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Review

Textured and stimulating insoles for balance and gait impairments in patients with multiple sclerosis and Parkinson's disease: A systematic review and meta-analysis

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ABSTRACT

The aim of this systematic review with meta-analysis was to investigate if using textured or other types of stimulating insoles improve gait characteristics and balance/postural control in patients with multiple sclerosis and Parkinson's disease. Primary outcomes for balance were the center of pressure (CoP) displacement and CoP velocity/sway rate. Primary outcomes for gait were the cadence, velocity, and step length. Standardized mean differences (SMD) were used to verify the efficacy of wearing the insoles on gait and balance outcome measures. Study quality was evaluated using the checklist of the CONSORT-Statement. Six studies were included in the review. Five studies had low methodological quality, scoring <17/37 on the checklist, one study had moderate methodological quality, scoring 27/37 on the checklist. Due to designs of the included studies, only immediate effects could be calculated. Among the primary outcome measures cadence, gait velocity and step length, there was no evidence of an effect of using textured/stimulating insoles compared with the respective control condition (Totals: SMD −0.09, 95% CI −0.35 to 0.16; SMD 0.18, 95% CI −0.17 to 0.53; SMD −0.13, 95% CI −0.31 to 0.05). Furthermore, among the primary outcome measures CoP displacement and CoP velocity, no evidence of an effect was found as well (Subtotals multiple sclerosis: SMD 0.07, 95% CI −0.15 to 0.28; SMD −0.08, 95% CI −0.55 to 0.39). Therefore, using textured or other types of stimulating insoles for the treatment of balance and gait impairments in patients with multiple sclerosis and Parkinson's disease seem to have no effect.

1. Introduction

Especially the elderly and patients with neurological diseases, such as multiple sclerosis, Parkinson's disease or peripheral neuropathy, show significant balance and gait impairments that could be associated with sensorimotor deficits and decreased foot sole sensitivity [1–5]. The balance and gait impairments are characterized by increased postural sway [6,7], reduced gait velocity, step length and stride length etc. [8,9] as well as increased cadence for Parkinson's disease [10,11] or decreased cadence for multiple sclerosis [12,13] and Parkinson's disease [14]. As the human foot, including cutaneous mechanoreceptors, is considered as a sensitive map that provides somatosensory feedback [15] and contributes to balance control, posture awareness [16–18], gait control [19] and mobility [20], textured surfaces in the environment as well as in footwear or on the surface of insoles are increasingly used to enhance plantar sensory feedback and improve impaired balance and gait in those with the aforementioned deficits. When the low-threshold cutaneous receptors of the glabrous skin of the foot sole are stimulated by pressure or vibration, the impulses are transmitted via sensory Aβ-fibers to the central nervous system [21]. The central nervous system uses this information to control static and dynamic posture as well as movement conscious and subconsciously [22]. When posture is disturbed, plantar cutaneous afferents provide this information, whereupon compensation strategies can be initiated [3,23]. Compensation strategies are important in situations, in which falls can occur. Foot sensation is associated with standing balance in people with multiple sclerosis [24]. Furthermore, decreased mobility, balance, and plantar sensitivity are related to an increased risk for falls in people with multiple sclerosis, Parkinson's disease and the elderly [6,7,25,26].

Insoles are usually used for the prevention and treatment of overuse injuries. Thereby, discussed aims of the different types of insoles are to alter movement biomechanics and provide shock absorption [27] that may reduce pain or degeneration of musculoskeletal structures. However, little is known about the

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influence of textured or other types of stimulating insoles to enhance somatosensory feedback and to improve balance and gait characteristics in patients with multiple sclerosis and Parkinson's disease. Therefore, the aims of this systematic review and meta-analysis were to identify and analyze the current literature about the effects of using textured or other types of stimulating insoles for the treatment of patients with multiple sclerosis and Parkinson's disease demonstrating impaired balance and/or gait. The research question was:

Does the use of textured or other types of stimulating insoles improve gait characteristics and balance/postural control in patients with multiple sclerosis and Parkinson's disease?

It was hypothesized that using these types of insoles would improve balance and gait outcome parameters in these patients.

2. Method

2.1. Design

A systematic review of clinical studies was conducted following systematic searches of MEDLINE (PubMed), Physiotherapy Evidence Database (PEDro) and Cochrane library [Cochrane Central Register of Controlled Trials (CENTRAL)] in February 2016. For term combination, the "advanced search" of PubMed and the procedure 'pio' (patient, intervention, outcomes) was used (Table 1). For searches of CENTRAL and PEDro the following term combinations were used:

- Parkinson" AND insoles" AND balance"
- multiple sclerosis" AND insoles" AND balance"
- Parkinson" AND insoles" AND gait"
- multiple sclerosis" AND insoles" AND gait"

The searches were restricted to clinical trials. Furthermore, the references of the identified studies were reviewed. The studies considered for further analysis were selected using the recommendations of PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses). A flow diagram of searches for studies is presented in Fig. 1. The following criteria for eligibility of studies for this review were used:

Table 1
Systematic search of Medline (PubMed). The search was conducted on 2nd February.

Search	Query	Filter	Results
#36	parkinson OR parkinsonism OR multiple sclerosis AND insole OR insoles OR insert OR inserts OR orthosis OR orthoses OR orthotic OR orthotics AND gait OR walk OR walking OR spatiotemporal OR spatiotemporal dynamics OR kinematics OR kinetics	Clinical Trial	16
#35	parkinson OR parkinsonism OR multiple sclerosis AND insole OR insoles OR insert OR inserts OR orthosis OR orthoses OR orthotic OR orthotics AND gait OR walk OR walking OR spatiotemporal OR spatiotemporal dynamics OR kinematics OR kinetics		73
#34	parkinson OR parkinsonism OR multiple sclerosis AND insole OR insoles OR insert OR inserts OR orthosis OR orthoses OR orthotic OR orthotics AND balance OR posture OR postural control OR motor control OR sensorimotor control OR somatosensory OR feedback OR proprioception OR proprioceptive	Clinical Trial	9
#33	parkinson OR parkinsonism OR multiple sclerosis AND insole OR insoles OR insert OR inserts OR orthosis OR orthoses OR orthotic OR orthotics AND balance OR posture OR postural control OR motor control OR sensorimotor control OR somatosensory OR feedback OR proprioception OR proprioceptive		49
#32	gait OR walk OR walking OR spatiotemporal OR spatiotemporal dynamics OR kinematics OR kinetics		770136
#31	kinetics		567467
#30	kinematics		94745
#29	spatiotemporal dynamics		3666
#28	spatiotemporal		17563
#27	walking		58296
#26	walk		79607
#25	gait		43055
#24	balance OR posture OR postural control OR motor control OR sensorimotor control OR somatosensory OR feedback OR proprioception OR proprioceptive		485965
#23	proprioceptive		6420
#22	proprioception		26036
#21	feedback		118159
#20	somatosensory		33785
#19	sensorimotor control		5439
#18	motor control		77762
#17	postural control		13115
#16	posture		78624
#15	balance		192689
#14	insole OR insoles OR insert OR inserts OR orthosis OR orthoses OR orthotic OR orthotics		42463
#13	orthotics		1322
#12	orthotic		6555
#11	orthoses		11603
#10	orthosis		11872
#9	inserts		20192
#8	inserts		20192
#7	insoles		722
#6	insole		538
#5	parkinson OR parkinsonism OR multiple sclerosis		149419
#4	multiple sclerosis		67851
#3	parkinson OR parkinsonism		82663
#2	parkinsonism		68131
#1	parkinson		70630