

# Investigation of muscle fatigue for pes planus orthotic insole solution using EMG

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**ABSTRACT** – Customized orthotic insole is a solution currently available for people with pes planus or flat feet problem. The customized thermoplastic polyurethane (TPU) orthotic insole is claimed to offer support, correction for deformities on the foot and reduction of muscles fatigue. The purpose of this study is to investigate the muscle fatigue while wearing a customized TPU orthotic insole using electromyography (EMG) testing. Four primary muscles fatigue with insole and without insole is compared under three different tasks which are walking, running and stair climbing. This study found that customized TPU orthotic insole can reduce the muscles fatigue.

## 1. INTRODUCTION

The application of additive manufacturing (AM) technology in medical sector can be a viable method apart of the application of AM in the industrial sector of manufacturing and prototyping. The use of the advanced FDM technique is expectedly would reduce the time to produce or fabricate a product. The effective methods and tools in testing the reliability of customized TPU orthotic insole as the best flexible material is highlighted as the result of the study (Figure 1).

In previous study, a customized insole as a solution for people with pes planus problem was successfully created and utilized [1]. The study was tested with patient with the involvement of an orthotics expert, Dr Ahmad Tajuddin Abdullah, an Orthopedic & Traumatology Surgeon from Mahkota Orthotics and Prosthetic. The subject reported an improvement of comfort experienced while using the customized insole [1]. The next step is to check on what happen to the muscles. The aim of the study is to identify/observe the appropriate muscles using EMG sensors during repetitive movement under several different tasks.

## 2. METHODOLOGY

The usability testing is conducted as to know the user experience using the orthotic insole. It was a task to reveals the strengths and opportunities for improvement of the insole. The efficacy and longevity of orthotic

insole is determined as to know whether the design and material used to produce orthotic insole is compatible or not with a human subject. Any cause of failure of the product during testing will be taken into consideration in order to come out with the best solution in future



Customized insole – 3D modeling



3D printed TPU flexible material



Customised insole – tested with orthotics expert



Without insole With insole

Results on pes planus with and without insole

Figure 1 The process of modeling, fabricating, and testing of the customized indole

Electromyography (EMG) testing is conducted in this study in order to evaluate the muscle fatigue on subject who suffers from flat feet. The EMG testing is conducted by instructing subject for EMG signal acquisition of what repetitive activities need to be done. The EMG signal processed through the Delsys EMGwork Analysis software where the signals are sampled at 1000 Hz (Figure 2).

A 13 years old boy having a flat feet problem participated as a subject in this study. The subject was selected according to the clinical assessment of feet screening obtained by a specialist as a conformation about the subject's feet problem condition [1]. The subject was given an explanation of the exercise method and procedure. The subject is asked to use his daily shoes to put the customised TPU orthotic insole as

shown in Figure 2. The subject need to perform three repetitive activities including walk, run and climb the stairs for 30 seconds, three times of each activity. Only the results for walking and running is shown on this paper due to space constraint.



Delsys Trigno Wireless EMG



Inserting TPU orthotic insole into the shoe.

Figure 2 The process of modeling, fabricating, and testing of the customized indole

The primary muscles involved in this project as shown in Figure 3 are for standing, walking, running and climbing activities [2].

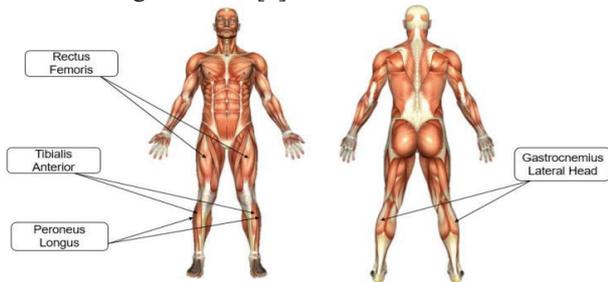


Figure 3 Primary muscles involves for EMG testing



Front view Rear view Side view

Figure 4 Sensor placement on the subject feet ( (a)-front, (b)-back, (c)-side)

### 3. RESULTS AND DISCUSSION

The results of the test during walking, and running activities has been analyzed, where the difference between the subject doing all these activities without insole and also with insole. Figure 5 shows the average root mean square (RMS) of all muscles on right and left during walking activity. From the Figure 5 (a) and (b), the average RMS of Tibialis Anterior (TA) right and left show less muscle fatigue with insole compared to without insole. Figure 5 (b) shows the average RMS of Peroneus Longus (PL) right and left, where there is less muscle fatigue with insole compared to without insole. The results for Rectus Femoris Figure 5 (c) and Gastrocnemius Lateral Head Figure 5 (d) is a bit inconclusive maybe due to the subject's muscle trying to accommodate the new insole usage on his feet.

Figure 6 shows conclusively that all muscles show less muscle fatigue RMS reading when doing running

activity with insole compared to without insole.

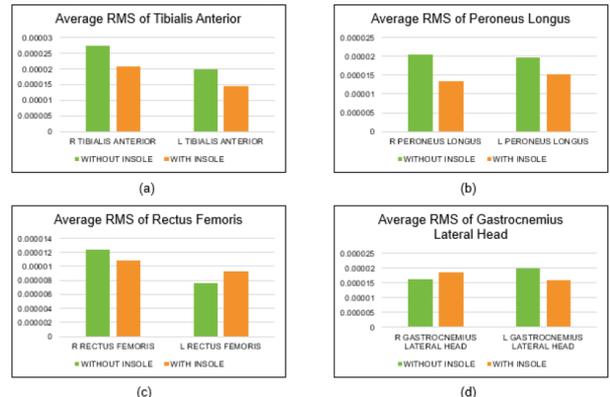


Figure 5 Average RMS of all muscles during walking activity

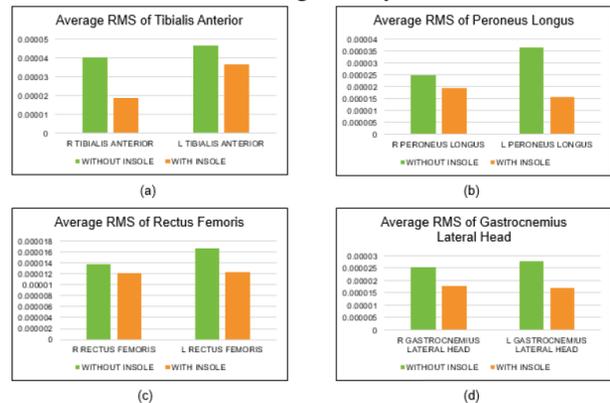


Figure 6 Average RMS of all muscles during running activity

### 4. CONCLUSION

The customized TPU orthotic insole is produced to help people that have a problematic feet especially flat feet as the effective way to treat the pain. Flat feet may cause pain all over the body including ankles, knee and lower back. The efficacy of customized TPU orthotic insole is proven using EMG testing which shows that the muscles fatigue can be reduce (20% less on average) by using customized TPU orthotic insole. This is simple method that can be adopted by medical orthotics practitioners to provide fast, economical, and personalize solution for their clients.

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