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## Original Research

# Effect Of Wearable Tubing Assistive Walking Device on Anterior Tibial Muscle Activity at Swing Phase in Post-Stroke Patients

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## ABSTRACT

**Background:** One-third of post-stroke patients experience gait disturbance which is commonly associated with drop foot at three months after acute stroke. One of the orthoses that are proposed to improve gait in stroke patient is Wearable Tubing Assistive Walking Devices (WTAWD). It is hypothesized that WTAWD reduce the anterior tibial muscle activity which may become hyperactive during the swing phase in post-stroke patient with drop foot as an attempt to perform foot clearance.
**Aim:** This study aims to investigate the effect of WTAWD on anterior tibial muscle activity during the swing phase in post-stroke patients.
**Material and Methods:** Eleven patients, aged 30-60 years, with post-stroke hemiparesis in the subacute and chronic phase who fulfill the inclusion criteria are chosen as research subjects. The subjects were asked to wear WTAWD on the leg with weakness. Surface Electromyography (sEMG) examination of anterior tibial muscle was performed when the patient walked with and without wearing the WTAWD.
**Results:** All 11 subjects completed the sessions and study protocol, with no losses throughout the study. None of the subjects reported any adverse effects during or after the intervention. A significant reduction of sEMG value on anterior tibial muscle activity was found when the patient wore WTAWD (p=0.001).
**Conclusion:** There is an effect of WTAWD on decreasing anterior tibial muscle activity during the swing phase in post-stroke patients. Further research is needed to measure the kinematic and temporospatial values to increase knowledge about the effect of additional WTAWD to improve gait in stroke patients.
**Keywords**: *Wearable Tubing Assistive Walking Devices, Ischemic stroke, Anterior tibial muscles activities.*

**Introduction**

Stroke causes dysfunction and limitation of daily activities. One-third of post stroke patients experienced gait disturbance. Damage to the neuromuscular system results in spasticity and weakness, which can result in decreased walking speed, increased energy requirements, and increased risk of falls. Gait disturbances in stroke are commonly associated with drop foot due to weakness of ankle dorsiflexor and plantar flexor muscles and spasticity of ankle plantar flexor. Previous study showed 20% of post-stroke patients suffer from drop foot three months after the onset (Burridge et al., 1997). Weakness of the ankle plantar flexor muscles results in reduced thrust and increased energy demand because most of the strength in walking is generated during ankle push-offs while weakness of the dorsiflexor muscles cause patients unable to lift the leg when in mid-swing because the dorsiflexion of the ankle is reduced. This condition results in toe-drag, decreased walking speed, shortened stride length, increased metabolism while walking, and an increased risk of falling.[1] In post-stroke patients with drop foot, anterior tibial muscles may become excessively activated during swing phase of the gait as an attempt to perform foot clearance during the swing phase[2]. The anterior tibial muscle has important roles in walking, which include absorbing the energy that crosses the ankle joint when the foot is in contact with the ground, controlling foot position and ensuring foot clearance during the swing phase.[3-5] Based on these important roles of anterior tibial muscle, the hyperactivity of this muscle may significantly increase energy expenditure and cause the patient to get fatigued easily. This muscle activity can be assessed objectively by using surface electromyography (sEMG).[6]

Ankle foot orthoses (AFO) are commonly prescribed to improve gait in post-stroke patients with drop foot. However, some physicians are reluctant to prescribe AFO because of the concern that it can cause muscle disuse, especially on the anterior tibial muscle. Use of AFO is thought to exacerbate muscle weakness and possibly delay recovery, resulting in permanent gait disorders and AFO dependence.[7] Wearable Tubing Assistive Walking Devices (WTAWD) is proposed as an alternative of AFO to improve gait in post-stroke patient with drop foot. Wearable Tubing Assistive Walking Devices is made of a pelvic belt, elastic tubing, and a conventional elastic band which makes it a lightweight, flexible, and portable device and, therefore, may be used routinely to assist walking.[8] Previous study showed that wearing WTAWD improves walking speed of post-stroke patient with drop foot, which may be associated with reduction of anterior tibial muscle hyperactivity.[8] This study aims to investigate the effect of using WTAWD on the anterior tibial muscle activity during the swing phase in post-stroke patients by using sEMG.

**Material and Methods**

This was an experimental study involving one group with pre-and post-assessment design aimed to assess the effect of wearing WTAWD on anterior tibial muscle activity during swing phase in post-stroke patient. This study was conducted in the outpatient clinic of the Medical Rehabilitation Installation Dr. Soetomo Academic General Hospital Surabaya and has received certificate of ethical eligibility from the Ethics Committee of Dr. Soetomo Academic General Hospital Surabaya. The total study subjects were 11 patients with inclusion criteria as follow: 1.) suffered from post-stroke hemiparesis in the subacute (2 weeks - 6 months) and chronic (<5 years) phase, 2.) aged 30-60 years, 3.), had Mini Mental State Examination (MMSE) score ≥ 25, 4.) able to walk independently more than 10 meters, with or without a walker, 5.) had Manual Muscle Test (MMT) score of ankle dorsiflexor ≤ 4, 6.) had spasticity in plantar flexors with Modified Asworth Scale (MAS) 1 or no spasticity, 6.) able to climb stairs (minimum two flight of stairs), 7.) able to do physical activity with metabolic equivalents (METs) ≥ 5 measured by a six-minute walk test, 8.) able to understand and follow simple verbal instructions, and 9.) willing to participate in the study by signing informed consent.

The subjects were excluded if they suffered from the following conditions: 1.) double hemiparesis, 2.) uncontrolled hypertension or severe cardiorespiratory disorder (NYHA 3-4), 3.) pain on lower extremity with a Wong Baker Scale score> 4, 4.) apraxia, 5.) visual problems that impair walking ability, 6.) impaired balance, 7.) other medical illness or neurological disease that impair walking ability, or 8.) other causes of decreased motor strength in the patient's ankle dorsiflexor besides stroke.

The subjects were asked to walk two times, first without wearing any orthosis and second with wearing Wearable Tubing Assistive Walking Devices on the leg with weakness. The WTAWD was made of a pelvic belt, elastic tubing, and a conventional elastic band designed in the orthotic and prosthetic division at Dr. Soetomo Rehabilitation Department. The activity of anterior tibial muscle in the swing phase was recorded using surface Electromyography (sEMG) when the patient walked with and without wearing WTAWD.

Statistical analyses were conducted using the Statistical Package for Social Sciences (SPSS version 20.0). The differences of sEMG result before and after the treatment were analyzed using parametric test (paired T-test) if the data distribution is normal and non-parametric test (Mann Whitney U test) if the data distribution is not normal. P value < 0.05 is considered significant.

## Results

All 11 subjects completed the sessions and study protocol, with no losses throughout the study. None of the subjects reported any adverse effects during or after the intervention. The sEMG data of anterior tibial muscle when the patient walked with and without WTAWD showed normal distribution; therefore parametric test (paired T-Test) was used to analyze the difference between the two. Anterior tibial muscle activity was significantly reduced when the patient walked while wearing WTAWD compared to when the patient walked without wearing WATWD (p=0.001).

**Figure 1**. Wearable Tubing Assistive Walking Devices

**Table 1**. Demographic Characteristics of Research Subjects

| Variable | Research subjects (n=11) |
|---|---|
| Age (years) | 51.64±6.36 |
| Sex | |
| • Male | 8 (72.7%) |

| | |
|---|---|
| • Female | 3 (27.3%) |
| Stroke episodes | |
| • 1 | 10 (90.9%) |
| • 2 | 1 (9.1%) |
| Hemiparese | |
| • Dextra | 3 (27.3%) |
| • Sinistr | 8 (72.7%) |
| Stroke type | |
| • ICH | 4 (36.4%) |
| • Infark | 7 (63.6%) |
| MMT | |
| Ankle | |
| • 0 | 2 (18.2%) |
| • 1 | 1 (9.1%) |
| • 3 | 2 (18.2%) |
| • 4 | 6 (54.5%) |
| MAS | |
| • 0 | 4 (36.4%) |
| • 1 | 7 (63.6%) |
| BMI | 24.21±3,1 |
| Onset | 2.45±2.3 |

**Table 2.** sEMG Result of Anterior Tibial with and without WTAWD (n = 11)

| | **Without WTAWD** | **With WTAWD** | **P** |
|---|---|---|---|
| **Anterior tibial muscle activity (mV)** | 0.07±0.02 | 0.06±0.02 | 0.001* |

*p<0.05

## Discussion

The decrease in anterior tibial muscle activity when the study subjects wear WTAWD indicated relaxation of this muscle, which, in turn, may reduce energy expenditure, prevent fatigue, and increase walking speed. In post-stroke patients with drop foot, the contraction of anterior tibial muscles during the swing phase may increase as an attempt to compensate for the decreased foot clearance.

The increase of contraction is negatively correlated with walking speed and the patient will quickly feel tired when walking. The use of WTAWD creates pulling forces on the hip and knee, helps ankle dorsiflexion by supporting an extension of the metatarsophalangeal joint, and control ankle plantar flexor spasticity. This mechanism may improve foot clearance and reduce the activity of anterior tibial muscle.

The results obtained in this study are in accordance with research conducted by Fujita concerning the assessment of muscle activity that affects the ability to walk in stroke patients.[2] When post-stroke patients with hemiparesis walk, anterior tibial muscle activity is highest in the swing phase in order to perform foot clearance and this is negatively correlated with walking speed. The hyperactivity of this muscle increases energy expenditure and causes the patient to get fatigue easily.[6] This trend indicates that people with a fast gait have low tibial anterior activity during the swing phase, whereas subjects with a slow gait have high tibial anterior activity during the swing phase, to compensate for the decreased ability of foot clearance. Previous studies have shown that stroke patients with hemiparesis have increased co-activation of the flexor and extensor muscles of the ankle, thus inhibiting ankle movement and contributing to a decrease in walking speed.[2]

There is a scarcity of studies about the benefit of WTAWD for post-stroke patients with drop foot. However, the use of AFO in general with a similar mechanism has been shown to decrease the activity of the anterior tibial muscles based on the sEMG results, increase walking speed, and make the patients feel lighter when walking.[9-11] Both AFO and elastic orthosis such as WTAWD were proven in improving walking ability in post-stroke patients[12]. The advantage of wearing elastic orthosis such as WTAWD is that it is better in maintaining ankle stability and flexibility when walking compared to AFO.[12]

## Conclusion

There is an effect of WTAWD on decreasing anterior tibial muscle activity during the swing phase in post-stroke patients with drop foot which, in turn, may reduce energy expenditure and prevent fatigue. Further research is needed to measure the kinematic and temporospatial values to increase knowledge about the effect of additional WTAWD in improving gait among post-stroke patients.

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