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Biomechanical and energetic effects of a stance-control orthotic knee joint

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Abstract—Users of traditional knee-ankle-foot orthoses (KAFOs) walk with either locked or unlocked knee joints depending on the level of stability required. Some users may benefit from new stance-control KAFOs that prevent stance-phase knee flexion but allow swing-phase flexion. We collected data from nine nondisabled adults who walked with KAFOs that incorporated the Horton Stance-Control Orthotic Knee Joint (SCOKJ) in the locked, unlocked, and auto (which provides knee stability during stance phase and knee flexion during swing phase) modes to investigate the biomechanical and energetic effects of stance-control orthoses. Studying nondisabled subjects allowed us to analyze the effects of stance-control orthoses in a homogenous population. In general, gait kinematics for the auto and unlocked modes were more similar than for the auto and locked modes. Despite the elimination of hip hiking in the auto mode, oxygen cost was not different between the auto and locked modes ($p > 0.99$). The SCOKJ allowed our nondisabled subjects to walk with a more normal gait pattern; however, future research should explore the effect of stance-control orthoses on persons with gait pathology.

Key words: energy expenditure, gait, KAFO, kinematics, knee-ankle-foot orthosis, orthotic device, oxygen cost, rehabilitation, SCOKJ, stance-control.

INTRODUCTION

Knee-ankle-foot orthoses (KAFOs) are often prescribed for patients with weakness of the muscles that control the knee and/or loss of structural integrity of the knee joint. Traditionally, the knee joints used in these orthoses were either locked or unlocked during ambulation depending on the level of stability required. However, walking with a locked knee for the entire gait cycle requires specific gait compensations, including hip hiking, vaulting, and circumduction, to create sufficient toe clearance during swing phase [1–3]. Other studies have demonstrated that these gait compensations tend to increase a person's energy expenditure [4–8]. While some patients may require the stability of a locked knee for the entire gait cycle, a subset of patients would benefit from a device that locks during stance phase to provide support for the weight-bearing limb and unlocks during swing phase to allow knee flexion, providing sufficient toe clearance by shortening the leg. Components exhibiting this behavior are referred to as "stance-control" devices.

Within the past few years, a number of stance-control orthoses have been developed for use in KAFOs. Each of

Abbreviations: ANOVA = analysis of variance, KAFO = knee-ankle-foot orthosis, MTP = metatarsal phalangeal, PCI = physiological cost index, PP = peak-to-peak, SCOKJ = Stance-Control Orthotic Knee Joint, SD = standard deviation, VA = Department of Veterans Affairs, VACMARL = VA Chicago Motion Analysis Research Laboratory.

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