an evolutionary point of view), has inevitably led to a loose structure and mixed content. Evolutionary medicine must maintain its ecological and holistic characteristics, so its therapeutic model in turn cannot fully follow modern medicine, the purpose of which is to treat, so the therapeutic effects of evolutionary medicine are not significant enough to meet the needs of medicine [44].

5. Outlook

Orthopedics, as a branch of medicine, focuses on the anatomy, physiology and pathology of the skeletal-muscular system. Drugs, surgery and physical methods are used to maintain and develop the normal form and function of this system. After reviewing the literature and outpatients, we have learned that there are many dysplastic disorders of the human movement system, such as developmental dysplasia of the hip (DDH), patellofemoral disorders of the small patella, and other disorders. But is such a large number of dysplastic disorders only related to skeletal and joint dysplasia? How are they related to the evolutionary insufficiency of human bones and joints? Evolutionary medicine uses evolutionary theory to explain diseases and medical problems from a four-dimensional space-time perspective (temporal factors + three-dimensional space) and studies diseases from a species rather than an individual perspective, and human beings have always been accompanied by diseases during the evolutionary process [45]. Evolutionary medicine suggests that for disease, we should try to explore its evolutionary historical causes, i.e., final causes [46]. Because it is more likely to answer the question of the causes of the occurrence of diseases of the skeletal system and the evolutionary pattern of diseases of the skeletal system.

As can be seen from the above discussion, evolutionary medicine explores the deeper (evolutionary) causes of disease and will provide the theoretical and practical basis for many aspects of modern medicine and facilitate its more rapid development. To date, evolutionary medicine has not had a significant impact on traditional medical education and practice, but interest in this theory is growing. We believe that evolutionary medicine will eventually be welcomed by the medical community for its ability to help people find deeper causes of disease and better treatments.

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