PRESSURES EXERTED IN OVERGROUND AND TREADMILL WALKING AND RUNNING

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INTRODUCTION

The pressures exerted by the foot and various pressure distribution styles could be leading contributors to certain injuries, such as ankle instability or stress fractures in the foot [1, 2]. In addition, reestablishing a ‘normal’ pressure distribution across the foot during walking may be a key step in rehabilitating after ankle or ACL reconstruction injuries. These hypotheses have been around for quite some time, but due to technological limitations they have been unable to be tested [3].

One such limitation is that the force plates which are commonly used to collect foot pressure information only report a single resultant force vector with no indication of how it is distributed across the foot. Because of this, we could gather seemingly similar data from a control subject and of interest, but in reality it is unclear whether the force is distributed the same way for each subject [3].

Recent technological advancements have allowed for the development of Pedar pressure sensing insoles. Each insole has 99 pressure sensors that track pressure over time. This allows the pressure distribution across the foot to be quantified and analyzed in a way that could not be done with force plates.

These insoles can not only provide a new source of data, but can also be used to test the accuracy of previous findings made using force plates. The Pedar pressure sensing insoles can now allow for comparisons of pressure distributions exerted in many different scenarios. It can now be determined whether or not pressure distribution varies from person to person or if there is a general pattern that the average person follows.

Using these insoles and their pressure sensing technology, pressure distribution patterns can be compared to evaluate the repeatability and consistency of certain actions. Obtaining this information will be useful for determining how many trials are necessary to collect stable accurate data. An assumption that has been made for a while is that the treadmills often used in laboratories are an accurate representation of walking and running in the real world. The insoles also provide a new way of determining whether this assumption holds true [3, 4].

In addition to all this new information about current lab techniques, the Pedar pressure sensing insoles can be utilized for a variety of clinical experiments. Understanding how pressure is distributed when a healthy person walks or runs allows abnormal pressure distributions to be identified and potentially corrected in people with ankle instability, recovering from various surgeries, and so on.

OBJECTIVE

The objective of this study is to make three different comparisons of the pressure distribution to try and develop overarching conclusions about the pressure distribution during these actions. In this study, 20 healthy subjects (subjects who do not have injuries or conditions impairing their movement) walk and run on a treadmill and overground. The pressure distributions are being compared between: right foot and left foot, walking and running, and overground and treadmill.

SUCCESS CRITERIA

For this study to be deemed successful there are a couple questions we are asking. Can we draw general conclusions from the three comparisons? Are there consistent patterns that hold true for all subjects? Do we understand the uses of the Pedar system?

METHODS

The study was designed to examine the pressure distributions of healthy subjects. Subjects with injuries or certain medical conditions might walk in an adapted way with different pressure distributions and for this reason were excluded from the study. Each of the 20 subjects participating in this study were prescreened to ensure good health and consented prior to the experiment.

Each subject underwent 28 trials. Four of the trials were static, eight were overground, and sixteen were treadmill. Half of each the overground and treadmill trials were walking, and the other half was running. The Pedar insoles allow data collection via Bluetooth as well as by using an SD card. We chose to use both methods, as we discovered that although the Bluetooth was more convenient, occasionally some of the data would not be collected. In these cases we used the SD card to recover the missing information.

Once the data was prepared, the foot was split into nine regions and masks were applied to the data in order to dictate which sensor data belonged to which region. Additionally, using Matlab, heel strikes were identified by graphing the full foot pressure of each foot in each trial for each subject. After heel strikes were identified, the data was averaged across the completed gait cycles in each trial. This averaged data was used to produce the results by graphing the averaged pressures in each region in accordance to the three comparisons and performing statistical analysis.

RESULTS

The results for this study are divided according to the three comparisons of interest. The first comparison is the pressure distribution of the right foot and left foot for each subject in each trial. This comparison shows that the right and left feet have symmetrical pressure distribution. Some trials had slightly higher pressures in the left foot while others had slightly higher pressures in the right foot. No pattern was able to be established as to when a subject would exert higher pressures in which foot.

The walking and running pressure distribution comparison did show distinct patterns and differences between them. Higher pressures were exerted in the running trials, and the running trials also showed a higher variability between the
trials. A consistent pressure distribution held true for all walking trials for each subject. In the heel and midfoot portions of the foot, higher pressures were exerted in the medial section of the foot as opposed to the lateral section. For the forefoot, the medial and central sections were fairly equal, while the lateral section has a lower pressure. Finally for the toe portion, the greater toe region experienced higher pressures than the lesser toe region. During the running trials, the pressure distribution was dependent on the running style of the subject and varied from person to person. The portion of the foot that had the most variation was the forefoot.

The comparison between the overground and treadmill trials showed no significant pressure distribution differences (p=0.0038). Some notable observations were made that were consistent across all subjects. These included slightly shorter strides for both walking and running on the treadmill when compared to overground. Additionally, the pressures exerted in the treadmill trials were slightly lower than those exerted in the overground trials.

DISCUSSION

Overall, the results collected from this study support those made by our hypotheses and by past literature. General conclusions for the three comparisons of interest were able to be made from the data. For the right foot and left foot comparison, it was determined that healthy subjects generally have fairly symmetric pressure distributions across both feet. The walking and running comparison resulted in some general guidelines for how the pressure should be distributed when walking, and showed that pressure distribution in running is highly variable. Lastly, the treadmill and overground comparison leads us to believe that surface does not impact how pressure is distributed across the foot, but can affect the value of the pressure exerted. These conclusions will allow injury-related pressure distribution abnormalities to be quickly identified in future studies.

When looking back at the success criteria that was put in place, we can confidently say: yes, general conclusions were able to be drawn from the results for all three comparisons, yes, patterns were seen that hold true across all subjects, and yes, we do understand the uses of the Pedar system. For these reasons, this study was deemed successful. We learned new information about pressure distributions that can be applied to future studies.

This study was completed using a brand new piece of equipment (the Pedar system) which resulted in a very large quantity of data. These two facts in combination were a limitation of this study and could have resulted in some sources of error. It is also important to keep in mind that this study is not yet fully completed and data is still being collected, meaning the results are subject to change slightly. This information can aid us in the future when studies of similar procedure are conducted on subjects who have undergone ACL or ankle reconstruction, or have disorders like cerebral palsy that might affect how a subject walks.

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REFERENCES


