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Fine Tuning Stimulation Parameters

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The ODFS® Pace has a series of default stimulation parameters that are automatically set each time you do a 'NEW SETUP'. The parameters were chosen to be the ones we thought would be suitable for an FES user who had a dropped foot due to stroke, had a fair amount of calf spasticity and was a slow walker (approx. 25s or more to walk 10m). Here is how the parameter values for rising ramp, extension time and falling ramp where decided and when and how you should adjust them.

Rising ramp: default 200ms

The main consideration was the calf spasticity. Spasticity is associated with exaggerated stretch reflexes. This reflex is speed dependent which means if you stretch the calf muscle quickly you will get a bigger reflex response in the calf than if you stretch it slowly. A longer ramp produces a slower stretch and hence can reduce the reflex and result in lower calf tone than a short ramp.

The next consideration is walking speed. Our fictional FES walker walks quite slowly. This means the time between the heel and the toe leaving the ground is quite long meaning strong dorsiflexion is not immediately required. Hence there is time for a long ramp before the foot needs to clear the ground. This also gives time for 'push-off' from the gastrocnemius and soleus. If stimulation reaches its maximum strength too soon and if there is some voluntary activity in the plantaflexion muscles, an unwanted co-contraction will result. If the FES user walked faster, a shorter ramp would be required so the foot was pick up soon enough to keep up with their gait. Generally people who have high calf tone also tend to be slower walkers so it is normally OK to shorten the rising ramp for faster users. As many users of the ODFS® Pace do walk faster than our imagined slow hemiplegic, it is common to need to reduce the rising ramp to between 150 and 50ms. Very slow walkers with high calf tone may have rising ramps set longer than 200ms but rarely longer than 300ms.

The final consideration is comfort. A longer ramp is normally perceived as more comfortable than a short one. It is possible compliance may be improved by using longer ramps. However the most important thing is that walking is safe and for this the stimulation must keep up with the walking. Paradoxically though, in some cases increasing the rising ramp can reduce calf tone and result in an improved range of ankle motion and lead to increased walking speed.

Bearing all these factors in mind, the best rising ramp will be the longest that is sufficiently quick to keep up with walking. Small changes of just 50ms can make a significant difference so don't be afraid to experiment.

Extension: default 200ms

In normal walking the anterior tibialis and toe extensors are contracting at their strongest at heel strike and apply a breaking force to the ankle, lowering the foot to the ground. Without this muscle action the foot would rapidly pivot forward on the heel and the slap the floor in an uncontrolled manner. The second action of the dorsiflexion muscles once weight is on the heel is to pull the tibia forwards, resulting in slight flexion of the knee. This then allows the quadriceps to provide 'shock absorption', absorbing the impact of the heel on the ground.

To produce these effects it is therefore required to continue the stimulation past heel strike to the point when the foot is flat on the ground. A further factor for the use of FES is the effect of calf tone or tightness due to shortening. This can not only oppose dorsiflexion but pull the foot into inversion through the action of tibialis posterior. Common peroneal stimulation through peroneus longus, brevis and tertius activity produces eversion, counteracting this pull into inversion. This ensures that the weight-bearing occurs along or medially to the midline of the foot, preventing turning of the ankle.

Thinking of our slow hemi walker again we estimated that a 200ms extension would be sufficient to end stimulation at the point the toe reaches the ground. For faster walkers a shorter extension is needed as the time between heel strike and flat foot is shorter. If the extension time is left long the period between the stimulation ending and the heel coming off the ground to start the next stimulation sequence is shortened and this means the stimulated muscles do not have an adequate rest period and muscle fatigue can result. An extension time of 100 to 150ms is typical for faster walkers. For very fast walkers or runners the extension time can be reduced to 0ms but this is unusual.

There are two reasons for using longer extension times and these are only practical with slower walkers for the reasons laid out above. The first is to improve knee control, preventing mild knee hyperextension in the initial loading response. The second is to prevent inversion of the foot before full weight bearing. Extension time may be increased to up to 350ms or so but more than this would be rare.

In all cases it is very useful to use the ODFS® Pace sounder or the separate plug in sounder for the ODFS®III and O2CHSII to set the extension time. While watching the movement of the foot, listen to the sounder and adjust the extension time until you hear that the stimulation ends at the point the toe meets the ground.

Falling Ramp: default 150ms

The purpose of the falling ramp is less well defined than the rising ramp or extension time. Its main function is to prevent an abrupt end to the stimulation, providing a more comfortable smooth end to the muscle contraction. For our slow hemi walker we estimated a 150ms falling ramp produced a comfortable effect. For faster walkers a shorter falling ramp will be needed so there is an adequate rest period between contractions. In most cases the falling ramp can be reduced without any adverse consequences and a 50ms falling ramp is often sufficient to smooth the end of the contraction. Longer ramps than 150ms are rarely used as this reduces the rest period between contractions.