# Detection of Gait Patterns in Challenging Environments



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## FALLS AND AGEING HEALTH CARE

One in three individuals over the age of 65 years (elderly) will fall at least once a year (James, 1993). This probability increases to one in two adults over 80 years (DHA, 2005). Consequently, gait modifications associated with ageing have been linked with increased falls' probability (Berg, Alessio, Mills, & Tong, 1997; Lord, Sherrington, & Menz, 2001). Despite an increasing research interest in recent times into the aetiology of falls, particularly in the elderly (>65 years), falls continue to be a major public health concern in Australia and worldwide. Fall-related injuries are the leading cause of accidental death in the elderly population, and account for the largest cause of hospitalisation for this population (Lord et al., 2001), with many elderly individuals experiencing physical, social, or functional ramifications following a fall. Consequently, the economic cost of falls to the public health system is escalating, with the total cost of fall injuries reported to be higher than road traffic injuries (DOH, 2004). The majority of falls associated costs include physician consultation, hospital stays, nursing homecare, rehabilitation, medical equipment, home modification and care, community based services, and prescription drugs and administration (DOH, 2004; Lord et al., 2001). Healthcare and related costs associated with falls are expected to double over the next 50 years (Close & Lord, 2006).

## GAIT CHARACTERISTICS AND TRIPPING

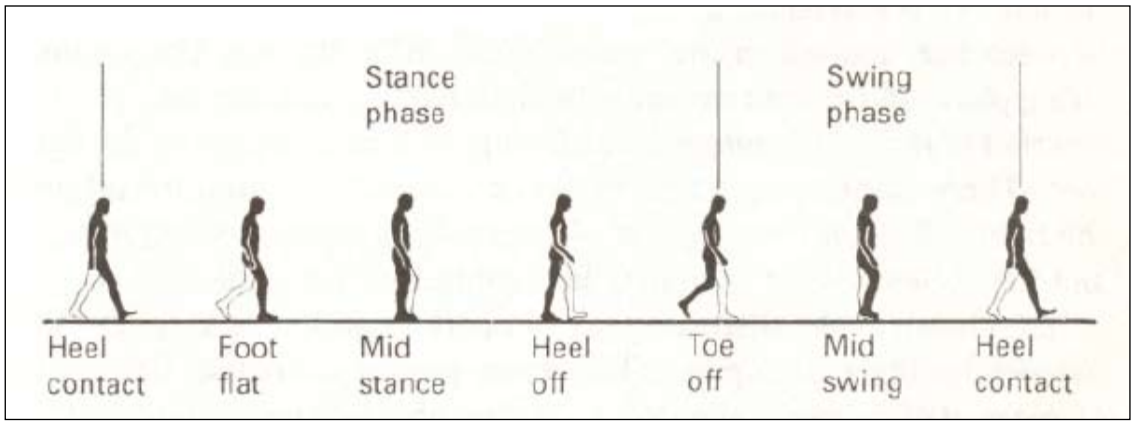
Walking or gait is the most common form of locomotion. A gait cycle is defined as the interval of time linking two successive occurrences of repetitive events of locomotion (most commonly foot contact/strike) (Kaufman & Sutherland, 2006; Whittle, 2003). The two main features of a gait cycle are standing and stepping, which are more technically known as stance and swing phases, respectively illustrated in Figure 1.

Typically the stance phase comprises approximately 60% of the gait cycle and is defined as the period when the foot is in contact with the ground. The swing phase makes up the remaining 40% of the cycle and is defined as the period between toe off to the second ipsilateral foot strike (i.e., when the foot is not in contact with the ground) (Kaufman & Sutherland, 2006; Russek, 1996; Winter, 1991). The purpose of the swing phase is to progress the body (most often in a forward motion), through sufficient clearance of the ground and to align the foot for the forthcoming heel contact. This is accomplished with the foot being swung through the air at a fast velocity and at a distance close to the ground (Perry, 1992; Winter, 1991).

Tripping refers to an unintentional disruption to the locomotion of the swing limb during a gait cycle, and consequently momentary suspension of the limbs' locomotion. This disruption can occur through an altercation with either the walking surface (ground) or an obstacle (e.g., mats, electrical cords) (AGC, 2002). Tripping is usually associated with two consequences: (i) stumble (in which balance is momentarily lost, however recovery occurs, and consequently does not result in a fall) or (ii) fall.

For safe uninterrupted trajectory during swing (to avoid tripping), the distance between the hip and the toe needs to be less than the distance between the hip and the ground surface or tripping hazard (Moosabhoy & Gard, 2006). The movements of the swing limb are a

*Figure 1. The events of the gait cycle (Adapted from Whittle, 1991)*




precise coordinated movement that is dependent upon a multisegment motor control chain of both stance and swing limbs (Winter, l991).

During the swing phase (60-100% of the gait cycle), the toe vertical trajectory undergoes two peaks as illustrated in Figure 2. Aforementioned, tripping avoidance is dependent upon adequate clearance of obstacles; it is the depression in vertical height between the two peaks in toe trajectory that is critical in order to avoid tripping (Weerdesteyn, Nienhuis, & Duysens, 2005; Winter, 1991). This drop in height is termed minimum toe clearance (MTC) and is a measurement between the lowest point of the foot (most commonly the toe) to the gradient of the walking surface during swing (Moosabhoy & Gard, 2006). The objective of MTC is to propel the limb forward with minimum energy expenditure (Perry, 1992). As a result of the timing, positioning, and velocity of the foot during low toe clearance, MTC height is the main contributing factor in tripping (Begg, Best, Dell'Oro, & Taylor, 2007; Murray & Clarkson, 1966; Winter, 1991).

Unfortunately gait modifications associated with ageing have been linked with an increased tripping risk and the ability to recover. Consequently, tripping is attributed as being the highest precipitating factor in elderly falls (35-40%) (Berg et al., 1997; Lord et al., 2001).

Prior investigations (Begg, Best, Dell'Oro, & Taylor, 2007; Winter, 1991) have found that the elderly demonstrate a lower MTC than the young and thus have an

*Figure 2. Illustrates the mean vertical displacement and vertical and horizontal velocity for the period of one cycle of nine participants walking a natural cadence in Winter (1991)*