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Annals of Physical and Rehabilitation Medicine 56 (2013) 384–395

Elsevier Masson France
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Original article / Article original

Contribution of new techniques to study the gait in old populations

Contribution des nouvelles techniques à l'étude de la marche chez la personne âgée

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Received 28 June 2012; accepted 25 May 2013

Abstract

Objectives. – For several years, the concept of “physiological senile gait” has been strongly contested and seems to be associated with abnormal gait. Indeed, some changes characteristic of senile gait appear early on in subjects with neurodegenerative pathologies. The aim of this article was to determine how recent contributions can improve the study of gait in old populations. This paper is a thematic review of recent contributions from medical imaging techniques as well as instrumental gait analysis techniques in older adults. This article did not focus on Parkinson’s disease or other specific diseases bearing certain gait disturbances, since they belong to literature focusing on these particular disorders.

Material and methods. – This work was not intended as a systematic review but only as a thematic one conducted by geriatricians in order to review the recent literature in order to better apprehend how new techniques could be implemented within their clinical practice. Articles were selected in online Medline and Cochrane Library databases, and some were previously identified by the authors.

Results. – This paper highlights the most recent contributions in magnetic resonance imaging, functional magnetic resonance imagery, positron emission tomography and instrumental gait analyzing devices better understanding the underlying gait mechanisms in elderly populations.

Conclusions. – This thematic review suggests that gait could be considered as a marker of “successful aging”. Its evaluation associated to longitudinal follow-up could be useful to predict cognitive and functional changes in frail older adults.

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Keywords: Gait; Aging; Imagery; Cognitive; Instrumental

Résumé

Objectif. – Depuis quelques années, le concept de « démarche sénile physiologique » est fortement contesté. Certaines modifications de la marche présentes chez le sujet âgé semblent le plus souvent être associées à des processus pathologiques débutants. Cet article propose une revue thématique des apports récents obtenus par les techniques d’imagerie médicale et les techniques instrumentales d’analyse de la marche appliquées aux personnes âgées. La maladie de Parkinson ainsi que d’autres pathologies incluant des modifications de la marche déjà décrites lors de publications spécifiques, ne sont pas spécifiquement évoquées dans cet article.

Matériel et méthodes. – Les références citées dans cet article ont été en partie sélectionnées en recherchant dans la Cochrane Library et dans Medline. Certains articles utilisés étaient déjà connus des auteurs. Cet article ne prétend pas être une revue systématique mais une revue thématique faite récemment par des gériatres cliniciens afin de rassembler les données récentes de la littérature et envisager leur intégration lors de leur pratique quotidienne.

Résultats. – Cet article résume les contributions récentes de l’imagerie par résonance magnétique structurale et fonctionnelle, de la tomographie par émission de positons et des instruments d’analyse des paramètres de marche permettant une meilleure connaissance des mécanismes sous-jacents de la démarche chez les personnes âgées.

Conclusion. – La qualité de la marche pourrait être considérée comme un marqueur de « vieillissement réussi » et l’analyse de sa détérioration pourrait aider à prévoir les changements cognitifs et fonctionnels y afférant.

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Mots clés : Marche ; Vieillesse ; Imagerie ; Cognition ; Instrumentale

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1. English version

1.1. Introduction

Over the last few years, studying gait in older adults has raised a great deal of interest. Indeed, gait changes can lead to falls increasing the risk of institutionalization, functional decline and onset of comorbidities [39]. Therefore, gait changes in older adults can be considered as a frailty marker. Recent studies have underlined that changes in certain gait parameters could be considered as a sign of cognitive frailty [11,37]. Therefore, the concept of a “physiological senile gait” has been strongly argued and the question in fact remains: Is the “physiological senile gait” truly physiologically norm or could it reflect the onset of some pathological disorders, such as cognitive ones, leading to falls? Furthermore, could there be a cut-off discriminating healthy older adults from frail ones?

It is well known that gait results from a motor command stemming from the central nervous system and is executed by the peripheral nervous system. The execution of this motor command involves not only the vestibular and peripheral nervous systems but also good quality osteoarticular and muscle features, without forgetting the cardiovascular system. Clinical features are the first step to evaluate gait, including thorough medical history (surgeries, treatments, and preexisting diseases), physical examination and other clinical tests, these elements are essential to understand the locomotor abilities in elderly populations. Nevertheless, nowadays there are two core components for analyzing in-depth gait features: anatomical and functional analysis of the central nervous system in charge of managing motor commands and measures of gait spatiotemporal parameters. In fact, motor command organization can be studied through imaging techniques such as magnetic resonance imaging (MRI), functional MRI (fMRI) and positron emission tomography (PET). The tests and tools for gait analysis used in daily clinical practice have shown their limits compared to instrumental gait analysis [11,43]. Walkway and accelerometric methods allow analyzing spatiotemporal gait parameters and these techniques have recently been used in old populations. The purpose of this article is to comment new, useful and promising techniques for gait analysis in elderly subjects. This article did not specifically focus on Parkinson’s disease or other pathologies where gait changes have already been defined in specific domains within the literature.

1.2. Method

The aim of this article was not to conduct a systematic review of the literature with precise inclusion or exclusion criteria, but instead to propose a thematic review based the most recent articles and those already known by the authors. The literature selection was based on:

- their contribution to the cover a large overview input within a large review of gait analysis;
- experience of the working team in gait studies;

- practical aspect of the knowledge contained within the article. In a second time, the references of each article were studied and some articles were selected by this way.

To select the most recent articles, we carried out a search in the Cochrane Library using the keywords “gait AND older”. This resulted in eight articles but in fact, only two were focused on gait (specifically gait rehabilitation) in older adults. In the same database, using the keywords “gait AND elderly”, only one article was found and this article only concerned gait rehabilitation. No articles were found on the input of medical imaging and instrumental gait analysis.

We searched for articles in MEDLINE with the same keywords and limited our search to “items with links to full text, Human, English, French and Age > 65 years published within the last 10 years”. We found more than 900 references. The most interesting references were selected based on the previously reported criteria. Forty-seven abstract were initially considered to amount to a final of 12 articles.

1.3. Results

1.3.1. Medical imaging contribution

1.3.1.1. Magnetic resonance imaging. Table 1 lists the following commented studies. Zimmerman [46] highlighted a correlation between the anatomical structures of the hippocampus and changes in gait parameters. In a group of 48 cognitively healthy older adults, mean age of 81 years, hippocampus volume was measured using volumetric MRI and its metabolism evaluated by proton nuclear magnetic resonance spectrometry. A correlation between step length and hippocampal volume was unveiled, as well as a relationship between step length variability and hippocampal metabolism. Some studies reported a relationship between vascular lesions and gait changes [24,26]. A recent study evaluated mobility in 331 adults with no history of strokes and not affected by dementia or Parkinson’s disease. In this group of healthy older adults, the vascular lesions in the white matter and subclinical strokes were associated with slower gait speed, shorter stride length and longer double support time [30]. Furthermore, the same study indicated a relationship between a greater step length variability and higher prevalence of infarcts, including basal ganglia infarcts [31].

Morphological MRI has also promoted the “vascular” theory to explain gait changes in relations to cognitive disorders linked with aging. Age itself has been related to microangiopathy. In two similar publications, the role of arteriosclerotic brain lesions in the development of dementia in patients with mild cognitive impairment (MCI) has been demonstrated [14,28].

In previous studies, vascular lesions have been identified as a significant risk factor for developing gait changes and/or cognitive decline. The risk of falls depends on how vascular lesions are distributed in the frontal region in charge of executive functions and organization of motor commands. Another study highlights the relevance of subcortical lesions not only in frontal regions but also in seven specific regions: frontal, temporal, parietal, and occipital lobes, basal ganglia,

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