Available online at www.sciencedirect.com
SCIENCE DIRECT
Gait and Posture 17 (2003) 142–151
GAIT & POSTURE
www.elsevier.com/locate/gaitpost

Adjustments in gait symmetry with walking speed in trans-femoral and trans-tibial amputees

Lee Nolan [a,*], Andrzej Wit [b], Krzysztof Dudziñski [b], Adrian Lees [a], Mark Lake [a], Michał Wychowañski [b]

[a] *Research Institute for Sport and Exercise Sciences, Liverpool John Moores University, Liverpool, UK*
[b] *Faculty for Rehabilitation, Academy of Physical Education, Warsaw, Poland*

Accepted 30 May 2002

Abstract

The effect of increased walking speed on temporal and loading asymmetry was investigated in highly active trans-femoral and trans-tibial amputees. With increasing walking speed, temporal gait variables reduced in duration, particularly on the prosthetic limb, while vertical ground reaction force (vGRF) increased in magnitude, particularly on the intact limb. Thus, temporal asymmetry reduced and loading asymmetry increased with walking speed. The greater force on the intact limb may reflect the method by which the amputees achieve greater temporal symmetry in order to walk fast, and could possibly account for greater instances of joint degeneration in the intact limb reported in the literature.

Keywords: Amputee gait; Asymmetry; Walking speed

1. Introduction

Amputees, by the nature of their prosthetic limb, are asymmetrical in their gait. The soft tissues of the residual limb (remaining part of the amputated limb) are not suited for load-bearing [1] and asymmetrical gait may be the means by which they protect their residual limb. Lower limb amputees have been reported to spend more time in stance on their intact limb and less on their prosthetic limb [2–4]. They load their intact limb more and their prosthetic limb less than able-bodied persons during natural cadence walking [4–6]. As a consequence, high forces repetitively applied to the intact limb can lead to pain and joint degeneration [7,8]. Up to 71% of unilateral lower limb amputees have reported pain in their intact limb and/or lower back [9–11]. Greater incidences of osteoarthritis have been found in the intact limb compared with the residual limb of trans-tibial amputees [9,12] and trans-femoral amputees [12]. A greater degree of degenerative joint disease has also been found in the intact limb and lower back of unilateral trans-tibial amputees compared with a matched group of able-bodied subjects [13].

The loading asymmetry between the intact and prosthetic limb may be expressed in terms of the vertical ground reaction force (vGRF) and impulse acting on the limbs. Able-bodied subjects have less than 10% force asymmetry during walking [14,15] while unilateral amputees have up to 23% force asymmetry depending on the type of prosthesis used [4,16–19]. The vertical impulse has also been shown to be greater on the intact limb than on the prosthetic limb for amputees [4], although the magnitude of vertical impulse asymmetry has not been reported. Asymmetry in walking over many years with a greater loading on the intact limb may be the cause of degenerative changes to weight bearing joints [9].

Limited data exist on the effect of walking speed on gait asymmetry. The vGRF has been reported to increase on both limbs of unilateral lower limb amputees with increasing walking speed, but more so on their intact limb. Zernicke et al. [16] reported in child trans-

* Corresponding author. Present address: Laboratory for Biomechanics and Motor control, Department of Neuroscience, Karolinska Institutet and Department of Sport and Health Sciences, University College of Physical Education and Sports, Box 5626, SE-114 86 Stockholm, Sweden

0966-6362/02/$ - see front matter
PII: S0966-6362(02)00066-8