REVIEW ARTICLE (META-ANALYSIS)

Review of Accelerometry for Determining Daily Activity Among Elderly Patients

Vivian H. Cheung, MBiomedE, Len Gray, MBBS, PhD, Mohanraj Karunanithi, PhD

ABSTRACT. Cheung VH, Gray L, Karunanithi M. Review of accelerometry for determining daily activity among elderly patients. Arch Phys Med Rehabil 2011;92:998-1014.

Objectives: To review studies that used accelerometers to classify human movements and to appraise their potential to determine the activities of older patients in hospital settings.

Data Sources: MEDLINE, CINAHL, and Web of Science electronic databases. A search constraint of articles published in English language between January 1980 and March 2010 was applied.

Study Selection: All studies that validated the use of accelerometers to classify human postural movements and mobility were included. Studies included participants from any age group. All types of accelerometers were included. Outcome measures criteria explored within the studies were comparisons of derived classifications of postural movements and mobility against those made by using observations. Based on these criteria, 54 studies were selected for detailed review from 526 initially identified studies.

Data Extraction: Data were extracted by the first author and included characteristics of study participants, accelerometers used, body positions of device attachment, study setting, duration, methods, results, and limitations of the validation studies.

Data Synthesis: The accelerometer-based monitoring technique was investigated predominantly on a small sample of healthy adult participants in a laboratory setting. Most studies applied multiple accelerometers on the sternum, wrists, thighs, and shanks of participants. Most studies collected validation data while participants performed a predefined standardized activity protocol.

Conclusions: Accelerometer devices have the potential to monitor human movements continuously to determine postural movements and mobility for the assessment of functional ability. Future studies should focus on long-term monitoring of free daily activity of a large sample of mobility-impaired or older hospitalized patients, who are at risk for functional decline. Use of a single waist-mounted triaxial accelerometer would be the most practical and useful option.

Key Words: Acceleration; Ambulatory monitoring; Motor activity; Movement; Walking; Rehabilitation; Review literature.

© 2011 by the American Congress of Rehabilitation Medicine

From the Centre for Research in Geriatric Medicine, School of Medicine, The University of Queensland, Brisbane (Cheung, Gray); and Australian E-Health Research Centre, Commonwealth Scientific and Industrial Research Organisation Information & Communication Technologies Centre, Brisbane, Queensland, Australia (Cheung, Karunanithi).

No commercial party having a direct financial interest in the results of the research supporting this article has or will confer a benefit on the authors or on any organization with which the authors are associated.

Reprint requests to Vivian H. Cheung, MBiomedE, Centre for Research in Geriatric Medicine, School of Medicine, The University of Queensland, Level 2, Bldg 33, Princess Alexandra Hospital, Ipswich Rd, Woolloongabba, QLD 4027, Australia, e-mail: *v.cheung@uq.edu.au*.

0003-9993/11/9206-00762$36.00/0
doi:10.1016/j.apmr.2010.12.040

THE GOALS OF IN-HOSPITAL geriatric rehabilitation units are to improve the functional status of frail functionally impaired older patients and decrease their chance of discharge into institutional long-term care.[1-5] However, studies showed that activity levels of older patients in rehabilitation wards are very low, and that they spend very limited time performing activities that could contribute to their recovery.[6-8] Hence, this may contribute to increase length of hospital stay, nursing home placement, readmission, mortality, and health care costs.[9] Monitoring the activity of older hospitalized patients may assist in patient management to improve mobility and functional independence,[10-12] especially for those undergoing rehabilitation. In day-to-day clinical practice, quantitative assessment of patient activity rarely is performed.

Previous studies that performed monitoring and recording of patient activity in hospital used 2 common approaches: direct observation[6] and interview/survey.[13,14] However, these methods are not practical for daily routine monitoring in hospital wards because direct observation is time consuming and resource intensive[6] and interviews/surveys with patients or clinical staff are subjective and potentially biased, particularly from patients who tend to overestimate their physical abilities.[13,14] Other research studies investigated the feasibility of technology-based monitoring techniques to record daily activities. These included the use of infrared, magnetic, and carbon dioxide sensors[15-18]; cameras[19-21]; pedometers[22-24]; and accelerometers.[24-26] Although use of infrared, magnetic, and carbon dioxide sensors and cameras is limited to monitoring subjects indoors, body-worn pedometers and accelerometers are versatile in providing continuous ambulatory monitoring. Pedometers have been used widely during the last decade to record activity in health applications, personal monitoring, and sports. However, the type of activity information derived from using pedometers has been limited to the step counts accumulated,[25] and not the pattern and/or duration of walking, which are important determinants for the management of rehabilitation patients. Furthermore, pedometers often have underestimated the number of steps during either slower gait speed or irregular and/or unsteady gait patterns, as found in frail older patients.[25] However, the evolution of accelerometer technology during the last decade[25-27] has provided the capacity to overcome this limitation in activity monitoring by providing the frequency and intensity of activity through raw acceleration signals. Hence, information about the chronology and duration of activities can be gathered by using accelerometers.

Developments in accelerometer technology during the last decade have evolved from uniaxial to triaxial accelerometers, improving measurements of acceleration from 1 to 3 axes, respectively. Although this advancement in accelerometers has given the capacity for 3-dimensional spatial movement measurement, characterization of the different activities relies on the extraction and analysis of acceleration signals through accurate and reliable algorithms. Such analysis would not only determine intensity (light, moderate, vigorous),[26-36] but also provide classification (lying, sitting, standing, walking, postural transitions)[37-45] of physical activity. While accelerometer devices have been used solely for activity intensity data in the form of "activity counts per minute,"[26-36] raw acceleration signals have been used to extract the classification of activities into different postures, postural transitions, or walking patterns.[37-45] Some leaders in the field of accelerometry activity monitoring include Lovell and Celler and colleagues,[42,44,46-52] Bussmann and Stam and colleagues,[37,53-56] and Culhane[41] and Lyons[32] and colleagues. Their research studies varied in regard to sample size, subject age and mobility status, type and number of accelerometer devices used, body positions of device attachment, and study setting.

The purpose of this article is to provide a critical review of all validation studies that used raw acceleration signals to classify daily activities in terms of postures, postural transitions, and walking, with a primary focus on the reliability and practicality of accelerometers for monitoring the activity of older or mobility-impaired patients for routine clinical practice.

METHODS

Search Strategy

This literature search was conducted using the MEDLINE and Cumulative Index to Nursing and Allied Health Literature (CINAHL) electronic databases provided by the EBSCOHost Research Database platform and the Web of Science electronic database from the ISI Web of Knowledge platform. To retrieve all relevant publications, key word searches were used to match words in the title, abstract, or key words field. These key words included activities of daily living, activity pattern, activity level, physical activity, motor activity, movement, mobility, accelerometer, accelerometry, movement classification, activity classification, ambulatory monitoring, mobility monitoring, sensitivity, specificity, and accuracy. A hand search was performed to ensure that all relevant publications were collected. The Cochrane Library also was used to search for review articles related to accelerometer devices applied in the field of activity monitoring or classification. However, no such review articles were found.

Selection Criteria

This literature search was conducted with the limitation criteria applied on databases that would return publications in English between January 1980 and March 2010. The choice of this date range was based on the period that accelerometer devices have been used for human movement detection. After discarding duplicates from the database searches, 526 articles were returned. From the review of abstracts, only publications that validated the use of raw acceleration data to classify postures, postural transitions, and walking were included in this review. Accelerometry studies that classified activities by intensity level were excluded. Figure 1 shows the flowchart of the search and filter process used in this literature review.

RESULTS

The literature search identified 54 journal articles that described the use of raw acceleration data to classify postures and mobility of human subjects. Raw acceleration data have been used in activity monitoring research since 1996. Data extracted from these journal articles included subjects' health status, sample size, age range, accelerometer devices used in studies (type, number, body positions of attachment), collection of validation data (study setting, duration of data collection), and activity classification algorithms/methods used in the studies. Details of each study are listed in table 1. Of 54 studies, 51 focused on the validation of basic postures, such as lying, sitting, standing, and walking,[37-51,53-55,57-88] and 3 focused on the differentiation of static versus dynamic activities.[52,56,89]

Participant Information

Of the accelerometer studies included in this review, 17 were conducted on patients and the remaining were conducted on healthy subjects (37 studies). The patients studied included those with failed back surgery,[37] low-back pain,[60,69] congestive heart failure,[55] stroke,[79,83] hypertensive/cardiac disease,[63,90] Parkinson's disease,[45] undergoing rehabilitation,[41,43,89] and amputees.[53,67] The sample population in these studies ranged from children to older adults. Thirty-four studies involved teenage to adult participants with a mean age range of 17 to 60 years,[37,39,42,46-56,60-66,68-70,74-76,78,79,82,83,86-88] and only 10 studies involved older subjects with a mean age of 60 years or older.[40,41,43-45,72,77,80,85,89] Of studies involving older patients, only 6 were at the hospital and/or with a rehabilitation need.[41,43,45,72,77,89] Most of the remaining studies were in healthy adult subjects with unreported age groups.

Most studies were limited by small sample size. Of the studies, 54% had 10 or fewer subjects,[37,38,40,41,43,44,47,53-57,59,60,62,69-76,79,81-84,89] whereas 12 studies had 11 to 20 subjects[45,49,51,64,66-68,78,80,86-88] and 11 studies had 20 or more subjects.[39,42,46,48,50,52,61,63,65,77,85] Of the 6 studies with older patients, only 1 involved more than 20 patients,[77] and the rest had 6 or fewer patients.[41,43,45,72,89]

Accelerometer Devices Used in the Studies

Types of accelerometer devices used in the studies throughout the literature varied. Of 54 studies included in this review, 15 used uniaxial,[37-39,53-56,59-62,65,67,76,83] 13 used biaxial,[40,41,43,45,57,63,64,66,71-74,77] and 26 used triaxial[42,44,46-52,58,68-70,75,78-82,84-90] accelerometer devices. Most studies before 2000 used uniaxial devices,[37-39,53-56,59-61,67] whereas most studies between 2000 and 2007 used biaxial devices.[40,41,43,45,57,63,64,66,72,73] From 2008 onward, most studies used triaxial accelerometer devices (16 of 21 studies).[50,51,58,68-70,75,78-82,84-86,89]

The magnitude of acceleration during human movements is related to the activity(s) performed, as well as the position of device attachment. Each accelerometer device is sensitive to acceleration generated within only the specified measurement range. Devices used in 15 of the identified studies had a measurement range of $\pm 6g$,[39-41,43,45,54,56,60,61,63,65,75,80,83,86] whereas 10 other studies used devices with a measurement range of $\pm 6g$ or more.[42,46,47,50-52,58,59,64,68] The frequency at which accelerations were sampled varied across devices. Four studies used devices with a sampling frequency less than 20Hz,[37-39,54] and 33 had a sampling frequency of 20Hz or greater.[40-47,49-53,55-58,61,63-65,68,71,74,75,78,79,82,83,86-88,90]

The number of accelerometer devices attached on the subjects and the body position(s) of device attachment varied across the literature. Of the 54 studies in this review, 23 used 3 or more devices,[37,39,53-57,59-62,64,66,67,71,73,76,80,83,86-89] 10 used 2 devices,[38,41,43,63,65,68,72,74,77,79] and 21 used only 1 device.[40,42,44-52,58,69,70,75,78,81,82,84,85,90] Most studies that used uniaxial accelerometer devices were through multiple attachments on the same body position of interest to compensate for the missing directional information.[37,53-56,59-62,67,76] Body positions used in these studies included the subject's sternum, thigh, back, waist, shoulder, and lower leg. The most commonly used body position was the waist,[42,44,46-52,70,75,81,84,86,90] most of which were studies that used a triaxial accelerometer device. Of the 6 older patient studies found in this review, 4 had 2 biaxial accelerometer devices attached to the sternum and

Download English Version:

https://daneshyari.com/en/article/3449170

Download Persian Version:

https://daneshyari.com/article/3449170

Daneshyari.com