

**Thesis**  
**The sooner the better?!**  
**Providing ankle-foot orthoses in the rehabilitation after stroke**  
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### *Summary thesis*

In stroke, the blood circulation in the brain is affected, being either ischemic or hemorrhagic. Depending on the location of the lesion, the effects can widely vary. Initial walking function is limited in approximately two-third of the patients. A “drop-foot”, the inability to dorsiflex the foot, with or without excessive inversion is estimated to be present in 20-30% of the people after stroke. Together with decreased knee and hip flexion, drop-foot causes foot-clearance problems during swing phase and also affects initial contact at the start of the stance phase. Insufficient foot-clearance is associated with high risks for stumbling and falling.

Ankle-foot orthoses (AFOs) are commonly used to correct drop-foot after stroke, as they can provide mediolateral stability in stance, facilitate toe-clearance in swing phase and promote heel strike. Positive effects of AFOs after stroke are reported on mobility and balance, ankle kinematics, walking speed, self-confidence and fear of falling. However, most of the studies reporting on AFOs after stroke included chronic patients, already provided with AFOs in daily life and able to walk independently, with or without AFO. Most studies assessed the immediate or short-term effects of AFOs. As a result, long-term studies on the effects of AFOs including more severely affected subjects, and studies including subjects early after stroke are lacking. In addition, an important question like the effect of timing of providing AFOs after stroke remains unanswered in the literature.

As presented in **Chapter 1**, the general aim of this thesis was to increase the understanding of the effects of providing AFOs early after stroke. Therefore, the EVOLUTIONS-project was conducted, a randomized controlled trial in which the effects of AFO-provision on two different time points in the rehabilitation after stroke were studied. Subjects were included within six weeks after stroke and randomized for AFO-provision at inclusion of the study (in week 1) or eight weeks later (in week 9). The subjects were provided with one of three commonly used types of off-the-shelf, non-articulated AFOs with variability in stiffness. Subjects randomized for delayed provision did not use an AFO in the first eight weeks of the study. Subjects were studied up to 17 weeks with (bi)weekly intervals. Follow-up measurements up to 26 and 52 weeks were included.

In **Chapter 2**, the effects of actual AFO-provision on functional outcomes related to balance, walking and activities of daily life are presented. Positive effects were found both when AFOs were provided early or delayed. When the positive effects of AFO-provision were compared between both groups,

and corrected for differences in baseline values at the two time points of AFO-provision, we found that early provision resulted in increased levels of improvement on several clinical scales, compared to delayed provision. This suggested that providing AFOs early after stroke might be beneficial. These results were confirmed in **Chapter 3**, where the effects of early or delayed AFO-provision on a functional level were studied over six months. After 26 weeks no differences in functional outcomes were found between both groups. However, the results suggest that early provision results in better outcomes in the first 11-13 weeks of the study. Clinically relevant, but statistically non-significant differences of 4-10 weeks were found in reaching independent walking levels and reaching higher balance levels thus favoring early provision.

In addition to functional outcomes, gait kinematics were studied. In **Chapter 4** we measured the short-term effects of AFO-provision using 3D gait-analysis in one single session. Ankle dorsiflexion significantly improved directly after AFO-provision, changing the ankle from a plantarflexion into a dorsiflexion angle at initial contact, foot-off and during swing. These results were obtained regardless of AFO-provision early or delayed after stroke. In general, knee, hip and pelvis angles did not change directly after AFO-provision. The long-term kinematic effects of early versus delayed AFO-provision are included in **Chapter 5**. We studied whether early AFO-provision decreased the development of compensatory movements in proximal joints, when foot-drop is limited by AFO-use early after stroke. 3D gait-analysis performed in week 1, 9, 17 and 26 of the study were included. Again, we found that the AFO accurately corrected drop-foot. After 26 weeks, no differences in kinematics in any of the joint angles were found between the two groups. This was the case for both the condition with or without AFO. Furthermore, changes in kinematics during the 26-weeks follow-up period did not differ between both groups. These kinematic results indicate that early or delayed AFO-use after stroke did not influence pelvis, hip and knee movements after 26 weeks. AFOs improved drop-foot, but did not influence movement patterns around pelvis and hip.

Previous literature suggested that AFO-use might increase muscle weakness, and thereby could impede recovery. Therefore, **Chapter 6** addresses the effects of AFO-provision on muscle activity of the tibialis anterior. Results showed that AFO-use reduced muscle activity during swing within a measurement session, compared to walking without AFO. However, 26 weeks use of an AFO did not affect tibialis anterior muscle activity during walking without AFO. Again, early or delayed AFO-provision did not affect the results. These results indicate that there is no need to fear negative consequences on tibialis anterior activity because of long-term AFO-use (early) after stroke.

In addition to effects on functional outcome measures, gait kinematics and muscle activation patterns, the effects on the occurrence and circumstances of (near) falls were studied. In **Chapter 7** diaries were used to register the number of falls/near falls, and in case of an incident, the location, performed activity, possible injuries and whether the AFO was used. We found that subjects in the early group, who had already been provided with AFOs, fell significantly more often in the first eight weeks of the study, compared to the delayed group who had not yet been provided with AFOs. No differences were found for near falls in this period, or for falls/near falls in week 9-52, in which both groups had been provided with AFOs. The majority of the falls in the early group in week 1-8 occurred without wearing the AFO. Falls mainly occurred during transfers and standing, during activities related to getting in/out bed, toileting and showering. The majority of the subjects had not yet reached an independent ambulation level at the time of the fall (Functional Ambulation Categories  $\leq 3$ ) and had low balance levels (Berg Balance Scale  $< 45$ ). This highlights the need for

careful instructions from clinicians and nursing staff to patients and their relatives, and to emphasize the potential risks of performing activities without the proper assistance, especially in situations without wearing the AFO and without independent walking ability.

Finally, in **Chapter 8** the main findings of this thesis are discussed, together with strengths and limitations of this research. In addition, implications for clinical practice and future studies are presented. Summarizing, the results of the current thesis show that clinicians, together with the patient, can decide what they value most in when making the decision on when to commence with AFO-provision. AFOs were found to improve drop-foot regardless of the timing of AFO-provision after stroke. Early AFO-use is expected to result in higher functional levels earlier in the rehabilitation. Despite potential functional gains in the first period of rehabilitation, early AFO-provision does not lead to higher functional levels after 26 weeks, compared to delayed provision. In addition, early or delayed AFO-provision did not influence pelvis, hip and knee kinematics on the short- or long-term. Therefore, AFOs should be provided to correct the drop-foot, but there is no reason to assume that early AFO-provision will influence the development of compensatory movements around the pelvis and hip in the rehabilitation after stroke. AFO-use reduced muscle activity of the tibialis anterior in swing compared to walking without AFO, when effects were measured within one measurement session. However, no negative effects over 26-weeks were found. Therefore, based on the results of our study, fear of disuse concerning the tibialis anterior does not seem to be a justifiable reason to delay AFO-use in the rehabilitation after stroke. One should be aware that higher numbers of falls were found in case that subjects were provided with AFOs early after stroke. Special attention needs to be made to the specific instructions given regarding AFO-use, since the majority of the falls occurred without wearing the AFO and while subjects were not allowed to ambulate independently.