# Long-term effects of CUSTOM-MOULDED Footorthoses (CMFO) with Neuromuscular Operating Elements (NME) on muscle activity during gait – a longitudinal study

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## SUMMARY
CMFO with NME are used in orthopedic practice and are still controversially discussed. The effects of the NME are yet not evaluated. In contrast to recent studies we were interested in muscular activation and the postulated muscle chain reactions. We detect significant changes in EMG caused by the CMFO with NME, but not in the postulated way. The obtained long-term results should allow a deeper understanding of footorthoses' effects and therefore influence the individual treatment for an increased patient's benefit.

## INTRODUCTION
Bourdiol developed in the 70s a FO by which the human posture should be changed positively. By influencing the plantar foot sensibility with NME on flat insoles, reflexes are activating so called muscle chain reactions. These elements are used in different, new FO-concepts to treat posture ailment of the whole human locomotor system.
Classical FO, like CMFO, focus on orthopedic foot problems and malpositions of the lower limb [1] [2]. Several scientific studies validated the effects of those FO [3]. But there is less proof of long-term effects and the sustainability of the FO [4]. NME are still controversially discussed due to the missing scientific background. Research topics of a majority of studies were the influences of the insoles during upright standing.
This analysis is going to test orthopedic insoles under dynamic conditions, which combine CMFO and NME. The aims of our study were to test the long-term effects of these FO and to analyze the postulated muscle chain reactions.

## METHODS
12 individuals (6 m, 6 w; age 36.7±3.1yr) with hypotonic posture and low back pain (LBP) had participated in this longitudinal trial. We focused our interest on two different muscle chains, the extension chain (EC) and flexion chain (FC). The used CMFO were OPCT Tonic01 (SIDAS) and the NME PostEva SH50 (SIDAS) (Figure 1).

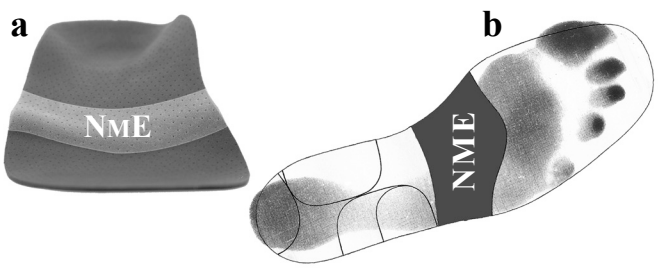


**Figure 1:** AP view on a right CMFO (a) with NME (bright area) and footprint with position of the NME (b)

Myoelectric signals of 24 muscles (12 per body half) (Figure 3) at the lower limb and trunk were recorded at a sampling rate of 2000 Hz with surface-EMG (SEMG) (Biovision) at the delivery date of the FO and after 8 weeks of intervention. All trials were performed on a treadmill (CallisOrtho, Sprintex) by using subjects own shoes. Subjects walked at their favored speed (range 3.5-5.0 km/h), but they had to use the same velocity on both testing dates. Data were collected over 60 s. Internal synchronized plantar pressure distribution measurement (MobilData, GeBioM; 200 Hz) was used to obtain the timing characteristics of the gait cycle.
The raw SEMG were high-pass filtered (Butterworth 20 Hz), rectified and smoothed with RMS 50. Afterwards 40 continuing double steps were separated, time normalized to 100 $\%_{gait\ cycle}$ and compacted to 101 data points (accuracy: 1 $\%_{gait\ cycle}$). Paired t-Test was used to control data at each percentage point of the gait cycle. Significant changes ($p<.05$) are considered as relevant, if they are (i) within the period of muscle activity and (ii) last for a continuous timeframe of more than 10 $\%_{gait\ cycle}$.

## RESULTS AND DISCUSSION
Subsequent only significant and relevant results are presented.

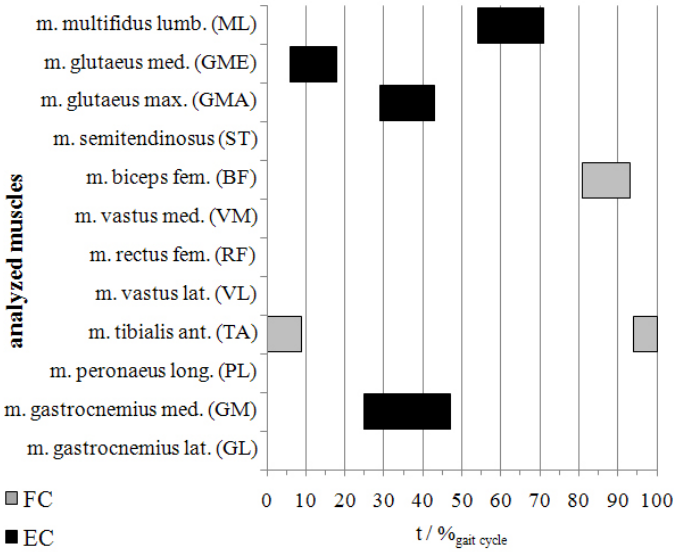


**Figure 2:** Periods of significant and relevant changes in activation for the analyzed muscles, grey bars show muscles of the Flexion chain (FC) and the black bars are muscles of the extension chain (EC)

After 8 weeks of intervention with the FO the muscles (Figure 2) of the EC can be influenced as it is following.

The electric activation of the GM decreases by 33 % during 25-47 $\%_{\text{gait cycle}}$. EMG of the GMA increases in the range of 29-43 $\%_{\text{gait cycle}}$ by 11 %. GME is reduced by 41 % in a window of 6-18 $\%_{\text{gait cycle}}$ within the time of using CMFO with NME and the activation of the ML increases by 52 % during 54-71 $\%_{\text{gait cycle}}$.
Two muscles of the FC show significant changes. The activation of the TA increases in the windows of 0-9 $\%_{\text{gait cycle}}$ and 93-100 $\%_{\text{gait cycle}}$ (interpreted as one closed area over 16 data points) by 38 %. During 81-93 $\%_{\text{gait cycle}}$ the EMG of the BF increases by 18 %.

The FO-concepts argue that NME inhibit the muscles of the FC and activates the EC muscles. But our results show that the activations at GM and GME decrease after the intervention period, whereas GMA and ML increase. Due to the contrary effects at the EC and the increase of muscle activity at the FC, our results do not confirm that the theory of the chain reactions is adequate to explain the influences of the CMFO with NME. Furthermore there are muscles which can not be affected significantly and relevantly.

However there is proof that the used FO have an influence on muscle activity. The activation of the TA increases significantly and relevantly around the initial contact due to 8 weeks intervention with the CMFO with NME. In other studies to foot orthotic device similar effects could be validated [3].
At the GMA we observe an increase of muscle activation during single limb support after the intervention period. ML action rises in our study as well around the end of stance phase, what can be interpreted as a mechanism for better stabilization in the lumbar region [5]. Several studies had shown that LBP correlates with a pathological activity of the ML. Furthermore patients with back pain got a benefit due to more ML activity and the resulting stabilization in lumbar region [6].

## CONCLUSIONS

Based on the results provided in our study the published muscle chain reactions can not be confirmed, but we detect significant and relevant changes in muscle activation during gait after an 8 week intervention period. ML activity, which is important for lumbar stabilization can be altered due to the tested FO. Based on our results we can deduce that the CMFO with NME have positive long-term effects on muscle activation. For orthopedic practice we can give the advice that it is important to control the effects of these orthoses after a few weeks of therapy. Furthermore, the CMFO with NME should be used at least for more than two month to get relevant effects with benefit for patients with LBP.
In a further study we will focus on the sustainability of the detected effect and the influences on gait kinetics.

## ACKNOWLEDGEMENTS

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## REFERENCES

1. Collins, N., et al. Foot orthoses in lower limb overuse conditions: a systematic review and meta-analysis. *Foot Ankle Int.* **28**: S. 396–412, 2007.
2. McMillan, A. und Payne, C.,. Effect of foot orthoses on lower extremity kinetics during running: a systematic literature review. *J. Foot Ankle Res.***1**: doi:10.1186/1757-1146-1-13, 2008.
3. Murley, G. und Landorf, K., Menz, H. Do foot orthoses change lower limb muscle activity in flat-arched feet towards a pattern observed in normal-arched feet? *Clin. Biomech.* **25:** 728–736, 2010.
4. Mills, K., Blanch, P. und Chapman, A. Foot Orthoses and Gait: A Systematic review and Meta-analysis of Literature Pertaining to Potential Mechanisms. *Br J Sports Med.* **44**: 1035–1046, 2010
5. McGill, S., et al. Coordination of muscle activity to assure stability of the lumbar spine. *Journal of Electromyography and Kinesiology.* **13**: 353–359, 2003.
6. MacDonald, D., Moseleyb, G. und Hodges, P. The lumbar multifidus: Does the evidence support clinical beliefs? *Manual Therapy.* **11**: 254–263, 2006.