Fig. 1. Six exemplary motion patterns over different motor tasks: original curves from the 10 subjects (top row plots), mean ± st.dev. (central row), median and 10–90 (gray) and 25–75 (darker gray) percentiles (bottom row).

References


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SEMG evaluation during treadmill walking: Methodological issues in searching signs of muscle fatigue

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Introduction

Evaluation of local muscle fatigue by means of surface electromyographic (sEMG) signal processing requires complex analysis especially in dynamic tasks [1]. In treadmill walking, before carrying out this complex analysis it is necessary to perform preprocessing steps for ensuring the quality and reliability of the results obtained. A first issue is the automatic estimation of the Signal-to-Noise ratio of sEMG signals. A second issue is the evaluation of the variations in the muscle activation timing due to learning, that maybe a confounding effect with respect to the fatigue phenomena. This work will focus mainly on this second aspect.

Materials and methods

Thirty subjects were recruited from the patients attending the outpatient clinic of the Department of Metabolic Disease at the University of Padova (Italy), as well as from university personnel. This group consisted of eighteen type 2 diabetic subjects and twelve controls matched for age and BMI. Patients were instrumented bilaterally with foot-switches, knee goniometers and surface EMG probes over Tibialis Anterior (TA), Gastrocnemius Lateralis (GL), Rectus Femoris (RF), Lateral Hamstrings (LH) and Vastus Lateralis (VL). Patients were then asked to walk on a treadmill. After a warming-up of 2.5 min at 2 km/h patients walked for 35 min at 4 km/h, with an inclination of 2%. Then an interval of 2.5 min of cool-down followed, again at 2 km/h. The signal acquisition started after 2–3 min from the beginning of the treadmill walk at 4 km/h, in order to give the patient time to acquire a fluid and natural gait at this velocity. Foot-switch signals, knee flexo-extension angle and EMG signals were recorded synchronously for 30 min by means of the system STEP32 (DemItalia, Italy).

EMG signals were acquired with a sampling frequency of 2 kHz, high-pass filtered at 20 Hz (FIR filter, 100 taps) to attenuate motion artefacts and low-pass filtered at 350 Hz to reduce high-frequency noise (anticausal IIR filter, 14th order).

Results

As an example, Fig. 1 reports the total time of activation of four of the examined muscles, expressed as percent of the gait cycle (mean over the population of controls and diabetic patients).

Discussion

It can be noticed that for some muscles the on-time remains constant during the whole exercise, while in other muscles it shows trends. These trends are due to patterns of muscle activation that change during the 30-min treadmill walk and that cannot be ignored when analysing spectral parameters for muscle fatigue evaluation.
Introduction

The application of Ankle Foot Orthosis (AFO) can correct kinesiological gait alterations, improving walking safety and speed in hemiplegic patients. For a proper prescription of an AFO various parameters must be taken into account, including kinesiological main problems at the lower limb joints, entity and cause of gait abnormalities, morphological characteristics of each patient and also orthosis aesthetic impact. Custom-made orthotics can consider all these issues and offer the maximum reachable personalization [1,2].

Among the materials used in the fabrication of the AFO, carbon fiber combines maximal tension strength and lightweight, allowing the construction of “skeletal orthoses”, with more acceptable cosmetic appearance, highly demanded by young patients [3].

Manufacturing of carbon fiber is susceptible of some important drawbacks:

- complex manufacturing processes,
- high costs,
- post-adaptation unavailable after brace manufacturing and
- frequent breakages in case of great mechanical stress.

We believe that an instrumental evaluation methodology applied to the orthosis can complete the clinical evaluation and allows the physiatrist and orthopaedic technician to optimize the design construction of carbon fiber AFO.

Materials and methods

Our objective aims to investigate several possible methods, suitable for the evaluation of a carbon fiber AFO in a dynamic way. Above all this study analyses several measuring devices and techniques to assess which one allows to achieve an accurate measurement of one or more key quantities (angles, speeds, accelerations and forces), useful to characterize the goodness of the orthosis [4,5]. These measurements were taken using sensors based on heterogeneous physical properties applied over a carbon fiber AFO, built by the orthopaedic company CPO in Parma and worn by an adult subject at a comfortable walking speed on level ground. In order to achieve a suitable solution, we investigated:

- ease of use, especially in practical contexts,
- instrumentation costs,
- the possible quantities to be monitored,
- measurement accuracy and
- possible clinical and functional significances (e.g., improvement of patient gait).

Results and conclusion

The availability of objective measurement of key factors during gait offers interesting ideas for further studies. In particular, our study will carry on investigating the possible relationship between obtained measures and functionality evaluation of the examined orthosis, to suggest guidelines to the design and construction of the carbon fiber braces.