ABDUCTOR HALLUCIS REHABILITATION: SPECIFIC VS FUNCTIONAL TRAINING

A quantitative study by Charlie Rassek

INTRODUCTION

Pes planus is characterised by an excessive decrease of the medial longitudinal arch (MLA) which has been associated with foot, lower extremity and lower back disorders (1-3). Those conditions represent a challenge for the health care system due to their impact on society (1).

The MLA plays an important role in foot biomechanics and plantar pressure (PP) distribution (4,5). Indeed, the lower the arch, the higher the plantar pressure underneath the MLA (PP_{MLA}) (4). Intrinsic foot muscles (IFM) and more specifically the abductor hallucis (AH) have a crucial role in foot posture and stabilisation by supporting the MLA (6).

IFM dysfunction could lead to a lack of MLA support (7), increasing the PP_{MLA} (4) and therefore risks of pes planus related conditions.

The short foot exercise (SFE) and balance tasks (BT) promote AH muscle activation (8,9) but are difficult to implement appropriately in clinical practice (10,11). Electromyography (EMG) biofeedback could provide a solution (10).

The aim of this research is to investigate the difference in direct effect of EMG biofeedback of the AH muscle on the PP_{MLA} during the SFE and a BT in healthy adults.

RESEARCH QUESTION

What is the difference in direct effect of electromyography biofeedback of the abductor hallucis muscle on plantar pressure underneath the medial longitudinal arch during the short-foot exercise and a balance task in healthy adults?

METHOD

Design
Quasi-experimental one-group pretest-posttest experiment.

Recruitment
Twenty-seven students from Fontys university of applied sciences participated in the study.

Data collection
Each participant stood barefoot with their right foot on an Emed®-x400 pedography platform (Figure 1). They were asked to perform the SFE and the BT with and without PhysiopluxGo EMG biofeedback system (Figure 2). Three trials were recorded for each task while measuring the pressure-time integral underneath the midfoot ($PTI_{midfoot}$) (KPa.s). An average of the PTI for the three trials was then calculated for each task using the Novel ® software.

Data analysis
Statistical analyses were made using the SPPS software. The Wilcoxon signed-rank test was used to determine the direct effect of EMG biofeedback of the AH on the $PTI_{midfoot}$ during the SFE and the BT and to compare the relative change of $PTI_{midfoot}$ between both tasks.

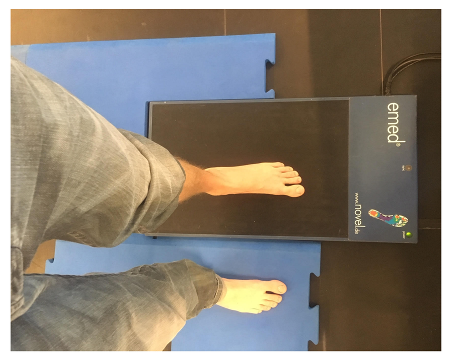

Fig 1. Emed®-x400 pedography platform.

Fig 2. PhysiopluxGo app and EMG biofeedback system.

RESULTS

Table 1. Direct effect of EMG biofeedback of AH on the PTI underneath the midfoot during the SFE and the BT.

	Median	IQR	P-value
$PTI_{midfoot}$ SFE vs $PTI_{midfoot}$ SFE FB			0,072
SFE (KPa.s)	80,6	70,2	
SFE FB (KPa.s)	80,6	52,9	
$PTI_{midfoot}$ BT vs $PTI_{midfoot}$ BT FB			0,009
BT (KPa.s)	190,1	48,5	
BT FB (KPa.s)	160,6	76,3	
Relative change $PTI_{midfoot}$ SFE vs Relative change $PTI_{midfoot}$ BT			0,000
Relative change SFE (%)	14,9	78,8	
Relative change BT (%)	-17,7	36,7	

The results of the Wilcoxon signed-rank test used to determine the direct effect of EMG biofeedback on the $PTI_{midfoot}$ during the SFE and the BT and to compare the relative change of $PTI_{midfoot}$ between both tasks were presented in Table 1.

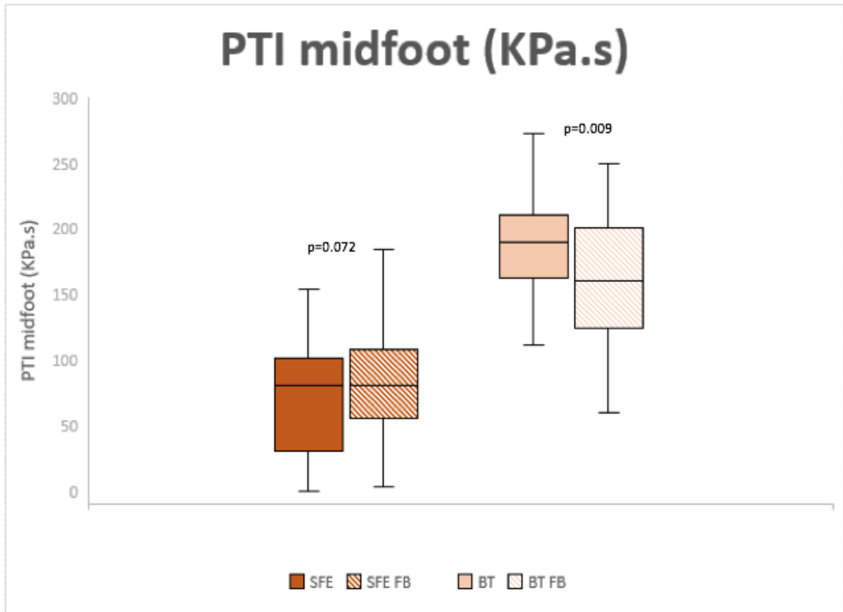

Fig 3. Pressure-time integral underneath the midfoot during the SFE and the BT.

As shown in Figure 3, no statistical significant difference was found during the SFE (p=0,072) suggesting that EMG biofeedback has no direct effect on the $PTI_{midfoot}$.
Contrarily, statistical significant difference was observed during the BT (p=0,009) suggesting that the use of EMG biofeedback decreased the $PTI_{midfoot}$.

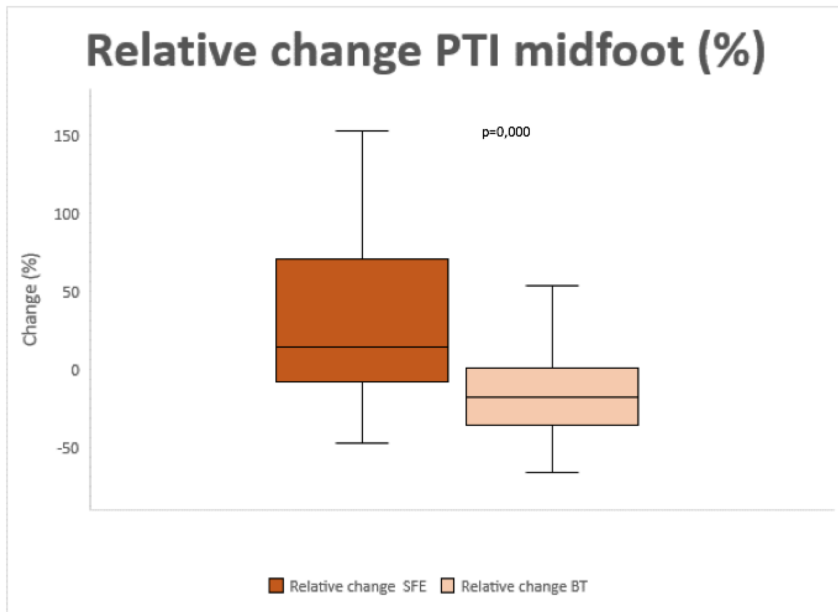

Fig 4. Relative change of PTI underneath the midfoot with the use of EMG biofeedback during the SFE and the BT.

As shown in Figure 4, statistical significant difference was found when comparing the $PTI_{midfoot}$ relative change between both tasks (p=0,000) suggesting that the use of EMG biofeedback was more effective during the BT to reduce the $PTI_{midfoot}$.

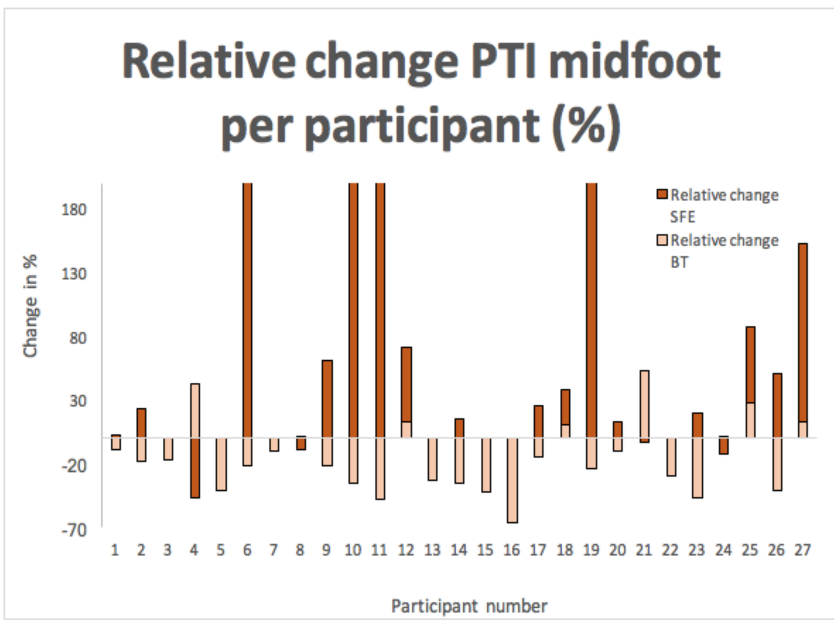

Fig 5. Relative change of PTI underneath the midfoot with the use of EMG biofeedback during the SFE and the BT per participant.

As shown in Figure 5, $PTI_{midfoot}$ was decreased after the use of EMG biofeedback for 19 participants during the BT. It was decreased for 4 participants during the SFE. However, it was increased during both exercises for 4 participants.

DISCUSSION

During the SFE, EMG biofeedback did not have any direct effect on the PTI_{MLA} confirming previous findings (10). Earlier study suggested a relation between SFE training period and decrease in PP_{MLA} (12). The SFE being a complicated concept to grasp, it may require time and training before fully benefit from it (13) as it requires AH control in a specific pattern.

During the BT, a different physiological mechanism may have occurred as PP_{MLA} was decreased with the use of the EMG biofeedback. IFM activity increase with increasing postural demand (9) and physiological load (14) by an unconscious process to maintain balance and foot arch posture. Conscious additional AH contraction facilitated by the EMG biofeedback may have led to reduce the PP_{MLA} by heightening the MLA (14). PP_{MLA} may also have been reduced following plantar flexion of the first metatarsal-phalangeal joint during AH activation suggesting a change in PP distribution. Further studies are needed to understand underlying mechanisms explaining the presumed benefit of EMG biofeedback.

The BT benefited the most from the EMG biofeedback as PP_{MLA} was reduced while it was increased during the SFE. However, some individual may benefit more from EMG biofeedback during SFE while other during the BT. Some individual did not benefit from it during any exercise. Every individual is unique and various motor strategies could be used to achieve a similar task (15).

The measurement protocol ensuring that results arise from the intervention itself, randomisation of tasks order and the accuracy and reliability (16) of the pedography platform ensured internal validity and reliability of the study. However, generalisation of our findings to a larger group remained limited as the experiment was conducted on asymptomatic population with narrow demographic characteristics.

In clinical practice, patient following rehabilitation training targeting IFM for excessive foot pronation may benefit from EMG biofeedback in combination with BT . However, further investigations are necessary. IFM rehabilitation protocols may benefit to focus on dynamic tasks such as balance tasks in combination with EMG biofeedback. Finally, it may be relevant to determine for each individual what exercise benefit him the most to achieve an effective training.

Future research should investigate the effect of EMG biofeedback of the AH for specific pathological populations such as pes planus. Determining the effect of EMG biofeedback on PP following a progressive and longer SFE training period should be considered. Finally, future study should investigate the change of PP_{MLA} considering additional foot regions.

CONCLUSION

Our results indicate that the use of EMG biofeedback may reduce the PP_{MLA} during functional tasks such as a single-leg balance exercise. However, additional research is needed to explain underlying mechanisms behind PP_{MLA} changes.

During specific foot exercises such as the SFE, the PP_{MLA} remained constant.

In clinical practice, it may be relevant to determine the most efficient exercise for each patient as individuals may benefit differently from the use of EMG biofeedback.

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