PREFACE

A SPECIAL SELECTION ON BIOMECHANICS IN MEDICAL APPLICATIONS – PART II

Part II of this special issue sums up the selections focusing on the Applications of Biomechanics in Medicine. The details of the accepted 20 papers are as follows:

Geon-Ho Kang *et al.* investigate the effects of laser-induced indirect stimulation on cognitive response and damage to absorbing medium. Through the human body experiment, they study the laser parameter condition that most subjects feel touch. In addition, thermal analysis simulations are performed to predict the condition of the laser pulse energy, the laser frequency, and the temperature at the damage threshold of the absorption medium. The results of this study are expected to be useful for conducting non-contact tactile sensation using laser, and this technique can be widely used in laser biomedical stimulation, haptic technology, and other biological and medical fields.

Bing-Ru Peng *et al.* optimize the minimum detectable difference (MDD) of computed tomography (CT) scan system using the Taguchi analysis and an accurate line group gauge is accomplished in this work. The indigenous line group gauge provides three sets of line arrays for CT scan image inspecting. Five factors of the CT scan imaging system (namely kVp, mAs, Pitch, field of view (FOV), and rotation time) are arranged into eighteen combinations on the basis of the Taguchi analysis. The special designation of L18 orthogonal array let five factors set onto the same baseline for comparing. The MDD furnish more accurate information than Full Width at Half Maximum (FWHM) as to the spatial resolution of peak profile. This advantage is critical for accurate diagnostics of hepatic carcinoma patients via the CT scan imaging.

Hyeong Min Jeon *et al.* compare the attenuation of axial rotation in different age-groups. Subjects walk on a level surface with gyro sensors attached at four locations of the back (pelvis, thorax, shoulder, and head), from which the angular motion is derived. Measurements include the average peak-to-peak amplitude of axial rotation at all sensor locations and the phase delay at each location with reference to the pelvis. Post-hoc test reveal that rotation amplitude is similar at pelvis, thorax, and shoulder in the elderly whereas it is significantly reduced at the thorax-shoulder

section in the young. The elderly also shows smaller phase delay at shoulder and head than those of the young. The result may suggest altered neuromuscular control and passive properties by aging.

Monan Wang *et al.* consider both the consideration of the solid phase, liquid phase, fiber-reinforced phase in the cartilage and the influence of the contents of major fibers and minor fibers near the cartilage surface. Based on these factors, a tangential zone of cartilage is established, and a certain improvement and optimization of the fiber-reinforced porous elastic model is performed. The Abaqus software and the Fortran language are used to complete simulation. The model is used to perform finite element analysis of different degrees of repairable depth under sliding conditions. Simulation results are used to explore differences in cartilage mechanical properties of different repairable depths, so as to select the best repairable depth for cartilage.

Jae Sung Park *et al.* propose a resonance frequency analysis model of a curved beam diaphragm that can improve the vibration transmission efficiency based on the B81 bone conduction system in order to address skin diseases and surgery problems encountered in the conventional bone conduction system. The diaphragm designed by finite element analysis is manufactured to confirm the improvement in efficiency. The vibration characteristics of the diaphragm manufactured by the proposed method are improved by 60% compared with those of the conventional diaphragm, and the resonance frequency is 916 Hz, which is suitable for bone conduction. Therefore, the vibration transmission efficiency of the actuator is improved with the resonance frequency analysis model of a curved beam diaphragm, and it may be used in various fields.

Mi-Hyun Choi *et al.* apply vibratory stimuli with various intensities (four levels) and frequencies (10, 50, 100, 150, 200, 225, 250, and 300 Hz) to the right index finger to extract cognitive characteristic functions for the intensity and frequency. The results can predict the degrees of various cognitive characteristics to be presented in this study through the various values of the frequency and intensity. It is expected that these results can be used as basic data for transferring touch information to devices that use touch information, such as a haptic interface. In the future, it will be possible to extract clearer cognitive characteristic functions by extracting the various parameters of vibratory stimulation and cognitive characteristics for variables, such as the stimulation duration, contact area, and body part.

Shupeng Zheng *et al.* describe a super-twisting sliding mode controller for the robot manipulator. To ensure the robot system has good transient and steady-state performances, the transformation function of tracking errors is devised. Through using transformed errors, we attain the surface of sliding mode and propose a modified structure of traditional super-twisting algorithm. Consider the derivative of lumped disturbance has unknown boundary, a novel adaptive law is derived for the modified super-twisting sliding mode control which does not require the boundary of disturbance. Simulation experiments show that the proposed control

algorithm not only improves the tracking performance of robot manipulators, but also facilitates the parameter tuning of controller.

Sang Hyuk Lee *et al.* aim to evaluate whether various blood viscosity (BV) models could produce similar arterial wall shear stress (WSS) results. They perform a blood flow simulation in carotid arteries obtained from time-of-flight magnetic resonance (TOF MR) angiography using the hemodynamic characteristics of subjects via carotid duplex ultrasonography. The patient-specific non-Newtonian BV is measured in 20 subjects who had MRI scans of carotid arteries with duplex ultrasonography. To precisely calculate the WSS on arterial segments, blood flow simulations should incorporate non-Newtonian dynamics, patient-specific blood viscosity, arterial geometry and proper inlet flow conditions. This novel approach can be used to assess the abnormal WSS in patients with arterial disease.

Lin Yang *et al.* propose effective and convenient testing methods and evaluation criteria for pregnant women's sports and psychology. The research idea is a method based on the pulse wave to detect pregnant women's cardiac reserve capacity and grade the Diastolic/Systolic value of pregnant women as a reference for grading individualized target heart rate range of moderate intensity exercise. The effective time and energy expenditure of pregnant women are assessed by monitoring the exercise process. The purpose is to help and guide pregnant women in the whole process of pregnancy self-movement management, and thus improve the quality of maternal health care services in China.

Yuri Kwon *et al.* classify the spinal posture during cross-legged sitting from the seat pressure pattern for future usage in the posture monitoring system. The seat pressure is measured for three spinal postures of flat, slump, and lordosis when subjects are instructed to pose a certain posture while seated on the floor with legs crossed. The contact area is divided into feet and buttocks by using a filter with a pressure threshold. Anterior and posterior tilt of upper body in the slump and lordosis postures would result in more pressure concentration in the feet and buttocks, respectively, which is incorporated in the classification algorithm of this study. The result of this study could be extended to the real-time or offline monitoring of the sitting posture.

Lei Wang *et al.* find a non-invasive pulse wave waveform index that is highly correlated with cardiovascular disease and establish an effective model for cardiovascular health assessment in middle-aged men to provide early warning of possible cardiovascular and cerebrovascular diseases. This paper collects pulse waves of healthy males at 6 age groups and collects 50 samples per age group. The study suggests that the pulse wave parameters of inflow time, fast inflow time and inflow time ratio has a significant and stable trend with age, indicating that they are closely related to vascular elasticity, compliance and stiffness, and can be used as predictors of cardiovascular disease.

Bin Yang *et al.* study the influence of tissue material performance sensitivity on frequency and mode shape under free vibration aiming at the uncertainty of material parameters of human brain tissue. The 50th percentile finite element (FE)

model of human head and neck with detailed anatomical characteristics are chosen as the research object, the parameters of skull, cerebrospinal fluid (CSF) and brain tissue materials with high sensitivity are analyzed by orthogonal test design and variance analysis. The results indicate that the material parameter of the skull has the greatest influence on dynamic characteristics of human head and neck, followed by CSF and brain tissue. This study provides an effective method for vehicle safety and head and neck injury protection and supplies a reference for FE analysis of head collision damage.

Woo Suk Chong *et al.* develop a multidirectional posture and motion evaluation tool system using a camera-based vision system. To analyze the kinematical information of the participants from multiple directions, cameras are installed on the top, back, left, and front sides of the system to collect multidirectional image information. A dedicated color light-emitting diode (LED) marker is developed for increasing recognition rate of marker. The training effect is expected to be improved by providing kinematic and kinetic information in real time during gait training. In the future, they are planning to develop customized training protocols for various types of musculoskeletal disorders such as scoliosis.

Xingang Bai *et al.* evaluate the effectiveness and safety of Lower Extremity Exoskeleton Robot improving walking function and activity in patients with complete spinal cord injury. Prospective, open and self-controlled trials are used, 8 patients with complete spinal cord injury accepted Lower Extremity Exoskeleton Robot training with Aider 1.0 and Aider 1.1 for 2 weeks. During the training, the incidence of adverse events (AE), the incidence of serious adverse events (SAE), the incidence of device defects and other safety indicators also are observed. The study indicates that it is safe and effective to use the lower extremity exoskeleton robot to complete the walking ability of patients with complete spinal cord injury.

Ya-Hui Lin *et al.* make a projection of effective blood concentration (EBC) readings of digoxin using the inverse problem algorithm based on clinical data for patients with heart failure diseases. Data collected from the clinical 168 heart failure patients are normalized to be included in same domain range (-1 to $+1$), and then calculated by the specific algorithm to optimize the numerical solution to evaluate EBC readings of digoxin. The evaluated 1st-order regression fit owns an optimal loss function ($\Phi = 2.1746$) coupled with correlation coefficient $r^2 = 0.892$ and variance of 89.20%. The algorithm holds its accuracy to handle the verified data that are out of the original bounds and demonstrate a useful analysis to handle the drug administration in pharmaceutical field.

Ji-Su Park *et al.* discuss the effect of motor imagery training combined with electromyography-triggered electrical stimulation (MIT EMG-ES) on lower extremities and activities of daily of living (ADL) in patients with stroke. Lower extremities function is measured by the Fugl-Meyer Assessment Lower Extremity (FMA-LE), Timed Up-and-Go (TUG) test and 10-m Walk (10 MW) test. ADL are measured by the Korea version of the Modified Barthel Index (K-MBI). The results of this study demonstrate that MIT EMG-ES is more effective in improving the

lower extremity function of stroke patients than MIT alone. Therefore, this study recommends MIT EMG-ES as a method for improving lower limb function and gait ability in hemiplegic patients after stroke.

Shuai Wang *et al.* compare the influence of the common turbulence models on simulation with the axial flow blood pump as the object. They use six turbulence models to simulate the pressure difference and velocity field of the pump and design a novel drive system of the axial flow blood pump. The results show that all turbulence models can predict the pressure difference information well. However, there are some differences in the distribution of velocity fields, which is vital for pump structural design and blood damage analysis. From the results of this study, the Reynolds Average Navier–Stokes (RANS) model with lower computational cost can also predict the flow field well, and the Large Eddy Simulation (LES) model will be considered in future research.

Jin Seung Choi *et al.* construct a system to measure the delay time of subject's movement in rhythmic auditory cueing and a pilot gait experiment for young adults while performing a cognitive dual task. The system consists of a metronome and an accelerometer sensor measurement unit and is implemented as a program using LabVIEW. This study aims to compare the delay time according to age by performing the same experiment for elderly subjects. The system can be used to identify the balancing ability and control capacity of the elderly, and it is expected to be used as an evaluation tool for training performance in the gait rehabilitation process.

Jae-Hoon Heo *et al.* test the dynamic change of center of pressure (COP) in different foot types. They analyze COP in each gait phase, i.e. loading response, mid stance, terminal stance, and pre-swing. COP trajectory is normalized by foot width and length. In the loading response and mid stance phases COP of Pes Cavus locate most laterally ($p < 0.05$). No difference among foot types exists at terminal stance and pre-swing phases ($p > 0.05$). Foot deformity is known to occur due to the abnormality of musculoskeletal system such as lower extremities muscles, bones, and ligaments. Because the role of musculoskeletal system differs between gait phases, this may have caused phase-dependent COP difference among different foot types.

Monan Wang *et al.* introduce the tangential zone of cartilage is into the fiber-reinforced model of articular cartilage. They use a modified articular cartilage model to simulate the mechanical properties of implanted cartilage with different elastic modulus. The simulation results show that the selection of implants with different elastic modulus will affect the repair of cartilage. Appropriately increase the elastic modulus of implanted cartilage, which can increase the bearing capacity of the repaired area and reduce the stress concentration at the junction. The damage of stress concentration on the repair surface should be considered. Through simulation, the mechanical state of the repaired cartilage under pressure can be obtained comprehensively, which provides a theoretical basis for clinical pathology.

Overall, the special selection is to summarize recent discoveries and groundbreaking studies that will account for new challenge research in the broad and relevant area of Biomechanics in Medical Application[1,2,8,12,13] in combination with biomedical imaging[3–7,9–11,14–16] and relevant areas. Hope that the selected papers will provide the readers with interesting examples of current research on the most outstanding theoretical frameworks in biomechanics applied to medicine.

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