TRACCIA #3

- Descrivere le principali tecniche per l'acquisizione di segnali elettromiografici dell'arto superiore, evidenziando possibili problematiche legate al loro utilizzo con un esoscheletro
- Descrivere una possibile architettura software per il controllo di un esoscheletro basato su *series-elastic actuators* tramite software LabView
- Descrivere una strategia per l'organizzazione e il *versioning* dei file relativi a un progetto di ricerca
- Ai sensi del "disciplinare per l'accesso e lo svolgimento di attività in sicurezza nei laboratori dell'istituto di biorobotica" si dia la definizione di "PORTALE SICUREZZA"
- Lettura e traduzione del terzo capoverso dell'articolo allegato

TRACCIA #4

- Descrivere le peculiarità di un attuatore *series-elastic*, evidenziandone potenziali vantaggi e svantaggi
- Descrivere l'implementazione di una *graphical user interface* in LabView per il controllo di un esoscheletro
- Descrivere metodologie e applicazioni per l'inserimento di riferimenti bibliografici in un documento Word
- Secondo il "Regolamento interno dell'istituto di Biorobotica della Scuola Superiore Sant'Anna" si definisca la figura del "Direttore di Istituto"
- Lettura e traduzione del quarto capoverso dell'articolo allegato

Keywords Soft exosuit, Exoskeleton, Stroke, Walking speed, Push-off, Ground clearance, Rehabilitation

Background

Stroke is a leading cause of serious long-term disability that results in a slow, unstable, and energetically inefficient gait. Paresis of the muscles on one side of the body contributes to asymmetric walking patterns poststroke. Impaired plantarflexor muscle activity on the paretic side results in reduced propulsive force [1], whereas impaired dorsiflexor activity results in reduced ground clearance and impaired limb loading [2–5]. Together, these impairments increase the risk of falling, which is often compensated for by hip hiking and hip circumduction strategies [6, 7]. These mobility deficits can hinder social participation and affect the quality of life [8], warranting the development of interventions that restore paretic plantarflexor and dorsiflexor function during walking [9].

For people with neurological conditions, wearable robots have the potential to help restore mobility. Rigid exoskeletons that provide full body weight and limb advancement support have been shown to be beneficial for non-ambulatory individuals with for instance a complete spinal cord injury [10, 11], but mixed results are found for ambulatory individuals with gait impairments such as most stroke survivors [10–13]. In fact, the high levels of assistance might reduce the user's neuromuscular activity [14–16]. Because active engagement is crucial for the experience-dependent plasticity that underlies motor recovery, the partial support provided by soft robotic exosuits are a promising therapeutic alternative to keep neuromuscular slacking to a minimum.

We developed a soft robotic exosuit to provide paretic plantarflexor assistance to enhance propulsion during the push-off phase and paretic dorsiflexor assistance to improve ground clearance during the swing phase and foot landing during the loading phase [17, 18]. This lightweight wearable device applies assistance via Bowden cables that connect to garment-like, functional textile anchors on the shank and foot. The textile-based interface allows exosuits to operate in parallel with the user's paretic muscles to augment, not replace, their movements. Our previous studies with a tethered exosuit and a preliminary version of the portable exosuit (5 kg total weight including motors and batteries worn at the waist) reported improvements in the mechanics, energetics, and functional walking capacity of a small cohort of community-dwelling people poststroke compared to walking with an exosuit unpowered [17, 19, 20] or walking without an exosuit [19, 21–23].

Motivated by these findings, we refined the form factor, usability, comfort, power consumption as well as the paretic gait event detection and cable position control algorithms of the portable exosuit, reducing its weight by nearly 25% to 3.8 kg (see *Methods*) [20]. The updated portable exosuit (Fig. 1) is designed to support long-distance overground walking, similar to everyday walking. Therefore, the purpose of this study is to extend our preliminary findings to a larger sample of individuals with chronic (>6 months) poststroke hemiparesis by evaluating the immediate effects of plantarflexor and dorsiflexor assistance during continuous overground walking in the laboratory at a comfortable walking speed, compared to walking without an exosuit.

Our previous results indicate that baseline comfortable walking speed, a common clinical prognostic measure and predictor of intervention success, may impact the user's ability to leverage exosuit assistance [19, 21, 23]. Therefore, the present study evaluates differences between people poststroke with comfortable walking speeds less than 0.93 m/s (limited community ambulators) and those with comfortable walking speeds greater than 0.93 m/s (full community ambulators), based on a recently introduced cut-off for functional stroke survivor groups [54]. Finally, the present study performs a thorough biomechanical evaluation, including effects on walking stability, control of foot landing, and slacking of the plantarflexor muscles. We hypothesize that the assistance provided by the updated portable exosuit will increase overground walking speed compared to walking without an exosuit by improving paretic ground clearance, foot landing, and propulsion. We expect these results to be enhanced in slower, more functionally limited participants. We further hypothesize that exosuit assistance will reduce the energy cost of transport, increase walking stability, and prevent plantarflexor muscle slacking.

Methods

Participants

Twenty individuals with hemiparetic stroke in the chronic phase of recovery were recruited for this study (9 F; age: 53±11 year (mean±standard deviation); chronicity: 8±6y, Table 1), but one was excluded from analysis as they could not complete the continuous walking protocol. We recruited participants with a broad range of ambulatory functional levels based on clinical walking test outcomes from referring clinicians. Inclusion criteria included: aged between 18 and 80 years; diagnosis of stroke with gait deficiencies; and self-reported ability to walk independently with or without assistive devices continuously for at least 4 min. Exclusion criteria included severe aphasia, a speech or language disorder, serious co-morbidities, more than two self-reported falls in the previous month or limited ability to express