Identification of Optimal Prosthetic Knee Control Parameter at Each Gait Sub-phase using Cyclograms and Neural Network

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ABSTRACT
To date, human walking behavior is typically characterized by plotting single kinematics and kinetics curves as a function of time or percentage of gait cycle. These kinematics and kinetics curves became the “textbook” to design prosthesis control that mimicks the normal gait by analyzing the prosthesis performance as close as the normal single-variable curve. However, designing a prosthesis control based on the single-variable curve is arguable with regard to the prosthesis performance towards the user as the interactions of co-existing parameter across the lower limb joints during the gait cycle could not be harmonized. The objective of this study was to identify optimal prosthetic knee control parameter at each gait sub-phase for transfemoral amputees through quantification of gait disparity of different pathological conditions using cyclograms – a diagram that consists of two gait parameters without its time axis. Twenty healthy able-bodied subjects and twenty-five prosthesis and orthosis users (consisted of ten transtibial amputees, five transfemoral amputees and ten different pathological profiles of subjects who wear orthoses) participated in this study. The subjects were required to walk at their comfortable speed in motion analysis setting. The extracted sagittal plane’s gait data (angle, moment and power) for ankle, knee and hip joint were coupled to form thirty-six cyclograms relationship. The coupled variables were analyzed using neural network. At each gait sub-phase, the optimal knee parameter(s) to be controlled were: Loading Response (LR) – knee power, Mid-stance (MSt) – Knee power, Terminal-stance (TSt) – knee moment and knee angle, Pre-swing (PSw) – Knee angle and knee power, Initial-swing (ISw) – knee angle, Mid-swing (MSw) – independent (no control), and Terminal-swing (TSw) – knee power. The option of utilizing the cyclograms to determine the gait disparity and the suitable knee parameter to be controlled at each of the gait sub-phase provide a new insight to examine the gait as an interaction between two parameters. The holistic study involving all the joints and its respective parameters supply the information of how the coordinated movement in walking could be simplified in a prosthetics knee design that could help to promote rehabilitative prospect towards the user.

REFERENCES