[The relationship between reduced knee-ankle proprioception and impaired gait in patients following stroke]

A Narrative Review
The relationship between reduced knee-ankle proprioception and impaired gait in patients following stroke.

A narrative review

Authors: A. Polak, M. van Ruiten

Coach: Dr. M. van der Esch

Amsterdam School of Health Professions, Department Physiotherapy, Tafelbergweg 51
1105 BD, Amsterdam.
Abstract:

**Introduction:** Gait remains abnormal in 70 percent of stroke patients after rehabilitation. One of the suggested factors responsible for the impairment in gait is reduced proprioception.

**Aim:** The aim of this study was to evaluate the relationship between reduced knee or ankle proprioception and impaired walking in established stroke patients.

**Method:** A structural database search was performed and the studies that met the inclusion criteria were selected for this narrative review.

**Results:** A relationship was found between reduced proprioception and impaired gait in chronic stroke patients. No relationship was found between reduced proprioception and impaired gait in acute and sub-acute stroke patients.

**Conclusion:** A relationship was found between impaired proprioception of knee or ankle and impaired walking in established chronic stroke patients. More research is needed to support these findings.
The relationship between reduced knee-ankle proprioception and impaired gait in patients following stroke.

Introduction

Gait remains abnormal in 70 percent of stroke patients after rehabilitation. These abnormalities vary from reduced walking distance and walking speed to the inability to walk independently. One of the suggested factors responsible for the impairment in gait is reduced proprioception. Proprioception according to Langhorne et al. is one of the most relevant body functions affected after stroke. A reduction of proprioception in the lower extremities can lead to impaired gait. However, only few studies investigated the relationship between reduced proprioception in the lower extremities and impaired gait post-stroke.

Following stroke different treatment approaches are used to improve gait. None have been found to be superior in improving walking. Currently, the Dutch Clinical Practice Guideline for Physical Therapy in Patients with Stroke, recommends walk training, using Body Weight Supported- Treadmill Training (BWSTT) and regular treadmill training. Treatment forms other than functional walk training with or without body weight support are not recommended in the Netherlands, due to lack of efficacy. However, the Australian Clinical Guidelines for Stroke Rehabilitation and Recovery also suggests joint position biofeedback with or without conventional therapy. In addition, Langhorne et al. recently recommended position feedback through biofeedback and moving platform training next to regular walk training. In this narrative review, two components of proprioception in patients post-stroke will be assessed, namely Joint Position Sense (JPS), and Joint Motion Sense (JMS) of the knee and the ankle.

Before studying the effect of improved proprioception on walking ability by exercise in patients post-stroke, the association between proprioception and walking ability has to be established. Therefore, the aim of the study is establish the positive relationship of impaired knee or ankle proprioception to impaired walking in established stroke patients by searching the literature.

Methods

Design: narrative literature review.

Databases: For this literature study a search was performed in online databases. Databases that were used are; Pubmed, Cochrane, Scopus, Google and GoogleScholar. The limits on the searches were English language and the availability of the articles online. The time limit of the search was no articles older than 2005.

Search strategy: Three searches were performed with the following keywords and strategies:
Keywords 1: Stroke [Mesh] OR (cerebrovascular accident) OR (ischemic stroke) OR (cerebral infarction) OR (brain ischemia) OR (intracranial hemorrhage) OR (intracerebral hemorrhage) OR (cryptogenic hemorrhage) OR (total anterior circulation infarct) OR TACI OR (partial anterior circulation infarct) OR PACI OR (lacunar infarct) OR LACI OR (posterior circulation infarct) OR POCI
Knee-ankle proprioception and impaired gait following stroke.

Keywords 2: Proprioception [Mesh] OR (proprrioceptive acuity) OR (joint motion sense) OR (joint position sense) OR (proprioceptive sense) OR (impaired proprioception) OR (reduced proprioception) OR (impaired joint position sense) OR (impaired joint motion sense) OR (reduced joint position sense) OR (reduced joint motion sense)

Keywords 3: (walking impairment)[Mesh] OR (walking disability) OR (reduced walking capacity) OR (gait impairment) OR (gait disability) OR (peripheral disability) OR (walking) OR (gait) OR (walk) OR (gait characteristics)

Searches performed: 1 AND 2; 1 AND 3; 2 AND 3; 1, 2 AND 3

Inclusion criteria: After the database research three hundred articles were found. Inclusion criteria: English language, proprioception of knee or ankle, acute, sub-acute and chronic stroke patients, walking impairment, and the ability to walk independently with or without walking aids. Four articles were admitted in this review.

Results

Four studies were found that met the inclusion criteria. Studies used are published between 2005 and 2007; no studies were found after 2007. All studies used an observational design.

The total number of subjects used in the four studies is n= 150. All subjects were diagnosed with a first time, unilateral stroke. Of the subjects, 9 were acute stroke patients (SD 8.1 days post stroke) Error! Bookmark not defined., 9 sub-acute (duration not specified) Error! Bookmark not defined. and 132 chronic.Error! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined. Twelve of the subjects suffered a hemorrhage and 20 patients an infarct.Error! Bookmark not defined. Error! Bookmark not defined. Nineteen subjects were left-sided hemiplegic, 20 right-sided.Error! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined. The remaining patients were only described to have suffered a stroke and were not specified to side or type of lesion. In one study type and side of lesion of the subjects are not presented.Error! Bookmark not defined. None of the studies used information about the type or side of the stroke in the data analysis. The four studies were evaluated for design, assessment and outcome as presented in Table 1.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Proprioception</th>
<th>Gait</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Author/year</strong></td>
<td><strong>n</strong></td>
<td><strong>Subjects</strong></td>
</tr>
<tr>
<td>Lee et al. (2005)</td>
<td>21</td>
<td>chronic</td>
</tr>
<tr>
<td>Lin et al. (2005)</td>
<td>21</td>
<td>chronic</td>
</tr>
<tr>
<td>Soyuer et al. (2007)</td>
<td>100</td>
<td>chronic</td>
</tr>
<tr>
<td>Winward et al. (2007)</td>
<td>18</td>
<td>Acute and sub-acute</td>
</tr>
</tbody>
</table>

Abbreviations: JPS, joint position sense; MS, motion sense; 6 MWT, 6 minute walk test; RMA, Rivermead Motion Assessment; RASP, Rivermead Assessment of Somatosensory Performance
**Design:** One study used a case control design and three a case series design. Lee et al. used a case-control setting to assess whether sense of movement is impaired at the ankle in subjects post-stroke, capable of walking independently (with or without walking aid). The 11 subjects were compared with 10 neurologically healthy subjects. Lin et al. presented a case series to determine the association between JPS of the knee and ankle and gait performance in 21 patients with chronic stroke (≥1 year). Winward et al. used case series to characterize the somatosensory recovery pattern of stroke patients in the first 6 months post-stroke in 18 subjects. Soyuer et al. studied the effects of spasticity, sensory impairment, and type of walking aid on falls in community dwellers with chronic stroke, using a case series setting. Soyuer et al. studied 100 chronic stroke patients (≥6 months post-stroke).

**Assessment:** To evaluate proprioception, one study used a ramp generator, two studies used a 2-inclinometer and one study used the Rivermead Assessment of Somatosensory Performance (RASP). Lee et al. used a ramp generator, a device that produces movements up to 0.001 degree to measure motion sense. Lee et al. measured the affected and non-affected ankle in both plantar- and dorsal flexion. Lin et al. and Soyuer et al. used a 2-inclinometer to measure the JPS. The 2-inclinometer is a computerized system which measures the position of the joints. JPS was measured by matching the unaffected joint to the affected joint of the knee and ankle. The absolute values of the differences in the angle between the 2 matching joints was recorded. Winward et al. used the RASP subtest 5 to evaluate JMS. The RASP was designed to develop a standardized, quantitative assessment of somatosensory performance in patients after stroke. Subtest 5 evaluates JMS in toe and ankle in both the affected and unaffected side. JMS was divided into detection of movement and detection of direction of the joint measured. The patients were asked if passive movement took place and in which direction movement took place.

Different assessments were used to evaluate gait. Lee et al. measured gait using the 6 Minute Walk Test (6 MWT). Lin et al. evaluated gait using a Vicon motion analysis system\(^a\) in a 10 meter walkaway. Vicon motion analysis system\(^a\) consists of 6 camera’s to record information from reflective markers placed on the joint to review gait kinematics. Gait characteristics measured were gait velocity, stride length, step length, swing time, single-stance time, double- support time. Soyuer et al. used the Rivermead Motion Assessment part A (RMA) and the second part of Tinetti Assessment Tool to evaluate gait. The RMA part A consists of the following subtest to measure gait; walk 10 m indoors with an aid, walk 10 m indoors without an aid, walk 40 m outside, run 10 m. The Tinetti Assessment Tool consists of a balance and a gait section. The gait section assesses indication of gait, step length and height, foot clearance, step symmetry, step continuity, path, trunk and walking time. Winward et al. used the Barthel-Index (BI) to assess the Activity Daily Living (ADL). A part of the BI evaluates mobility.

**Outcomes:** Both Soyuer and Winward et al. do not give information about the gait outcomes Lee et al. found approximately 60% of the subjects to have impaired proprioception at the ankle in dorsiflexion and plantar flexion. The motion sense in the unaffected ankle was not significantly different to that of the control group. Lin et al. found 62% of the subjects to have impaired proprioception. Thirty-three percent of which had an affected knee JPS, and 29% an affected ankle JPS. Soyuer et al. found a difference in knee JPS of repeat fallers compared to non fallers and one time fallers. No difference was found concerning impairment in the ankle JPS (\(p>0.05\)). Winward et al. found that 5 of 9 acute subjects scored 100% accuracy on the RASP sub-test 5 one month post-stroke, 2 subjects scored 80-93% accuracy.
Six of 9 subjects of the sub-acute group, achieved 97-100% accuracy in JMS by 33 weeks. Winward et al found proprioception generally less impaired than other somatosensory modalities. Proprioception demonstrated the greatest level of recovery.10

Lee et al. found joint motion sense at the ankle to be moderately related to walking distance (Spearman’s rho = 0.63 to 0.77; p < 0.05). Error! Bookmark not defined. The distance walked by the subjects in the 6MWT was significantly less (p = 0.01) than the distance walked by the control group.

Lin et al. found impaired ankle JPS to show a significant contribution in the variance gait velocity and stride length.

Soyeur et al. found a relationship between repeat fallers and impaired knee JPS (F=7.45, p=0.001), compared to non fallers and one time fallers. Falling was a consequence of impaired gait.

Winward et al. studied the relationship between impaired proprioception and ADL, including walking.

Discussion

The aim of this study was to establish the relationship between proprioception and gait in stroke patients. It was hypothesized that reduced proprioception is positively associated with impaired gait in established stroke patients. In this narrative review it was found that reduced proprioception was associated with impaired gait in chronic stroke patients. However, the evidence for this association is weak, due to the limited number of studies found and the small number of subjects used. No relationship was found between reduced proprioception and impaired gait in acute and sub-acute stroke patients.

Comparison between the four studies is hampered by the different assessment methods and by the difference in assessment outcomes. In spite of these differences, the relationship between reduced proprioception and impaired gait in chronic stroke patients seems acceptable and might be important for clinical rehabilitation of stroke patients.

The results of this narrative review show an important aspect of assessment and treatment of stroke patients with impaired gait. Information in guidelines about impaired walking and the influence of reduced proprioception is absent or not clear. The Dutch Clinical Practice Guideline for Physical Therapy does not ascribe a role to proprioception in relation to impaired gait. The Australian Clinical Guidelines for Stroke Rehabilitation and Recovery suggest joint position biofeedback with or without conventional therapy. However, to support this statement more research is needed in order to establish the relationship between proprioception and gait, as well as to study the effect of proprioceptive training on walking ability.

In other central neurological diseases, research on the relationship between proprioception and gait showed that proprioception training improved walking ability.10 The Parkinson’s disease guideline recommends the use of proprioceptive cues to manage impairments of gait.11

This narrative review has limitations. There was a time limitation of 15 weeks to conduct the research and to write the review. The Cochrane methods were not used in this review. There was a limitation in language, only studies written in the English language were admitted. The number of studies found and the small amount of subjects used in this review is low. In spite of these limitations, a lack in research concerning the relationship between proprioception and gait in stroke patients was found. Our results indicate that future studies are needed with the aim to improve the assessment and therapy of patients following stroke and impaired walk.
Future studies should focus on impaired proprioception of all joints of the leg. It is suggested to measure both JMS and JPS in order to evaluate proprioception in the joint. In the four studies used in this review, either JPS or JMS was measured. However, JMS and JPS describe different functional proprioceptive characteristics of joints. Future studies should also focus on the assessment of gait in stroke patients. There are many reliable methods to assess gait. In the studies both speed or distance were measured, as well as spatio-temporal analysis to evaluate gait. The spatio-temporal gait analysis system gives more information about the impaired gait characteristics. However, recent literature recommend the 6MWT to evaluate gait. Future studies should use the 6MWT to assess gait.

Finally, the type and number of patients is of importance. No relationship was found between reduced proprioception and impaired gait in acute and sub-acute stroke patients. However, in chronic stroke patients a relationship between proprioception and gait was found. Therefore we recommend to assess established, stable chronic stroke patients in future studies, because in this phase sequels become apparent. The observational studies found used small number of patients. Therefore, future studies should include more than 100 patients with the aim to improve the statistical power of the study.

Studies used the ankle or the knee to study proprioception in relation to gait. Some authors also found an influence of hip complaints in abnormal gait following stroke. No studies were found on hip proprioception. Future studies should also include hip proprioception assessment. A complete insight of proprioception in the lower extremity will benefit future treatment of impaired gait following stroke.

**Conclusion**

A relationship was found between impaired proprioception of knee or ankle and impaired walking in established chronic stroke patients. More research is needed to support these findings.
References

9 Clinical Guidelines for Stroke Rehabilitation and Recovery. Australian National Stroke Foundation; 2005
11 Graziano M. Illustrations of Physiotherapy Interventions in Parkinson’s Disease. European neurological review 2008; (2).

Vicon 370; Vicon Motion System, 14 Minns Business Park, West Way, Oxford, OX2 0JB, UK.