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REVIEW ARTICLE (META-ANALYSIS)

Effect of Chemodenervation of the Rectus Femoris Muscle in Adults With a Stiff Knee Gait Due to Spastic Paresis: A Systematic Review With a Meta-Analysis in Patients With Stroke

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Abstract

Objective: To determine the effect of motor branch block (MBB) or neuromuscular block (NMB) of the rectus femoris on knee kinematics during swing, functional outcome, and energy cost in adults with spastic paresis presenting a stiff knee gait.

Data Sources: PubMed, Embase, CINAHL, and Cochrane Library were searched. Studies were collected up to February 26, 2013. Reference lists were additionally scrutinized.

Study Selection: No restrictions were applied regarding study design. Patients were adults suffering from a central neurological disorder. Interventions had to include MBB or NMB. Outcome measures had to include knee kinematics during the swing phase. Study selection was independently performed by 2 reviewers.

Data Extraction: Two reviewers independently assessed the methodological quality of included studies. Data on kinematics, functional outcome, and energy cost from patients with stroke were extracted from the total population and when possible pooled.

Data Synthesis: A total of 9 articles describing 12 different studies were included. Knee kinematics (peak knee flexion or knee range) during swing improved significantly in all the included studies. The average increase in peak knee flexion varied from 1.9° to 15.4°. Data pooling of peak knee flexion in patients with stroke showed a significant improvement of 7.37° ($P=.000$) in NMB studies and of 9.35° ($P=.002$) in MBB studies. Data pooling of knee velocity at toe-off showed a significant improvement of 53.01°/s in NMB studies. In MBB studies, this improvement was not significant. Data pooling of knee range of motion, functional outcomes, and energy cost showed no significant difference.

Conclusions: According to this review, chemodenervation of the rectus femoris shows a significant improvement in peak knee flexion during swing. The effect on functional outcomes and energy cost is still unclear.

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Stiff knee gait (SKG) is characterized by a diminished knee flexion during swing[1-3] and is commonly observed in patients with spastic paresis such as cerebral palsy (CP) or after stroke, traumatic brain injury, and multiple sclerosis. Clinically, an SKG can result in problems with foot clearance, leading to tripping and an increased risk of falling. Compensatory movements, such as ipsilateral hip circumduction or contralateral vaulting, performed to clear the foot can result in an increased energy expenditure.[4] The pathophysiology of SKG is not fully understood, and several hypotheses are postulated in the literature. The role of overactivity of the rectus femoris (RF) is often cited.[5-9] RF overactivity is associated with an increased knee extension moment in swing and decreased knee flexion velocity at toe-off, both potentially decreasing peak knee flexion.[7] Other possible

A part of this study was presented to the European Society of Movement Analysis for Adults and Children Congress, September 12-17, 2011, Vienna (Austria); and the International Society for Posture and Gait Research Congress, June 24-28, 2012, Trondheim (Norway).

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mechanisms cited in the literature are decreased strength of the hip flexors and ankle plantar flexors,[1,2] leading to decreased power to propel the leg into swing[5-10] or spasticity in the vasti or soleus to decrease knee flexion velocity.[11] Traditional gait training techniques based on the Bobath concept have not proven to improve SKG or any other movement patterns during gait.[12] Other treatment options for SKG include chemodenervation of the RF or transfer of the RF.[9,13-15] Functional electrical stimulation of the gastrocnemius or hamstrings has also been tried.[16,17]

Chemodenervation is a technique in which a pharmacologic compound is used to paralyze a muscle or a group of muscles.[18] Chemodenervation of the overactive RF is thought to improve SKG by reducing the internal knee extension moment in swing. The 2 methods described in the literature are neuromuscular blocks (NMBs) and motor branch blocks (MBBs).

For the treatment of SKG, NMB is achieved by injecting botulinum toxin (BTX) in the RF muscle itself. BTX can be injected either at a specific site or at multiple sites. BTX denervates the muscle by blocking the release of acetylcholine at the neuromuscular junction.[19] MBB is achieved by denervation of the branch of femoral nerve supplying the RF by injecting a local anesthetic agent or phenol. The effect of an injection with a local anesthetic agent lasts for few hours and can be used to predict the effects of longer term treatment such as with phenol or BTX.

Both methods have been frequently described in the literature. However, the effect of RF chemodenervation on knee kinematics, functional outcome, and energy cost is still unclear and inconsistent. Numerous studies have been performed to study these outcomes; however, these studies generally have used small study populations, making it difficult to generalize the results. Combining the results of these multiple studies would be interesting. It will enable one to reach meaningful decisions.

The purpose of this study was to systematically review the effects of chemodenervation of the RF on SKG. The primary objective of this systematic review was to determine the effect of chemodenervation (MBB and/or NMB) of the RF on knee kinematics during the swing phase in patients walking with SKG due to spastic paresis. The secondary objective was to determine whether this treatment results in an improvement in functional outcomes and energy cost of walking in these patients.

Methods

Literature search

A computerized literature search was conducted in Embase, PubMed, CINAHL, and the Cochrane Central Register of Controlled Trials (The Cochrane Library) until February 26, 2013. In addition, the reference lists of all relevant articles were screened for potentially relevant studies missed in the literature search. Main MeSH terms were Cerebrovascular disorders, Stroke, Brain injuries, Multiple sclerosis, Spinal cord, Hereditary spastic paraplegia, Knee, Leg, Lower extremity, Rectus femoris, Botulinum toxins, Nerve block, Organic chemicals, Gait, Walking, Kinematics, Kinetics, Range of motion, Energy metabolism, Outcome assessment, and Functional outcome.

List of abbreviations:

10MWT	**10-meter walking test**
BTX	**botulinum toxin**
BTX-A	**botulinum toxin type A**
CI	**confidence interval**
CP	**cerebral palsy**
MBB	**motor branch block**
NMB	**neuromuscular block**
RF	**rectus femoris**
SKG	**stiff knee gait**
SSWS	**self-selected walking speed**

Selection criteria

For inclusion in this review, a study had to be published as a full-text article in English, German, or Dutch language journals. No restrictions were applied regarding the study design. Studies were considered for inclusion if patients were adult, had a central neurological disorder, and walked with a gait pattern characterized by SKG with diminished (peak) knee flexion during the swing phase. Interventions had to include either NMBs or MBBs. Outcome measures included at least kinematics during the swing phase.

Selection of studies

Study selection and scoring of methodological quality were performed by 2 independent reviewers (M.T. and E.P.) and compared for consensus. In case of disagreement between the reviewers, a third reviewer (M.N.) was consulted and a final decision was made.

Data extraction

Data extraction was performed using a structured diagram. The content of the studies was categorized according to the description of selected articles, study characteristics, selection of patients, drug injection, adverse events, kinematics, functional outcomes, and energy cost.

Methodological quality

A method developed by Downs and Black[20] was used to assess the methodological quality of the included studies. The Downs and Black checklist is a scale used for the assessment of the methodological quality of randomized and nonrandomized studies of health care interventions. The instrument consists of 27 items measuring methodological quality and is based on epidemiological principles, reviews, and existing checklists for randomized studies. The checklist scores 5 subscales: reporting (10 items); internal validity, which consists of bias (7 items) and confounding (6 items); external validity (3 items); and power (1 item). The maximum (quality index) score of the checklist is 32 points. Test-retest reliability and interrater reliability ($r=.88$ and .75, respectively) and face and content validity are good.[20]

Data synthesis

Further consideration was given to investigate whether it was possible to pool data from patients with stroke because most of the study population suffered from stroke. If the included studies failed to report information needed for data pooling, we contacted the primary author to obtain the required information. When the primary author could not provide the information or when there was no response on the request, the study was excluded for data