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Title(English)	Biomechanical characteristics of independent walking in unilateral transfemoral prosthesis users
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論 文 要 旨

THESIS SUMMARY

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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

Currently, lower limb loss affects millions of people worldwide, and is considered as a serious bodily impairment that can limit an individual's functional mobility. In particular, transfemoral prosthesis users (TFPUs) have more difficulty regaining independent ambulation compared to transtibial and foot prosthesis users. Because mobility is essential to a satisfactory quality of life for TFPUs, regaining the ability to walk is a primary rehabilitation goal after lower limb amputation. Therefore, the specific aim of this dissertation was to investigate the biomechanical characteristics of independent walking in unilateral TFPUs. Understanding these characteristics may provide insights into the improvement and evaluation of lower limb prosthesis design parameters and effective gait rehabilitation to resume independent walking. In this thesis, we focus on four areas; the balance of mediolateral ground reaction force, the lower limb joint kinematics and kinetics, the risk of prosthetic knee buckling, and whole-body angular momentum. **In Chapter 2**, mediolateral ground reaction force (GRF) variables were compared between the prosthetic and intact limbs of TFPUs when executing straight walking to examine their mediolateral GRF production strategies. To sustain walking in a straight line, the net mediolateral GRF impulses should be counterbalanced between the prosthetic and intact limbs. Since the stance time of the prosthetic limb has been reported to be shorter than that of the intact limb, I hypothesized that the mean mediolateral GRF of the prosthetic limb would be greater than that of the intact limb. The results of the present study were consistent with this hypothesis. Further, the SPM analysis revealed significantly larger medial GRF in the prosthetic limb than in the intact limb from 40% to 63% of the stance phase. These and further insights on these mechanics may serve as guidelines on the improved design of prosthetic devices and the rehabilitation needs of TFPUs. **In Chapter 3**, lower limb joint kinematics and kinetics in the intact, prosthetic and able-bodied control limbs were compared to enhance our understanding of joint control and muscular effort during walking in unilateral TFPUs. Asymmetry in kinematics and kinetics of walking has been commonly observed in unilateral TFPUs. Thus, I hypothesized that the intact limb of TFPUs generates more joint power at ankle, knee and hip when compared to the prosthetic limb as well as the limbs of age-matched able-bodied individuals while walking. As hypothesized, the results showed that the peak ankle positive power at pre-swing and peak hip positive power from loading response to mid stance in the intact limb were significantly larger than that in the prosthetic limb. Moreover, it appeared that the intact limb of the TFPUs generated larger peak joint power by producing more ankle plantarflexor and hip extensor moments. The present study highlighted the importance of ankle and hip muscle strength for walking among unilateral TFPUs during the rehabilitation after their amputations. **In Chapter 4**, to predict the potential risk of prosthetic knee buckling in unilateral TFPUs, I investigated the demographic factors that can be associated with the prosthetic knee angular impulse (PKAI). TFPUs have difficulties in preventing falls due to prosthetic knee buckling, defined as the sudden loss of postural support during weight-bearing activities. The risk of prosthetic knee buckling can be evaluated by determining the prosthetic knee angular impulse during the early stance phase. The results showed that PKAI had a significant negative linear relationship with the subject's body height and body mass. However, PKAI showed no significant correlation with age, the time since amputation, and the current prosthesis use history. Awareness about demographic factors associated with PKAI during walking can contribute to fall assessments in gait rehabilitation programs for unilateral TFPUs. **In Chapter 5**, to examine how TFPUs regulate dynamic balance during walking, the step-to-step changes in the average whole-body angular momentum was compared between TFPUs and an able-bodied control group. To achieve continuous walking without falling when encountering disturbances, maintaining whole-body dynamic balance is a prerequisite in unilateral TFPUs. Whole-body angular momentum is a common and useful measure for assessing dynamic balance during human walking. As unilateral TFPUs demonstrate asymmetric ground reaction forces and external moment arms between intact and prosthetic limb steps, we hypothesized that the unilateral TFPUs would have different step-to-step average whole-body angular momentum compared to non-impaired controls. In the sagittal plane, the TFPUs generated greater average positive (rotating backward) and negative (rotating forward) whole-body angular momentum than the controls during intact and prosthetic steps, respectively. In the transverse plane, the average whole-body angular momentum generated in TFPUs was similar to that in the controls during the intact steps, but the average positive whole-body angular momentum (toward the prosthetic leg swing) was smaller than that of the controls during prosthetic steps. In the frontal plane, the average whole-body angular momentum of the TFPUs was similar to that of the controls during steps on both sides. These biomechanical analyses each expand our understanding of the underlying neuromechanical principle and control mechanism of bipedal locomotion in unilateral TFPUs, and indicate pathways toward the role of the prosthesis design and rehabilitation process to regain the independent walking in TFPUs.