Methodology

Promoting integrative medicine by computerization of traditional Chinese medicine for scientific research and clinical practice: The SuiteTCM Project

Arthur de Sá Ferreira
Laboratory of Computational Simulation and Modeling in Rehabilitation, Post-graduation Program of Rehabilitation Science, Augusto Motta University Center, Rio de Janeiro, RJ, Brazil

BACKGROUND: Chinese and contemporary Western medical practices evolved on different cultures and historical contexts and, therefore, their medical knowledge represents this cultural divergence. Computerization of traditional Chinese medicine (TCM) is being used to promote the integrative medicine to manage, process and integrate the knowledge related to TCM anatomy, physiology, semiology, pathophysiology, and therapy.

METHODS: We proposed the development of the SuiteTCM software, a collection of integrated computational models mainly derived from epidemiology and statistical sciences for computerization of Chinese medicine scientific research and clinical practice in all levels of prevention. The software includes components for data management (DataTCM), simulation of cases (SimTCM), analyses and validation of datasets (SciTCM), clinical examination and pattern differentiation (DiagTCM, TongueTCM, and PulseTCM), intervention selection (AcuTCM, HerbsTCM, and DietTCM), management of medical records (ProntTCM), epidemiologic investigation of sampled data (ResearchTCM), and medical education, training, and assessment (StudentTCM).

DISCUSSION: The SuiteTCM project is expected to contribute to the ongoing development of integrative medicine and the applicability of TCM in worldwide scientific research and health care. The SuiteTCM 1.0 runs on Windows XP or later and is freely available for download as an executable application.

KEYWORDS: traditional Chinese medicine; evidence-based practice; computer-assisted decision making

1 Introduction

Chinese and contemporary (i.e., Western) medicines present different approaches to the health-disease process in humans. Contemporary medicine focuses on both structure-function and safety-efficacy relationships to guide and provide treatment supported by up-to-date evidence\(^1\). This scientific approach is possible due to the continued development of methods and techniques for assessment of sampled data from populations and interventions for primary (health promotion and specific protection), secondary (diagnosis and treatment), and tertiary (rehabilitation) levels. Traditional Chinese medicine (TCM) focuses on a philosophic-holistic approach supported by systematic relationships between a human being and nature\(^2\). TCM practitioners also developed methods and techniques for interventions in all levels of prevention, but made no remarkable progress on analysis of sampled data and epidemiological methods for clinical research. The mutual interest of health practitioners from both medical systems is promoting the growth of integrative medicine\(^3\), a medical system that allows a unified view of the healthy status. The integration of research methods that promoted the
evidence-based approach to the practice of contemporary medicine may also be applied to TCM. On the one hand, research on TCM may improve its safety and reliability. On the other hand, the use of therapeutic resources from TCM may prove its efficacy for health care. In a continuous cycle, scientific research and clinical practice are mutually reinforced to benefit the population (Figure 1).

TCM has at least five aspects that must not be overlooked. (1) Medical theories based on philosophic, systematic correspondences between human and nature. Contemporary medicine is based on the biopsychosocial model[41], while TCM considers philosophical trends and systematic correspondences from Taoism, Buddhism and Confucianism to explain the health-disease process[5,6]. Several medical theories were developed to explain the ongoing morbid process in patients, such as yin-yang, eight principles (ba gang), five phases (wu xing), six levels (liu jing), four levels (wei qi ying xue), and triple burner (san jiao)[7]. Although not formally described as such, it is possible to find in ancient books detailed descriptions on the “natural history of patterns” in analogy to the natural history of disease, for each of these theories. (2) Functional rather than structural aspect emphasized. TCM theories focus on homeostatic process of the body and its relationship with nature[1,2]. Despite the controversy concerning the development of Chinese medical theories by ancient practitioners based on anatomy[3], apparently it did not significantly change the medical theories until Western anatomists and physiologists influenced pre-modern authors. (3) Knowledge acquisition by series of single cases. Both ancient and contemporary literature on TCM is well known by its large amount of clinical cases. Case reports are marked by in-depth discussions on medical theory and personalized approach (i.e., patient-centered) to diagnosis and treatment[29]. Despite the attempt of some ancient authors to describe series of cases on the same pattern, no apparent effort was made to analyze them collectively as a “sample”. Experience based on sampled data from populations appeared much later, and only under the scientific study of TCM. (4) Long-term practice for development of medical theories. The history of TCM encompasses much more than the three millennia estimated by dating the Huangdi Neijing[10]. In ancient books it is common to find discussions on treatments that are no longer effective and suggestions for their improvement or replacement. Although the general principle that “good results are sustained over time” might be applicable to TCM practices that are currently available, it certainly does not ensure its safety and effectiveness. (5) Verbal and written knowledge transmission. Transference of clinical knowledge among practitioners was subjected to cultural influence and also changes in the dominant philosophy. Records of traditions presented in ancient books were transferred either by “studying the classics” or “oral transmission” (master-disciple relationship)[11]. Certainly there were improvements and detriments[12] in the medical knowledge and practice throughout history, and losses that may not be recovered at all but may be prospectively preserved.

The available ancient Chinese literature provides a huge amount of information on human anatomy, physiology, semiology, pathophysiology, and therapy[13,14]. In this scenario, computer methods are the best choice for management, processing and integration of several aspects that might be overlooked if considered in a case-by-case fashion[13]. Indeed, computerization of TCM as a scientific approach is not a new topic since several computational models were already proposed for acquisition, processing, and analysis of data[16-20]. However, the majority of existent models were developed to perform specific tasks (e.g., pattern differentiation, dataset organization, data mining, computer-aided drug design) and thus loose the integrative nature of health care in TCM. Some models depend on dedicated or expensive hardware for acquisition of biomedical signals from patients that may be not suited for large-scale applications or even clinical environments. In addition, most computational models are much complex and, most importantly, not linked to traditional mode of thinking of TCM. Therefore, it is proposed a collection of computational models and methods mainly derived from statistical sciences and epidemiology for computerization of scientific research and clinical practice of TCM. This work introduces the “SuiteTCM project” to be presented in a series of articles dealing with an integrative computational system for TCM research and practice.

2 The “SuiteTCM Project”

2.1 Objective

The objective of the “SuiteTCM Project” is to develop and implement computational methods and computational
models for validation and objective analyses of TCM theories and practices, mainly related to dataset management, pattern differentiation and intervention selection. The final product of this project is the software to be used by both scientific researchers and clinicians.

2.2 General requirements
The “SuiteTCM” software must respect the traditional mode of thinking for dataset organization, diagnosis and intervention, in special: holism, dynamism, and personalized approach[7]. Simultaneously, it must provide objective models and methods for acquisition, processing, and analyses of clinical and biomedical data related to TCM practice in both small- and large-scale scenarios. It should be formal enough for data collection and statistical analysis, while flexible enough for clinical usage and practice. More specifically, the “SuiteTCM” software should be able to: (1) store, organize, display, and share information from TCM including patterns (and its manifestation profiles), acupuncture points (including its location, traditional functions, etc.), herbal compounds (including its characteristics), and food (including its nature, flavor, etc.); (2) store, organize, display, and analyze data from clinical examination of patients according to TCM; (3) perform qualitative-quantitative analyses of phenotypes (i.e., manifestation profiles of patterns), biomedical information (including complimentary exams), tongue images (including chromotopography), and pulse images (including pressure pulse waveform signals); (4) formulate and suggest the diagnosis and diagnostic hypotheses based on TCM theories for pattern differentiation; (5) formulate, suggest, store, organize, display, and analyze prescriptions of acupuncture points, herbal compounds, and food; (5) allow follow-up of clinical data from patients, including the monitoring of the timeline of diagnosis and prescribed acupuncture points, herbal compounds, and foods; (6) be used as a tool for TCM education, teaching, training, and assessment; (7) perform statistical analyses and scientific validation of theoretical and clinical databases; (8) manage data in both idiographic (i.e., single subjects) and group study designs (including randomized clinical trials).

2.3 Software design: modular architecture
Several components were designed for full integration between the scientific and clinical approaches. The flowchart of the functional characteristics of the “SuiteTCM” software is exhibited in Figure 2. These components will be addressed in forthcoming articles of the project. A summary of their current and expected functionalities is provided below.

The user interacts with the software for generation of knowledge datasets. Using the DataTCM, the user can create, edit, and share datasets of patterns, acupuncture points, herbal compounds, and food. In addition, it is possible to perform quality control of those datasets concerning errors due to manual entries of data. The SimTCM is designed to simulated cases by defining their manifestation profiles from the available datasets of patterns or stored medical records. The SciTCM is designed for statistical evaluation of the content on those datasets regarding its pattern differentiation performance. Datasets of patterns are used by the DiagTCM for clinical examination, i.e., detection of health or disease statuses and patient classification by pattern differentiation. The TongueTCM and the PulseTCM are designed for pattern differentiation by tongue inspection and pulse palpation, respectively, if tongue images and pressure pulse signals are available. The AcuTCM, HerbsTCM, and the DietTCM are designed to aid in prescription of acupuncture points, herbal compounds and food, respectively. These prescriptions are based on pattern differentiation and traditional theories. Using the ProntTCM the user can edit, visualize and analyze a patient’s electronic record for intervention follow-up. The ResearchTCM is designed to perform epidemiological analyses of real cases or simulated data (from the pattern dataset). Finally, the user can study medical theories on the datasets and test his/her clinical skills on pattern differentiation and treatment selection using the StudentTCM based on real or simulated data. Those softwares are integrated by their common data source (datasets, simulated cases and real data from patients), as well as code sharing among softwares.

2.4 Computational implementation
The SuiteTCM software is implemented in LabVIEW 2012 (National Instruments, Texas, USA) for Windows Server 2003 R2 (Microsoft, Chicago, USA) or higher (currently up to Windows 7). Minimal computational requirements are 256 MB RAM memory, screen resolution of 1024 x 768 pixels, and a disk space of 353 MB.
3 Discussion

It is a challenge to combine both TCM knowledge and state-of-the-art scientific methods for research and healthcare, on both individual and group levels. Moreover, to implement solutions for both tasks in a fully integrated computational model is specially defying. Several issues need to be considered to achieve a satisfactory computational system for both researchers and clinicians, without important losses of accuracy and interpretation of data. For instance, computational methods must present a user-friendly, intuitive interface for human interaction so they are accessible by experts in both TCM (physicians, physical therapists, nurses, nutritionists, and other healthcare professionals) and computational sciences. The software platform chosen for development of “SuiteTCM” is designed for fast design and implementation of algorithms. It presents with several built-in computational algorithms for data management, statistical analysis, and signal processing and analysis. However, new algorithms developed specifically for this project must be cross-validated with other statistical package softwares to examine their validity and accuracy.

One of the main features of the “SuiteTCM” software that differentiates it from previous models is its holistic computational approach provided by the code sharing between softwares. To achieve so, three softwares – DiagTCM, DataTCM, and SimTCM – play a major role in this project. Pattern differentiation bridges the patient’s manifestation profile to the therapeutic intervention. In addition, pattern differentiation is considered as a promising step to guide the intervention to several mild and severe diseases. Therefore, the DiagTCM is one of the core components in the “SuiteTCM project”. Since pattern differentiation and the selection of the best set of interventions from those suggested ones depend on medical theories, the DataTCM comprises another core component of this project. Finally, as it is necessary to develop standards for evaluating computational methods for TCM, the SimTCM component as a data-driven model for validation of datasets is a core component of the system.

It was suggested that modern medicine should fully incorporate TCM theories and practices provided that they are supported by scientific evidence. In this direction, an interesting scientific approach is to seek for evidence that corroborates data reported by TCM practitioners or not – ancient and contemporary ones – instead of testing new theories based on TCM. The epidemiologic approach is well suited to study the morbidity of TCM in human populations. Data derived from real patients and scientific studies can be used to assess the effectiveness of TCM practices, identify relevant areas for research and inform research protocols, identify morbidity data specific to TCM and thereby guide the public and health-related professions on its applicability for particular condition.

In the scenario of integrative medicine, the “SuiteTCM Project” is expected to contribute to the ongoing development of integrative medicine and the applicability of TCM in worldwide scientific research and healthcare.

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5 Competing interests

The author declares that he has no competing interests.

REFERENCES


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