Effects of ankle-foot orthosis on paretic ankle dorsiflexors

Chapter 8

Summary

In case of a foot drop due to a peripheral nerve lesion or radiculopathy, the use of an ankle-foot orthosis (=AFO) is often considered. The AFO corrects the foot drop during swing phase and helps to control foot placing after heel strike. However, a possible negative side effect of AFO use might be a further decrease in strength of the paretic dorsiflexors due to disuse. Especially in those patients with a chance of nerve regeneration and subsequent strength recovery, this could be harmful. **Chapter 1** discusses the aim of this thesis, i.e. to determine the effects of six weeks of AFO use on (1) the activity of the paretic muscles during walking, (2) restoration of strength, and (3) walking performances in patients with a paresis of the ankle dorsiflexors existing between six weeks and one year.

Various approaches were used to answer these questions. Muscle activity of five lower leg muscles was measured by surface EMG registration while the subject walked on a level treadmill. Isometric ankle dorsiflexion strength was determined on a dynamometer with the ankle joint in 0° and 30° plantar flexion. Finally, walking ability was assessed using 3 walking tests: the 10 metre walking test, the 10 metre walking test with three steps and a six-minute walking test with a cognitive task. The SIP68 mobility scale and a questionnaire concerning the subjective effect of AFO use on different walking tasks were finally added.

In **chapter 2**, a short overview of the aetiology of a drop foot, the clinical symptoms, and the surgical and paramedical interventions is given. Peroneal nerve lesions at the fibular head are mainly caused by compression of the nerve, due to prolonged bed rest, operations, sitting with crossed legs, and, less frequently, by trauma. An L5 radiculopathy may also result in a drop foot and is mostly caused by a protruded lumbar disc. Treatment and prognosis are dependent on the primary cause and duration of the nerve lesion. Treatment can be either conservative or surgical. There is no consensus when surgical intervention is indicated, neither in case of a peripheral lesion nor with a radiculopathy. Only in case of traumatic interruption of the nerve or a distinct mass pressing on the nerve, surgical intervention is commonly advocated. Either way, physiotherapy and/or an orthosis are often (temporarily) prescribed to facilitate walking. The effects of physiotherapeutic training on strength recovery and nerve regeneration is not clear, nor is the effect of AFO use on walking ability and muscle activity.

In **chapter 3** the results of immobilisation on strength reduction of the ankle dorsiflexors are described in 15 neurological healthy subjects who had an ankle braced in a plaster cast after an uncomplicated fracture of the lower leg. Immediately after cast removal, isometric ankle dorsiflexion strength in 30° plantar flexion was 28% lower compared to the healthy side. We concluded that ankle dorsiflexors are susceptible to immobilisation. Thus, a negative effect of partial immobilisation during AFO use could be possible as well. Reproducibility of the strength measurements in healthy adults was described and reference strength values were reported.

Chapter 4 describes the influence of AFO use on muscle activity, as measured by surface EMG. EMG activity was recorded to study both quantitative and qualitative changes during the step cycle. The reproducibility of the EMG measurements in healthy adults resulted in a correlation coefficient, reflecting within-subject signal reproducibility, varying between 0.68 and 0.96 (mean 0.86). The immediate change in EMG pattern of the tibialis anterior muscle (TA) induced by AFO use was compared between 29 patients with a dorsiflexor paresis and 14 healthy persons. In both groups, activity of the TA decreased significantly when using an AFO. In healthy persons a decrease of 20% was seen during the first 10% of the step cycle. In patients with a paresis the decrease in EMG activity was 7%. However, this decrease was measured over the whole step cycle. Next, the patients were randomly assigned to two groups, with and without daily AFO use. Overall EMG activity did not change during six weeks follow up. Differences between walking with and without orthosis did not change during follow-up in the AFO group in any of the muscles recorded. There was no indication that a gradual decrease in muscle activity due to central adaptation took place.

In **chapter 5** the influence of AFO use on strength restoration is studied by comparing the recuperation of the recent paresis between twenty-nine patients alternately assigned to a group using an AFO or a control group during six weeks. No significant difference in duration of the paresis and in torque at entering the study (T0) was present between the two groups. Isometric torque production of ankle dorsiflexors was measured and expressed as ratio of the paretic and healthy side, in two measurement sessions, over a period of six weeks (T0- T6) with the ankle in 0° and 30° plantar flexion. Only in 30° plantar flexion, both groups showed a significant improvement of strength between T0 and T6; the non-AFO group 17% (SD=15), the AFO-group 9% (SD=12). There was no significant difference between the two groups (in 30° plantar flexion). In the AFO-group no significant shift in strength ratio between 0° and 30° occurred. It was concluded that the use of an orthosis did not influence restoration of strength in these patients.

Because the relation between an impairment and the subsequent disability is a main feature in rehabilitation medicine, the relation between the degree of paresis and the performance on several walking tests was studied in **chapter 6**. The following tests were used: 10 metre walking test (with and without three stairs), a complex walking task (six minute walk with cognitive loading) and a subjective evaluation (SIP68 mobility scale and questionnaire). When relating torque values to walking performances, the highest correlation was found between strength and the "10 metre" and "10 metre with stairs" test ($r = -0.51$, i.e. an inverse relationship). No threshold in the amount of strength loss was found below which walking ability sharply decreased. All walking tests were performed with and without AFO in random order. No significant improvement could be demonstrated from AFO use on the 10 metre tests. Improvement on the six minutes test was significant at $p=0.06$, the questionnaire revealed a positive

opinion on AFO use related to overall walking function and effort.

Finally, in **chapter 7** an overview is presented of the various studies of this thesis, and some additional findings are discussed. The general answer to our main question, i.e. does AFO use counteract muscle activity and strength restoration in patients with a recent foot drop, is: "No, it does not". Our data indicate that it is safe to use an AFO when necessary. Subjectively most AFO users reported an improvement on walking performance and experienced less physical effort. However, we could not demonstrate a significant positive effect of AFO use on the walking tests used.

The present study also provided some additional findings, the first of which were the qualitative and quantitative differences in muscle reaction on AFO use between paretic muscles compared to healthy muscles. Although within-subject reproducibility of strength and EMG measurements in the patient group were similar to the healthy subjects, large inter-individual differences in the patient population existed in contrast to the healthy subject population. Also, especially the EMG measurements, reflected significant qualitative differences between healthy and paretic muscle patterns during a step cycle. These observations underline that results obtained from a healthy population can not be extrapolated to patients.

Second, we concluded that the estimation of severity of the paresis during clinical examination, which is often done by using the healthy side as a reference, can lead to an underestimation of the paresis. We found strength values of the healthy leg in the patient group with the unilateral paresis to be lower as compared to the reference group. On the contrary in subjects with an ankle fracture (discussed in chapter 3), strength of the healthy leg was similar to that in the reference population. Because the same instrument and protocol was used, and patients with a polyneuropathy were excluded from this study, this suggested a general decrease of strength in the healthy leg of the patient group which ranged from 25-50%. Obviously, this phenomenon will interfere with the estimation of the severity of paresis. Whether an explanation must be sought in a global reduction of physical activities, the type of treatment given, patients age or in a reduction of central nervous drive is not clear. Also, to what extent and how quick contralateral reduction of strength and skill is seen remains unclear and is open to further investigation.

Third, we now question the use of the walking tests as a means of evaluating the effect of an AFO. The use of walking tests and questionnaires in our study did not provide information to help deciding whether or not a patient profits from AFO use. The subjective evaluation was often positive and patients reported for instance less fear, more stability and les fatigue. The walking tests probably were not sensitive enough for these items.

Finally, we discussed the relation between the impairment (strength loss) and disability (walking problems). We concluded that the effect of an orthosis on the patient's ability to walk is not predominantly related to the severity of the

paresis, but seems mainly dependent on the compensation mechanisms the patient is able to use. Future research, therefore, should be directed to understanding the different compensation mechanisms and methods necessary to optimise relearning of motor processes and the use of these compensation mechanisms in neurological impaired persons.