Advances in Research Methods of Pharmacodynamic Substances in Traditional Chinese Medicines and Their Application in the Teaching of Traditional Chinese Medicine Analysis

Jiangwei Tian*

China Pharmaceutical University, Nanjing 211198, Jiangsu Province, China

*Corresponding author: Jiangwei Tian, jwtcpu463@sina.com

Abstract: With the continuous progress of science and technology, the research methods of pharmacodynamic substances in traditional Chinese medicine are developing, and the application of these methods in teaching is becoming more and more extensive. By introducing these research methods into the classroom, teachers can help students to deeply understand the nature and mechanism of action of pharmacodynamic substances in traditional Chinese medicine, and improve their interest in and knowledge of traditional Chinese medicine. This paper introduces the definition of pharmacodynamic substances in traditional Chinese medicine, research methods, and their application in the teaching of traditional Chinese medicine analysis.

Keywords: Traditional Chinese medicine; Pharmacodynamic substances; Teaching of traditional Chinese medicine analysis; Teaching application

1. Introduction

As an important part of Chinese traditional medicine, traditional Chinese medicine has a long history and a unique theoretical system. However, the pharmacodynamic substance basis of Chinese medicine has always been a research difficulty. With the continuous development of modern science and technology, the research methods of the pharmacodynamic substances of Chinese medicine have been constantly innovated and improved. Understanding the progress of these research methods and their application in the teaching of traditional Chinese medicine analysis is of great significance in promoting the modernization, standardization, and internationalization of traditional Chinese medicine.

2. Pharmacodynamic substances in traditional Chinese medicine

Pharmacodynamic substances of traditional Chinese medicine refer to the chemical components of traditional

Chinese medicine that can produce medicinal effects. These components are the basis for the therapeutic effect of traditional Chinese medicines, and they are also important indicators for the quality control of traditional Chinese medicines. Therefore, the study of pharmacodynamic substances in traditional Chinese medicine is one of the core contents of traditional Chinese medicine research [1].

3. Progress of research methods on pharmacodynamic substances in traditional Chinese medicine

3.1. Research methods of pharmacodynamic substances in traditional Chinese medicines
3.1.1. Chemical analysis methods
Chemical analysis methods play an important role in the study of pharmacodynamic substances in traditional Chinese medicine. Through the separation, purification, and identification of chemical components in traditional Chinese medicine, the pharmacodynamic substance basis of traditional Chinese medicine can be clarified. Commonly used chemical analysis methods include:

(1) Thin-layer chromatography (TLC): This method is a simple and rapid method for separating and detecting chemical components in traditional Chinese medicine, by separating different components on a thin-layer plate, and then analyzing them qualitatively or quantitatively by color development reaction.

(2) High-performance liquid chromatography (HPLC): This method has the advantages of high separation efficiency, high sensitivity, and high automation, and is suitable for the separation and detection of complex mixtures.

(3) Gas chromatography (GC): This method is suitable for the separation and detection of volatile and thermally stable components.

(4) Mass spectrometry (MS): This method allows for the structural identification and molecular weight determination of compounds in traditional Chinese medicine, and helps to determine the type and molecular formula of compounds.

3.1.2. Pharmacological research methods
Pharmacological research methods are methods to study the mechanism of drug action and drug efficacy by observing the action of drugs on organisms or organs and tissues. Commonly used pharmacological research methods include:

(1) *In vivo* experimental method: Through the administration of traditional Chinese medicine or its active ingredients to animals, the effects on the physiological and biochemical indexes of animals are observed, so as to evaluate the efficacy of traditional Chinese medicine.

(2) *In vitro* experimental methods: Through *in vitro* experiments, the effects of Chinese medicines or their active ingredients on cells, tissues, or organs are observed, so as to explore the mechanism of their efficacy.

3.1.3. Biological research methods
Biological research methods are used to reveal the material basis of the efficacy and mechanism of action of traditional Chinese medicines by studying the reaction and mechanism of action of living organisms to the drugs. Commonly used biological research methods include:

(1) Bioinformatics analysis: The collection and analysis of information in biomedical databases, mining biomarkers, drug targets, etc., provide powerful support for the study of the pharmacodynamic

substances of traditional Chinese medicine and the elucidation of the mechanism of action.

(2) Gene expression profiling: By detecting the changes in gene expression profiles of cells or tissues before and after drug treatment, we can search for gene markers related to drug efficacy and provide clues for the elucidation of drug action mechanisms.

(3) Proteomics analysis: The analysis of the proteome of cells or tissues before and after drug treatment can find protein markers related to drug efficacy, in order to gain a deeper understanding of the drug's mechanism of action.

(4) Metabolomics analysis: By testing and analyzing the metabolites of organisms after drug treatment, we can understand the effects of drugs on the metabolism of organisms, thus revealing the material basis and mechanism of drug effects.

(5) Drug target research: The study of the interaction between the drug and the target of the organism can discover the direct action of the drug, which helps to elucidate the mechanism of action and effect of the drug.

(6) Pharmacodynamic evaluation methods: Through the establishment of scientific and reasonable pharmacodynamic evaluation methods, the pharmacodynamic effects of traditional Chinese medicines or their active ingredients are evaluated and compared to provide a basis for drug research and development and clinical application.

(7) Pharmacokinetic study: The study of drug absorption, distribution, metabolism, and excretion process in the organism helps the understanding of the dynamic changes and action characteristics of the drug in the body, to provide support for the rational application and optimization of the drug [2].

3.2. Progress of research on pharmacodynamic substances of traditional Chinese medicines
3.2.1. Chemical separation and purification technology

With the continuous development of separation and purification technology, researchers can isolate single compounds or groups of compounds from traditional Chinese medicines by various methods such as chromatographic technology and crystallization technology. These isolated compounds can be used for further pharmacodynamic screening and research.

3.2.2. Activity screening and evaluation

Through activity screening and evaluation, the components with medicinal effects in traditional Chinese medicine can be initially identified. Commonly used screening methods include cell models, animal models, and so on. In addition, screening methods based on computer-aided drug design have been widely used [3].

3.2.3. Metabolism and absorption studies

Understanding the metabolism and absorption process of active ingredients of traditional Chinese medicines *in vivo* helps to deeply understand the mechanism of their pharmacodynamic effects. In recent years, technical means such as metabolomics and proteomics have been widely used in the study of pharmacodynamic substances of traditional Chinese medicine.

3.2.4. Quality control and research

In order to ensure the quality and safety of traditional Chinese medicines, quality control and research on their pharmacodynamic substances are crucial. In recent years, quality control methods based on fingerprinting have been widely used, which can comprehensively reflect the composition and proportion of various chemical components in traditional Chinese medicine.

3.2.5. Systems biology and network pharmacology

The development of systems biology and network pharmacology has provided new perspectives for the study of pharmacodynamic substances in traditional Chinese medicine. These approaches enable an in-depth study of the mechanism of pharmacodynamic effects and the network of inter-component interactions of traditional Chinese medicines from a holistic and systemic perspective [4].

4. Application of traditional Chinese medicine pharmacodynamic substance research methods in the teaching of traditional Chinese medicine analysis

4.1. Application of chemical analysis method in the teaching of traditional Chinese medicine analysis

Chemical analysis is one of the commonly used research methods in the pharmacodynamic substances of traditional Chinese medicine, which qualitatively and quantitatively analyzes various components in traditional Chinese medicine by chemical means to reveal the intrinsic quality and efficacy of traditional Chinese medicine. Through the study of elemental analysis, organic functional groups, compound types, identification of drug components, purity check, content determination, and analysis of Chinese medicinal preparations, students can have a comprehensive understanding of the application and importance of chemical analysis in the analysis of traditional Chinese medicine, which is of great significance to the cultivation of traditional Chinese medicine analytical talents with professionalism and practical skills, and helps to promote the healthy development of China's traditional Chinese medicine industry and the process of internationalization.

One example is its application in elemental analysis. Elemental analysis is the important foundation of traditional Chinese medicine analysis, through the determination of the content of various elements in traditional Chinese medicine, the quality and safety of traditional Chinese medicine can be initially judged. In teaching practice, students should be trained to master various methods of elemental analysis, such as atomic absorption spectrometry, atomic fluorescence spectrometry, etc., in order to be able to accurately determine the elemental content in practical work. As for the learning of organic functional group-related knowledge, when teaching in practice, teachers need to focus on training students to understand the chemical composition and properties of traditional Chinese medicine through the identification and analysis of organic functional groups. In addition, students should be guided to understand the chemical reaction principles of various functional groups and their application in the quality control of traditional Chinese medicine [5].

Teachers can also use chemical analysis to carry out the teaching of compound type identification and drug composition identification; for instance, the identification of compound type is an important part of traditional Chinese medicine analysis. In teaching practice, students should be trained to master the properties and characteristics of various types of compounds so that they can accurately identify the types of compounds in practical work. In addition, students should be guided to understand the extraction and separation methods of various types of compounds, in order to lay the foundation for the subsequent identification of drug components and content determination. Drug composition identification is the core task of traditional Chinese medicine analysis. In teaching practice, students should focus on cultivating students to master the chemical properties and characteristics of various drug components, so that they can accurately identify the types and contents of the components in practical work.

4.2. Stimulating students' thinking with research cases on pharmacodynamic substances in traditional Chinese medicine

By introducing actual research cases of Chinese medicine pharmacodynamic substances, teachers can help students understand the research methods and ideas, and deepen their understanding of theoretical knowledge. For

example, teachers can introduce some successful cases of research on pharmacodynamic substances in traditional Chinese medicine, explain their research process, methods, and results, and guide students to think about scientific problems and technical difficulties. Experimental courses can also be organized to let students carry out the operations of separation, purification, screening, and evaluation of Chinese medicine pharmacodynamic substances by their own hands, which can cultivate students' experimental and practical skills. The experimental content can be adjusted and optimized according to the actual situation to meet the needs of students at different levels [6].

Taking the herbal compound for the treatment of diabetes as an example, chemical analysis methods, pharmacological research methods, and biological research methods were used to study the pharmacodynamic substances of the herbal compound. Firstly, the chemical components in the compound formula were isolated and purified by chemical analysis methods. Secondly, pharmacological research methods were applied to evaluate the pharmacodynamic effects of each component in the compound formula. Lastly, biological research methods were used to explore the mechanism of action of pharmacodynamic substances.

In the teaching of traditional Chinese medicine analysis, teachers should pay attention to the combination of theoretical and practical teaching, and guide students to deeply understand the principles and methods of the study of pharmacodynamic substances in traditional Chinese medicine through actual cases. At the same time, teachers should also focus on the latest progress and development trends of the research on pharmacodynamic substances in traditional Chinese medicine, and constantly update the teaching content and methods.

4.3. Deepening the learning of drug action mechanisms with the study of traditional Chinese medicine drug targets

Applying the study of traditional Chinese medicine drug targets in the teaching of traditional Chinese medicine analysis not only enhances students' interest and enthusiasm in learning but also helps to improve students' understanding and mastery of drug action mechanisms. By studying the interactions between drugs and their targets in organisms, we can find out the direct target of drugs, which can help to elucidate the mechanism of action and effects of drugs. Simply put, target research can reveal how traditional Chinese medicine can play a therapeutic role in a specific disease or pathological process, and through the in-depth understanding of the target, students can better understand the mechanism of action of drugs, thus enhancing the overall understanding of drug action. Moreover, target knowledge can help students better understand the pathogenesis of diseases, laying the foundation for students to engage in the research and development or clinical application of traditional Chinese medicine in the future [7].

Teachers can introduce some research cases on the pharmacodynamic substances of traditional Chinese medicine, such as the antimalarial mechanism of artemisinin, etc., to help students understand the relationship between the target and drug action through actual cases. At the same time, they can also design experiments for the targets of traditional Chinese medicines, so that students can learn how to study the targets of drugs by experimental means in practice, thus improving their practical skills. Discussions can be carried out on the targets of certain traditional Chinese medicines, encouraging students to think and explore from different perspectives and improving their learning interests and critical thinking.

In addition, teachers can utilize modern information technology tools, such as artificial intelligence and big data technology, to assist students in target point research, so that students can understand the latest research means and methods. Modern teaching techniques can also be used to establish a comprehensive evaluation and feedback mechanism to provide scientific and reasonable assessment and feedback on students' learning outcomes, which helps to improve the quality of teaching and students' learning effects. Teachers can evaluate and guide students according to their performance and learning outcomes, help students find their shortcomings, and provide suggestions for improvement [8].

5. Conclusion

In summary, in the teaching of traditional Chinese medicine analysis, teachers should pay attention to the latest progress and trends of these research methods, and update the teaching content and methods in a timely manner, in order to cultivate high-quality talents in traditional Chinese medicine with innovative ability and practical experience. At the same time, teachers should also focus on cultivating students' interdisciplinary thinking and teamwork in order to meet the demand for diversified talents in the field of traditional Chinese medicine research.

Disclosure statement

The author declares no conflict of interest.

References

[1] Chen J, Zhao L, Wang Y, 2020, Application of Model Organism Zebrafish in Multimodal Identification of Pharmacodynamic Substances in Traditional Chinese Medicine. Chinese Journal of Traditional Chinese Medicine, 45(14): 3387–3394.

[2] Guo S, Cai Y, Zhang A, 2022, Progress of Metabolomics-Based Research on Pharmacodynamic Evaluation, Discovery of Pharmacodynamic Substances and Mechanism of Action of Traditional Chinese Medicines. Drug Evaluation Research, 45(11): 2338–2346.

[3] Yang M, Dilixiati D, Zhao F, 2022, Progress in the Application of Network Pharmacology in the Study of Pharmacodynamic Substance Basis, Mechanism of Action and Toxicity of Traditional Chinese Medicines in the Genus Aconitum. Chemical and Biological Engineering, 39(4): 18–23.

[4] Zhao L, Li J, Zhang Y, et al., 2022, Advances in the Methodology of Pharmacophore Research Based on In Vivo Processes. Chinese Pharmaceutical Science, 12(23): 39–42.

[5] Ren Y, Liu X, Chen L, et al., 2022, Key Technology and Application of Efficacy-Oriented Identification of Pharmacodynamic Substances in Traditional Chinese Medicine. China Science and Technology Achievement, 23(17): 53–53.

[6] Shi F, Lu H, Zhang Z, 2021, Progress in the Study of the Relative Dynamics of the Material Basis of Chinese Medicinal Efficacy. Advances in Pharmacology, 45(11): 855–861.

[7] Dong F, Wang Z, 2020, Discussion on the Research Ideas of the Material Basis and Action Mechanism of Chinese Medicine Efficacy. Health Vision, 2020(18): 93.

[8] Li X, Cao X, Liu J, et al., 2020, Discussion on the Research Ideas of the Material Basis and Action Mechanism of Chinese Medicines. Journal of Guangzhou University of Traditional Chinese Medicine, 37(2): 366–370.