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The effectiveness of ETOIMS in improving gait speed in patient with spastic paraplegia:A pilot study

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Object
Patients with a lesion below the spinal cord T1 level can develop spastic paraplegia and show reduced gait speed due to spasticity as well as weakness. In this study, we applied electrical twitch obtaining intramuscular stimulation (ETOIMS) to the spastic paraplegic patients with gait disturbance. The ETOIMS is a Method to alleviate pain and achieve muscle relaxation by eliciting muscle twitching with electrical stimulus to the deep motor end-plate zone (MEPZ) by a monopolar needle. We present paraplegia patients who underwent ETOIMS alongside conventional stretching, strengthening exercises, and gait training, and showed improved gait speed and pattern due to muscle relaxation.

Method
We enrolled previously diagnosed spastic paraplegic patients who visited the department of rehabilitation medicine of a tertiary hospital with a complaint of gait disturbance between March 2017 and March 2018. Electrical stimulation was delivered by a monopolar needle electrode with 2-mA intensity, 0.2-ms pulse duration, and 1-Hz frequency with unipolar negative waves for 10 seconds at each stimulation point, which induced muscle twitching. The target muscles were the bilateral quadratus lumborum, multifidus originating from L4 and L5 spinous process, and gluteus medius. The participants underwent a 50-m gait test before and after ETOIMS. The gait speeds, subjective symptom changes, and gait patterns were compared before and after the interventions.

Result
Total 5 patients were enrolled and basic characteristics of the patients are shown in Table 1. The diagnoses were as follows; cervical myelitis (n=1), hereditary spastic paraplegia (NIPA1 mutation) (n=1), spinal cord tumor (n=2) and spinal cord injury (n=1). The ages were ranged from 26 to 70 years. The ambulatory motor index varied from 18 to 30. The walking aids and the antispasmodic agents in use are listed in Table 1. Tables 2 and 3 show the changes of gait parameters, stiffness and muscular pain after the ETOIMS. All patients subjectively reported the reduced stiffness during walking, and the alleviated muscular pain. After the 1st ETOIMS, the patient 1~4 showed 57%, 29%, 33%, 6% improvement in gait speed respectively. The patient 1 showed a cumulative effect in gait

speed by following two interventions, showing total 167% improvement. During gait, increased pelvic dissociation was observed. None reported any complication except for mild soreness at the stimulated sites, relieved within 2 days.

Conclusion

The ETOIMS is effective in improving gait speed and stability via relaxing the muscles or alleviating the pain in the lower back and gluteus in patient with spastic paraplegia. It is a promising minimally invasive intervention because it is easy to be performed without anesthesia, needs no injectate and the side effects are very minor. As this study is a pilot study without a control group, further controlled study is needed.

Table 1. Basic characteristics of the patients

Patient Number	Age	Sex	Height (cm)	Weight (kg)	Diagnosis	The period of diagnosis to ETOIMS	AMI	MAS		Assistive device	Medication
								Hip adductor	Knee extensor		
1	70	M	166	66	Paraplegia due to myelitis	20 months	20	G1+/G1+	G1+/G1+	Bilateral monocane	Baclofen 30mg
2	59	M	176	76	Hereditary spastic paraplegia	7 months	20	G2/G2	G2/G2	None (Independent gait)	Baclofen 5mg
3	54	M	172	72	Paraplegia due to spinal cord tumor	2 months	30	G0/G0	G1/G1	None (Independent gait)	Baclofen 30mg
4	57	M	160	64	Paraplegia due to L3/L3(s) SCI ASIA-C (Traffic Accident)	33 months	18	G1/G1	G1/G1	Bilateral quadcane	None
5	26	F	162	60	Paraplegia due to spinal cord tumor	21 months	30	G0/G0	G0/G1	None (Independent gait)	Tizanidine 1mg

ETOIMS, electrical twitch obtaining intramuscular stimulation; AMI, Ambulatory Motor Index; MAS, Modified Ashworth Scale; SCI, spinal cord injury.

Table 2. ETOIMS effects for spastic gait

		1st ETOIMS		2nd ETOIMS		3rd ETOIMS	
Pt.1		Pre	Post	Pre	Post	Pre	Post
	50m gait (sec)	160	122	121	104	83	60
	50m gait (m/min)	18.75	29.51	24.79	28.85	36.14	50
	Patient's report	Legs feel heavy and stiff	Legs feel lighter Decreased stiffness	Decreased knee stiffness	Reduced low back pain		Reduced low back pain
	Gait pattern	Short stride length Decreased pelvic dissociation Decreased knee flexion Steppage gait Thoracic kyphotic posture	Decreased stiffness in hip adductor, knee extensor		Decreased stiffness in hip adductor, knee extensor; improved anterior tilting		Decreased stiffness in hip adductor, knee extensor; improved pelvic dissociation Longer stride length
		1st ETOIMS					
Pt.2		Pre			Post		
	50m gait (sec)	81			63		
	50m gait (m/min)	37.04			47.62		
	Patient's report				Walking much smoother; decreased low back pain		
	Gait pattern				Decreased stiffness in hip adductor, knee extensor		
Pt.3		Pre			Post		
	50m gait (sec)	44			33		
	50m gait (m/min)	68.18			90.90		
	Patient's report	Legs feel heavy, low back pain			Feeling smoother during walking; decreased low back pain		
	Gait pattern	Significant shifts in center of gravity during gait			Decreased knee extensor stiffness		
Pt.4		Pre			Post		
	50m gait (sec)	398			377		
	50m gait (m/min)	7.54			7.96		
	Patient's report	Legs feel heavy, low back pain			Feeling of the muscles relaxed, decreased low back pain		
	Gait pattern	Reduced stride length, foot clearance			Decreased stiffness in hip adductor		
Pt.5	Evaluation	Pre			Post		
	50m gait (sec)	37			38		
	50m gait (m/min)	81.08			78.95		
	Patient's report	Feeling of muscle stiffness			Feeling of muscle relaxation; decreased low back pain		
	Gait pattern	Hip hiking as compensation for Lt. knee spasticity; decreased weight bearing			Decreased knee extensor stiffness with decreased quadratus lumborum pain		

Abbreviations: Pt., Patient; VM, vastus medialis; VL, vastus lateralis, GMed, gluteus medius; QL, quadratus lumborum; TFL, tensor fasciae latae

Table 3. Gait patterns and patient's symptom reports before and after ETOIMS

Pt.	ETOIMS		50 m walking test		Patient's symptom report	Gait pattern	
			Duration (sec)	Speed (m/min)			
1	1st	pre	160	18.75	Heavy and stiff legs Low back pain Frequently likely to fall	Hip	Decreased pelvic dissociation and hip flexion
						Knee	Decreased knee flexion during swing phase
						Ankle	Decreased ankle dorsiflexion at initial heel contact (steppage gait)
		post	122	29.51	Lighter and less stiff legs Decreased low back pain		
	2nd	pre	121	24.79	Leg stiffness improved		
		post	104	28.85	More improved stiffness Decreased low back pain		
	3rd	pre	83	36.14	Leg stiffness improved		
		post	60	50.00	More improved stiffness Decreased low back pain Less likely to fall	Hip	Improved pelvic dissociation and hip flexion
						Knee	Increased knee flexion during swing phase
						Ankle	Increased ankle dorsiflexion at initial heel contact
2	1st	pre	81	37.04	Heavy and stiff legs Instability in lower trunk-pelvis Frequently likely to fall	Hip	Decreased pelvic dissociation, hip flexion and extension, hip hiking, scissoring
						Knee	Decreased knee flexion during swing phase
						Ankle	Decreased ankle dorsiflexion at initial heel contact (steppage gait)
		post	63	47.62	More stability in lower trunk-pelvis Much smoother walking	Hip	Improved pelvic dissociation and hip flexion, decreased scissoring
						Knee	Increased knee flexion during swing phase
						Ankle	Increased ankle dorsiflexion at initial heel contact
3	1st	pre	44	68.18	Heavy legs and stiff knee Low back pain	Hip	Posteriorly tilted pelvis with sway-back posture, decreased pelvic dissociation
						Knee	Decreased knee flexion during swing phase
						Ankle	Decreased right ankle dorsiflexion at initial heel contact (steppage gait)
		post	33	90.90	Lighter and less stiff legs Decreased low back pain	Hip	Improved pelvic dissociation with less sway-back posture
						Knee	Increased knee flexion during swing phase
						Ankle	Increased right ankle dorsiflexion at initial heel contact
4	1st	pre	398	7.54	Heavy and stiff legs Frequently likely to fall back	Hip	Decreased pelvic dissociation, hip flexion and extension, scissoring Hip external rotated during swing phase
						Knee	Decreased knee flexion during swing phase
						Ankle	Decreased ankle dorsiflexion at initial heel contact, foot drag during swing phase
		post	377	7.96	Less stiff leg Smoother walking	Hip	Improved pelvic dissociation with decreased scissoring frequency
						Knee	Not improved significantly
						Ankle	Not improved significantly
5	1st	pre	37	81.08	Stiff knee Left low back pain	Hip	Decreased pelvic dissociation
						Knee	Intentionally flex left knee more than right side to prevent dragging
						Ankle	No specific finding
		post	36	78.95	Smoother and lighter walking Decreased low back pain	Hip	Improved pelvic dissociation,
						Knee	Still intentionally flex left knee more than right side to prevent dragging
						Ankle	No specific finding