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Compliance monitoring of home based electrical stimulation training of elderly subjects

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Abstract: *Home based training by using neuromuscular electrical stimulation requires sufficient monitoring to guarantee optimal training results. In a clinical study elderly subjects should follow a specific training of both anterior thighs. The schedule consists of 24 training days within 9 weeks where each training session consists of 3 series of 6 or 10 minutes. The compliance of five subjects (4 females) were evaluated based on an evaluation software programmed in Visual Studio C#. The training device is a custom-built voltage-controlled stimulator where the stimulation parameters are monitored. The average stimulation voltage of all subjects was 18,81 V with an average current of 57,33 mA. The monitoring of the training demonstrates the importance for evaluation for the study success.*
Trial Registration: ClinicalTrials.gov NCT01679977

Keywords: *evaluation software, stimulator design, pulse shape recordings*

Introduction

Aging is associated with a significant decline in neuromuscular function. Reduction of muscle mass and strength is often related to dysfunction of mobility and is a predictor of future disabilities [1]. Cross sectional studies report a decrease in muscle strength of around 40% between 25 and 80 years old subjects [1] under isometric test conditions of the knee extensors. Muscle training can dramatically improve the muscle strength, power and functional abilities of elder individuals [2][3]. There is a strong evidence that neuromuscular electrical stimulation increases muscle strength especially in periods with reduced mobilization [4].
The aim of this study was to record the intensity of home based training using electrical stimulation by monitoring compliance data.

Methods

The home based electrical stimulation training targets the anterior thigh muscles using a custom-built programmable voltage-controlled stimulator [5]. The system has an easily operable control unit and two stimulation channels. Using a universal serial bus link the stimulation parameters and the training protocol were programmed with a custom-made software. A specific stimulation training for both channels was stored on a secured digital (SD) card of the control unit. During the stimulation the subject could influence the amplitude and emergency shut-off.

The compliance monitoring was composed of the set amplitude value and the pulse voltage shape and current shape. Especially the current information, e.g. charge, is an important parameter for monitoring muscle activation [6] using voltage-controlled stimulators. Also basic information like date and number of successfully completed training series are recorded. The evaluation software is programmed in Visual Studio C# (Microsoft, Redmond, USA). It allows the analysis of a specific training series up to the whole training. The main measures of the compliance were the average stimulation voltage amplitude and current amplitude.

The compliance data of five subjects (4 females) were evaluated from a current study. Stimulation training was performed for 9 weeks, with 2 sessions per week in the first two weeks and then increased to 3 sessions per week. A training session consisted of 3 series of training separated by 5 minutes breaks. A series took 6 minutes in the first two weeks and then 10 minutes which consisted of 75 contractions of one thigh (stimulation time: 3.5 s; off time: 4 s). The stimulation pulses were rectangular, biphasic and voltage controlled with pulse width of 2x300µs and a rate of 60 pulses per second.

Results

The output voltage amplitude of the stimulation training was set over all subjects to 18,81 V with a corresponding current amplitude of 57,33 mA (Table 1). The variability over the whole training of subject A227 (Fig. 2) was +/- 12% and +/- 15% of the voltage and current, respectively.
For each burst one stimulation pulse (Fig. 1-B,C) is recorded. Figure 1-A shows the manually set amplitude of each burst during one training series (6 min. training, 45 bursts).

Table 1: Average (avg.) voltage and current (standard deviation) of all training sessions for each subject.

subject	avg. voltage (V)	avg. current (mA)
A227	22,22 (3,37)	48,59 (5,96)
FTVS028	19,05 (2,97)	61,61 (6,63)
FTVS026	16,62 (3,76)	58,89 (5,02)
FTVS029	20,22 (2,47)	62,80 (5,14)
FTVS024	15,93 (2,83)	54,75 (4,74)
mean value	**18,81 (2,58)**	**57,33 (5,78)**

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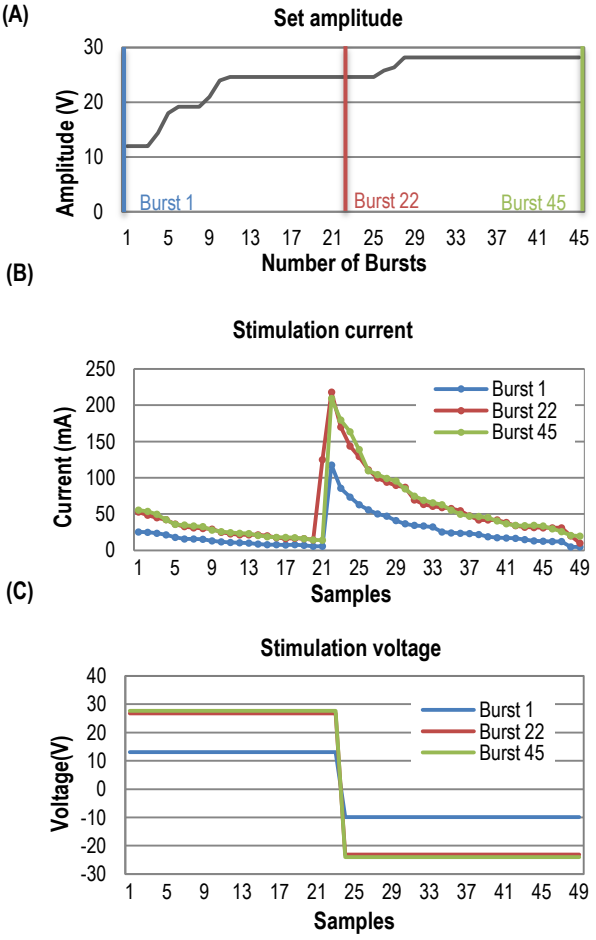

Figure 1: Stimulation current (A) and voltage (B), with a sampling rate of 83,3 kS/s. Set amplitude value (C) of one training series. Three impulses (Burst 1, Burst 22, Burst 45 of a training series) are visualized. The data refers to training series number 48 of subject A227.

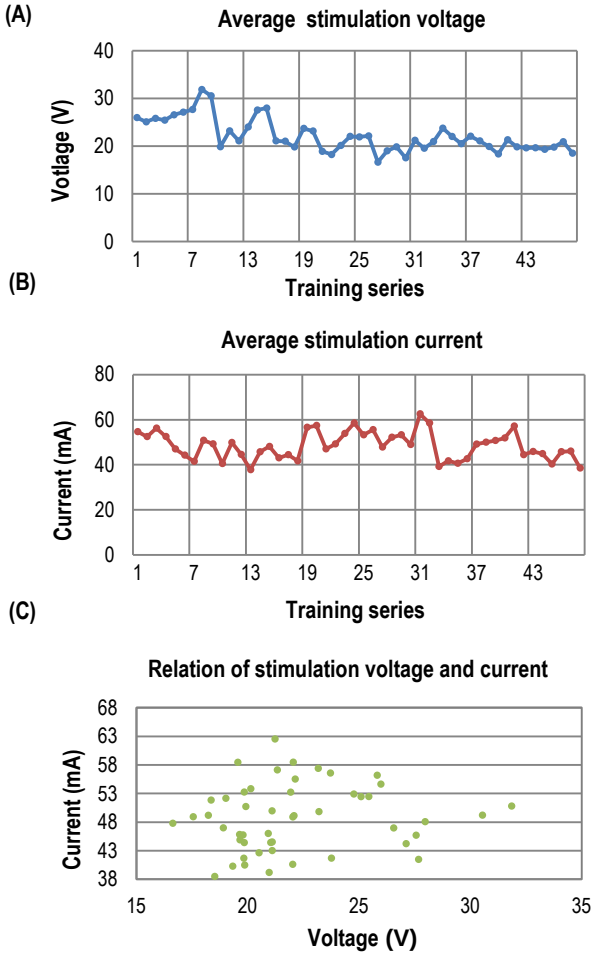

Figure 2: Average stimulation voltage amplitude (A) and current amplitude (B). The correlation between both measurements (C). The data refers to the first 48 training series (16 days) of subject A227.

Discussion

Monitoring of the training is important for evaluation of the study success, especially concerning home based training. It gives knowledge about the usage of the stimulator at home. Therefore, electrode interface failure, wrong or insufficient usage of stimulator can be detected. This information makes it easier to interpret training results.

Acknowledgment

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