Chapter 3.12
Wearable Systems for Monitoring Mobility Related Activities:
From Technology to Application for Healthcare Services

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ABSTRACT

Monitoring the performance of daily life mobility related activities, such as rising from a chair, standing and walking may be used to support healthcare services. This chapter identifies available wearable motion-sensing technology; its (potential) clinical application for mobility assessment and monitoring; and it addresses the need to assess user perspectives on wearable monitoring systems. Given the basic requirements for application under real-life conditions, this chapter emphasizes methods based on single sensor locations. A number of relevant clinical applications in specific older populations are discussed; i.e. (risk-) assessment, evaluation of changes in functioning, and monitoring as an essential part of exercise-based interventions. Since the application of mobility monitoring as part of existing healthcare services for older populations is rather limited, this chapter ends with issues that need to be addressed to effectively implement techniques for mobility monitoring in healthcare.

DOI: 10.4018/978-1-60960-561-2.ch312

INTRODUCTION

One of the major challenges in health care is the ability to timely initiate interventions that prevent loss of functional abilities and maintain or improve quality of life. The individual capacity for safe locomotion is a major indicator for independent functioning in older people. However, within the growing population of older people, safe and independent mobility can be at risk due to age-related diseases such as osteo-arthritis, Parkinson's or Alzheimer's disease, and stroke. In addition, older people may become inactive and develop frailty without overt pathology. The latter increases the incidence and impact of falls which are a major threat for health related quality of life in older people (Skelton and Todd 2004).

In the next decades, Europe will face a sharp increase, in both relative as well as absolute terms, in the number of older adults. This development is a result of an increasing number of older adults and an average ageing of the population. In 2008, less than 15% of the Dutch population was aged 65 or older; by 2040 this percentage will have increased and reached its peak at approximately 26% (CBS, 2009). Estimates of ageing in other European countries, such as Germany and Italy, are even higher (Eurostat, 2008). The demographic trend towards an ageing society poses social as well as economic challenges. While the demands on health care services are steadily increasing, the (relative) number of persons to give care and to finance health care decreases. Thus, there is a need to adapt health care services. New technologies may aid in providing solutions.

Effective interventions are needed to maintain functioning and prevent the loss of independent mobility in older people. Wearable technology for monitoring the performance of daily life mobility related activities, such as lying, rising from a chair, standing and walking may be used to support interventions, which aim to maintain or restore independent mobility. However, at present the routine-use of movement monitoring for the clinical management of care in older populations is limited. Therefore, this chapter aims to identify the potential relevance of wearable systems for monitoring mobility for exercise-based interventions and healthcare services by addressing: available wearable motion sensing technology and its application in methods for mobility assessment and monitoring; clinical applications of mobility monitoring; user perspectives on mobility monitoring; and present shortcomings that prevent an effective implementation of wearable solutions for mobility monitoring in health care services.

AVAILABLE WEARABLE TECHNOLOGY FOR MONITORING HUMAN MOVEMENTS

A general principle underlying studies of human movements is to consider the human body as a set of rigid bodies (e.g. foot, shank, or thigh), interconnected by joints (e.g. ankle, or knee). Human movement analyses thus require measuring the kinematics of one or more body segments, e.g. by a camera-based system for position measurements or by different motion sensors. The resulting kinematic data are input into further analyses. Depending on research aims, measurements may be simple (e.g. head or trunk position to study walking distance and speed), or highly complex (e.g. full-body measurements to study inter-segmental dynamics). Recent developments in the miniaturization of movement sensors and measurement technology have opened the way for wearable motion sensing technology (Bonato 2005) and the ambulatory assessment of mobility related activities (e.g. Aminian & Najafi 2004, Zijlstra & Aminian 2007). The recent advances even allow full-body ambulatory measurements by motion sensors. However, since monitoring techniques need to be applied over long durations and under real-life conditions, a number of feasibility criteria should be taken into account. These criteria encompass technical criteria (e.g.