

# **Analysis of Foot Pressure Distribution in Healthy and Children with Different Foot Deformities While Standing**

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## **Abstract:**

One of the most common activities that humans do is standing and walking. Most of the activities carried out by humans are closely related to the feet, such as standing, walking, climbing heights, driving vehicles and many more. Therefore, foot health is of great importance, as foot problems affect all these activities. Our goal in this project is to focus on the problems that children suffer from by measuring Distribution of foot pressure in the case of standing and walking and extracting useful data and working to find solutions to these problems through a design that suits each problem.

## **Introduction**

Our first involuntarily movement is walking, which is any human's daily activity and gait plays an important role in the human movement. The synchronization of both neural and musculoskeletal systems is essential to achieve stability and balance of the body during movement. Analysis of gait parameters plays an important role in the evaluation of different factors. The feet are the major source of support during gait and are corresponding to the rapid changes of the surrounding and thus, are exposed to large force. The deduction of the human foot pressure distribution can provide the essential information and thus, greatly assist the medical diagnosis. This foot plantar uses the FSR, force sensitive resistor sensors to collect the necessary data which is then processed to give digital output [1]. These values are fed in custom-made software to give a pedobarography image that depicts visually the different pressure distribution of the foot. The study of pressure fields acting between the plantar surface of the foot and a supporting surface is called pedobarography. This image will be saved in a document format and can be studied by doctors for proper diagnoses. Thus, this foot plantar pressure device will provide better efficiency and improve functionality than the already existing devices in the measurement system. Feet are in contact with the surrounding environment during motion and thus, interact with the ground. Many activities are solely possible due to the movement of feet such as walking, running. Thus, the importance of feet in daily activities is immense and so proper care should be taken to avoid injury. To analyze the condition and suitable standard of feet is with the help of foot plantar characteristics. Thus, an accurate and secure measurement system for foot plantar pressure is imperative. Footwear has been one of the first factors for determining the foot plantar pressure. 1997 witnessed the influence of mean peak plantar pressure on shoes with and without viscoelastic insoles, thus, giving the optimized effective result. In time, many various studies were available for foot pressure measurement and designs of footwear for non-disabled people Deformity Considering the applications that are connected to disease diagnosis, many scientists have determined that foot problems are mainly because of diabetes that causes extreme foot plantar pressures in specific sites under the foot. Diabetes is now considered as a widespread condition and, according to reports. number of patients suffering from diabetes is ever increasing. Balance is considered as a top priority for various sports and other biomedical applications such as soccer balance training and forefoot loading during running. Pressure distribution is promptly seen in aged and other impaired personal due to the gait instability [2]. Foot pattern: is the phase in which the foot touches the ground (usually the heel) and moves along the ground before being lifted to propel the body forward (using the forefoot) to perform walking. The pressure starts in the heel area and then travels down the bottom of the foot through the instep. Therefore, the highest average pressure in a normal foot is under the heel and instep, and the lowest pressure distribution is under Cubic bone. In an abnormal foot, the higher pressure distribution in a flat foot is below the cuboid bone, and in a hollow foot the pressure distribution is lower under all parts of the foot. In clubfoot, the pressure distribution is different and the contact area of each mask is different, and the contact area time of the left foot and right foot is spectral one of the most commonly discussed topics in pediatric practice. Is static and dynamic changes in the position of the feet? Foot deformity is the most common condition in clinical practice (about 70-80% of the population) [1]. For many people, this is the cause of foot pain and fatigue. Diagnosis of poor foot should go beyond clinical observation and visual examination [2]. The bones of the foot make up about

1/4 of the bones of the human body. Each foot contains 25 bones, 33 joints, 107 ligaments that connect the bones to each other (ligament), 19 muscles, and many ligaments which connect the bones to the muscles (tendon), which work to keep the bones in place and move them in all directions. The foot is also made up of a network of nerves, skin and soft tissues [3]. The stance phase, which corresponds to 60% of the cycle in the normal gait, occurs when the foot is in contact with the ground. It begins with the “initial contact (IC)” event, when the heel touches the ground, and ends with the “toe-off (TO)” event, which is when the toe is lifted [4]. During this phase, the body weight is transferred from the rear leg to the front leg. The stance phase can be further divided into three periods: two “double-support” periods (periods in which both the feet touch the ground), one at the beginning (initial double support) and the other at the end (terminal double support), and a third, “single-limb support” period for the remaining part [5]. The stance period takes about 0.6 s during an average walking speed. The extension in the percentage of the cycle of these three periods depends on the walking speed. The swing phase, which corresponds to 40% of the cycle in the normal gait, occurs when the foot is without contact with the ground (foot in the air). It begins with the “pre swing” event, when the foot is pushed and lifted off the ground, and ends with the “terminal swing” event, which is when the foot is positioned for initial foot contact to start the next gait cycle [4]. Measuring the distribution of foot pressure in the static state, which is the measurement in the case of the child standing still. 2. Measuring the distribution of foot pressure in the dynamism state, which is the measurement in the case of the movement of the child during walking. Figure shows these two measurement methods [7]. General analysis of foot pressure distribution and changes in the foot is a common topic in medical and biomechanical practice. Foot deformities are the most common medical condition for many people who experience fatigue and pain in the feet. Therefore, the examination and diagnosis of the foot should be done in ways that go beyond clinical diagnostic methods such as foot observation, visual examination and identification of the problem because the diagnosis is not very accurate. Several additional methods for assessing foot position have emerged. These methods differ in design, shape and different applications. Chapter two is a short description of theory methods used [7].

As early as the 1990s, developed a system for measuring the pressure distribution beneath the foot using seven force-sensitive resistors (FSR) and they used it to differentiate pressure between walking and shuffling. In 1995, built a footswitch system capable of detecting temporal gait parameters using two FSR sensors. Later, in 1997, Cleveland Medical Devices Inc. created an in-shoe wireless system which could measure time of foot contact, the weight on each foot and the center of pressure (COP) of each foot. Also the platform used to measuring foot pressure distribution. These systems used a set of thick-film force sensors these sensors are [8]: By which two capacitor plates move closer together as a result of the applied force.

The change in charge causes a change in voltage such as Novel [9]. Functionality of a capacitive sensor: If the sensor is unloaded (A), the high-frequency signal measured at the receiver is low. This signal corresponds to zero. If the sensor is loaded with increasing pressure (B and C), the distance between the surfaces becomes smaller and the signal at the receiver becomes correspondingly stronger. Thus, this change in the receiver signal is a measure of the pressure produced [9]. Structure of the Parotec sensor: Piezoresistive pressure sensors are embedded in a hydrocell where they measure the fluid pressure (Fig. Paromed). The pressure transducer of the Fast Scan system consists of resistive layers applied between two thin plastic films. The geometric arrangement of the circuit paths defines the size and number of

individual lattice-like elements distributed over the film (Fig. Megascan). The pressure sensors in GeBioM System insole measurement system are all individually wired. (Fig. GeBioM). In the Medilogic system, the sensors are applied as conductor lines on a flexible sole [9]. This sensor is made of semiconductor materials. It is a pressure-resistant material that consists of a bulk resistivity that is affected by pressure and force. When the sensor is discharged, the resistance is high, but when the sensor is loaded (there is a force exerted on the resistance), the resistance is low. Accordingly, when there is pressure on the quartz crystal, electric charges are produced from the surface, and in turn, these charges produce voltage [10][11]. This system provides information about dynamic pressure and force, as well as provides information about walking pattern and time spent. The sensors are placed inside the shoes to measure the pressure imposed on them by the body, but this type of system fails due to the lack of stability of the sensors in a good way, which leads to slipping and giving inaccurate results as well as The spatial resolution of the data is very low due to the small number of sensors [12]. It is a device that represents a very great progress in building foot pressure maps and analyzing gait by means of a platform that contains a large number of small pressure-resistant sensors. The platform is connected to a computer that displays a map of the foot pressure distribution and accurate information about the areas of foot contact with the platform, and this is useful in determining the type of foot in relation to if it is normal or abnormal. This system gives very important parameters such as maximum foot pressure, average foot pressure, surface area, contact time and other parameters. All of these parameters lead to very accurate results that help in determining the problem and finding solutions [13].

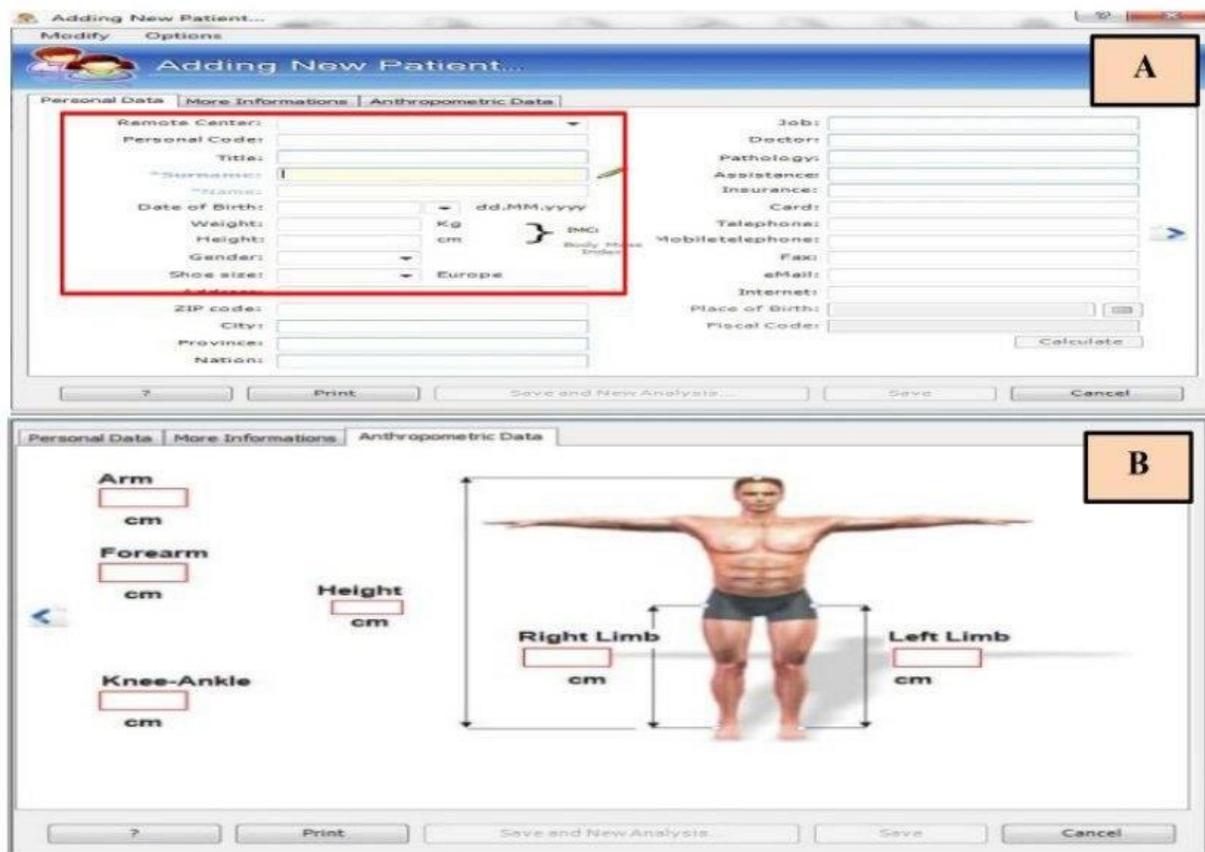
As a result of the effectiveness of this system and the accurate results that can be obtained in addition to the ease of measuring the distribution of foot pressure compared to the previous systems, it will be adopted to analyze the distribution of foot pressure in children in the case of static and in the case of dynamic.

## **Materials and method**

Work in this chapter will explain the process of measuring the distribution of foot pressure in both cases, static and dynamic, on children between the ages of (5-15) years of both sexes. Measuring .Practical part the tactilus device was used to obtain the correct foot pressure distribution and use it as references in the process of data analysis to obtain solutions to the problems that children suffer from. Therefore, by searching for the most common foot problems that children suffer from, it was found that the case of flat foot and high arch foot is the most prevalent problem, which has a significant impact on the health of the bones of children, as well as a cause of pain and fatigue in the lower limbs of children. On this basis, we conducted an analysis of the distribution of foot pressure for children in the case of static and in the case of dynamic, as follows:

First step:

General information about the child is taken, such as age, weight, height, shoe size and other measurements as shown in the figure:



interface for entering volunteer information (A. personal data and B. Anthropometric data).

The second step:

Is to measure the distribution of foot pressure in the stationary position, that is, the child stands with barefoot in a balanced position with his hands on both sides on the platform in the position marked by the footprint without moving for several seconds.



Figure (.2): Measuring in static state.

The third step:

Make the child walk straight across the platform and take the first foot print in the case of going and take the second foot print in the back case to form an integrated map of the foot pressure distribution that contains the pressure distribution of the right and left feet.



Figure (3): Measuring in dynamic state.

From the previous steps, images were obtained containing many information and parameters describing the type of foot and the distribution of foot pressure in each of the contact areas.

Subject 1:

Was 9-years old girl, Static state show heavy high arch feet.

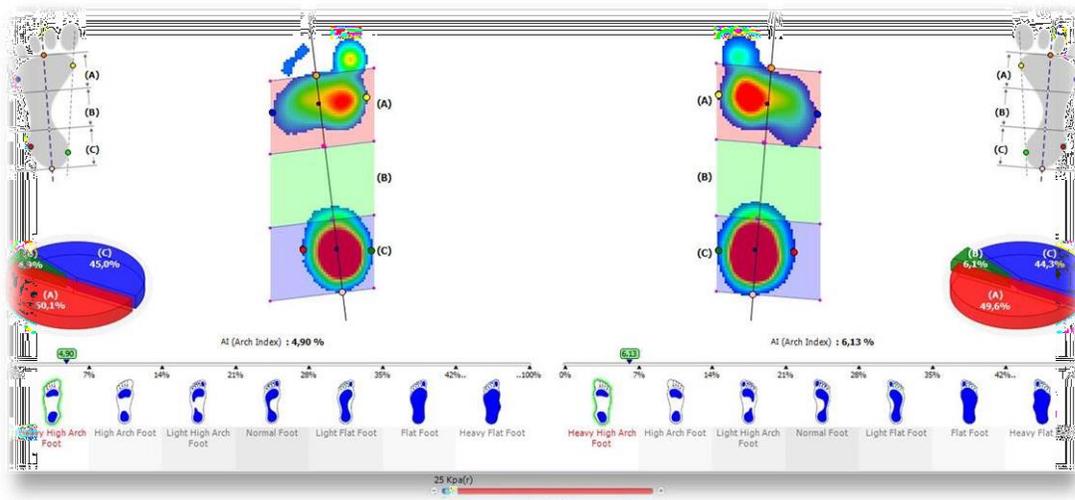


Figure (4): Foot Pressure Mapping, with the division of the foot into three main areas and an indication of the type of arch of the foot.

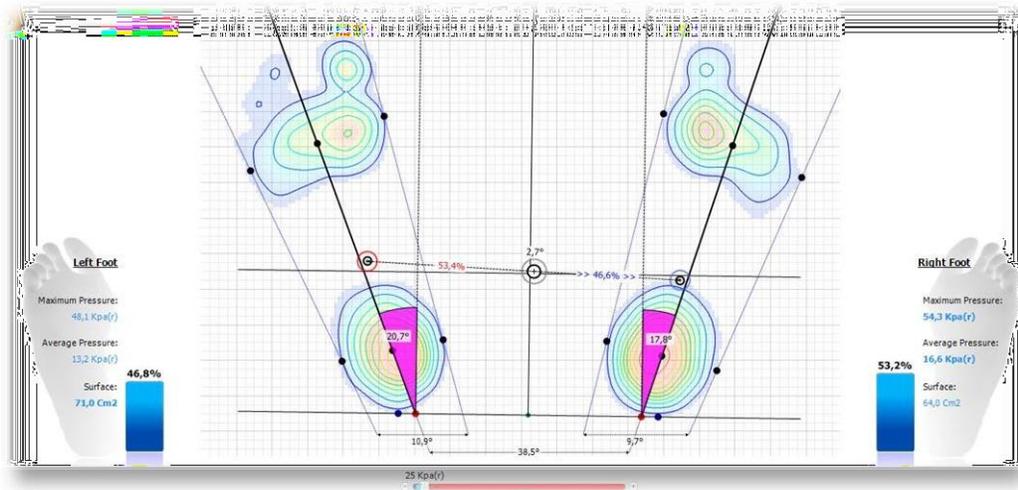


Figure (5): Foot Pressure Mapping with foot axis and COP.

The dynamic state show the feet normal

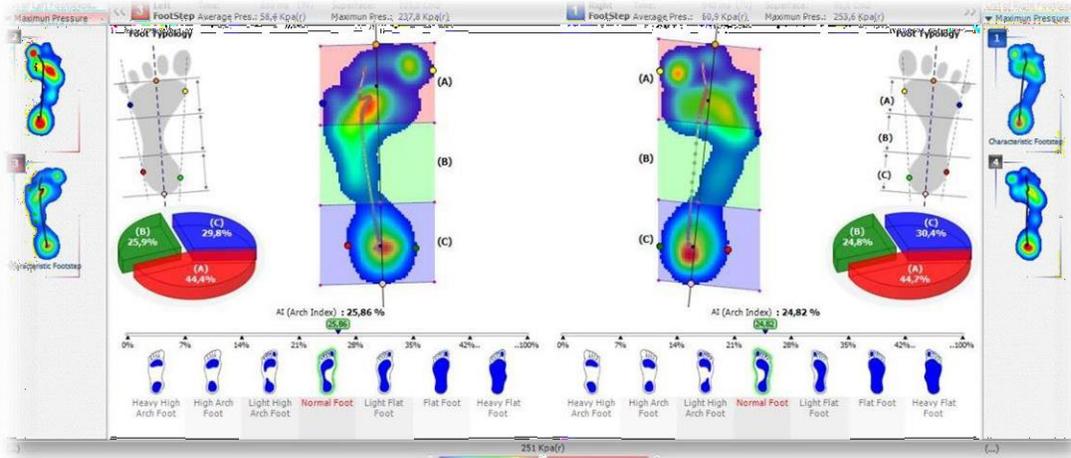


Figure (6): Foot Pressure Mapping, with the division of the foot into three main areas and an indication of the type of arch of the foot.



Figure (7): Foot pressure mapping.

Subject 2:

Was nine years old male, the static state show the light flat feet.

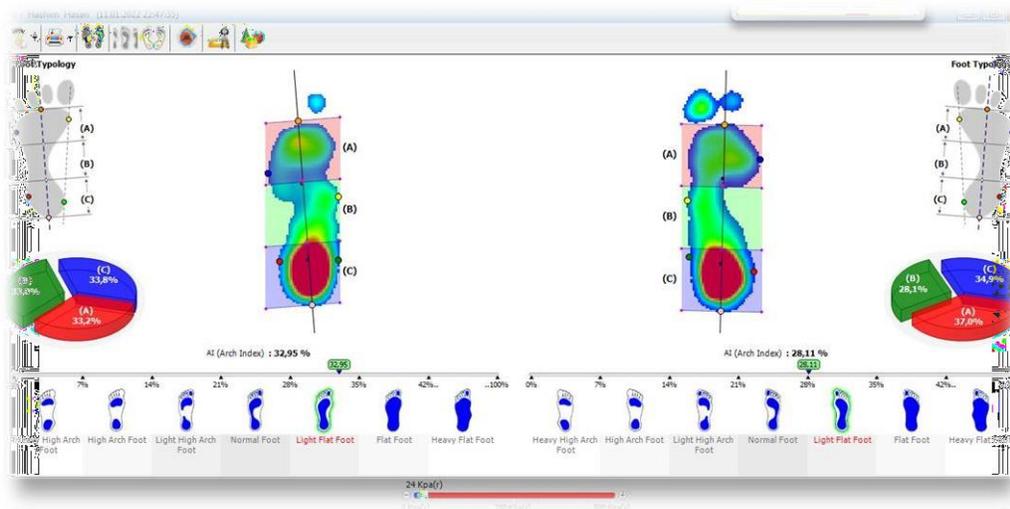


Figure (8): Foot Pressure Mapping, with the division of the foot into three main areas and an indication of the type of arch of the foot.

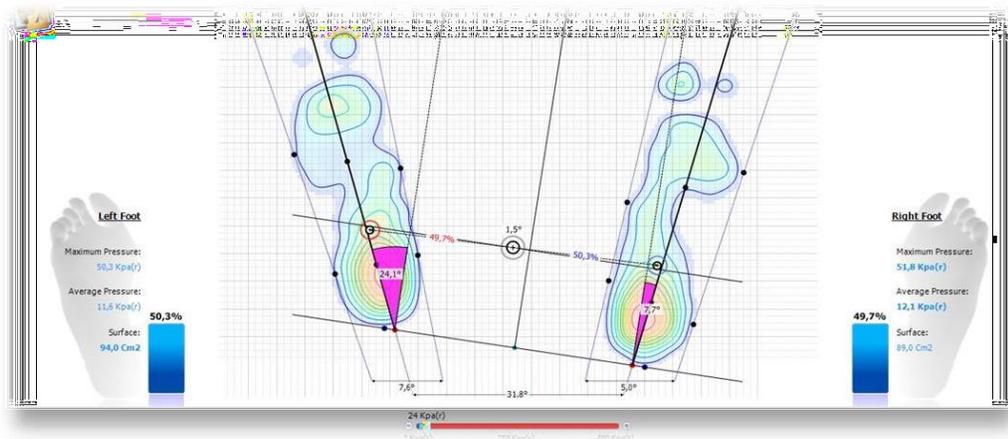


Figure (9): Foot Pressure Mapping with foot axis and COP.

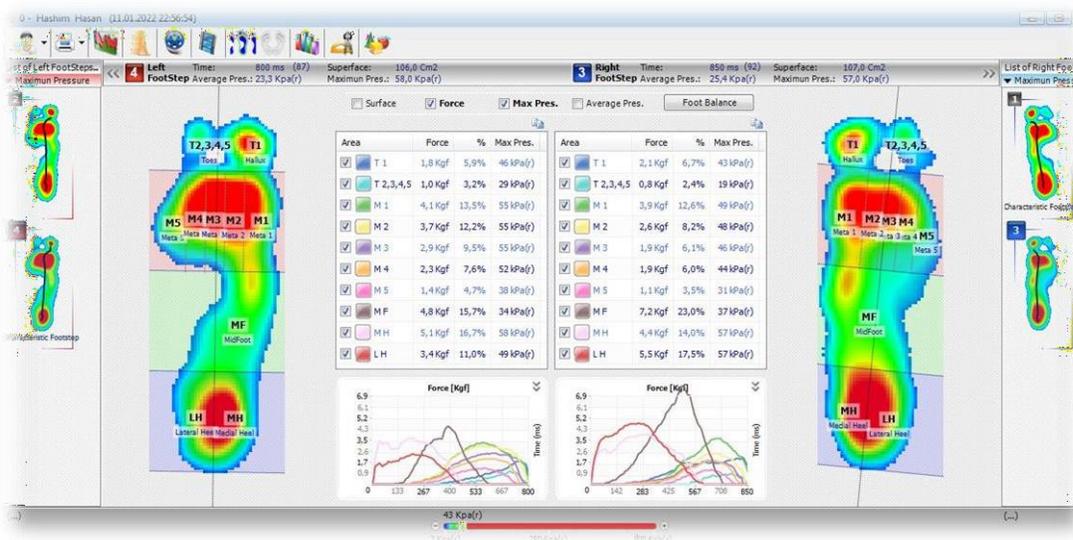


Figure (10): foot pressure mapping.

Subject 3:

Was 13-year-old girl who had normal left foot, light flat right foot in static state.

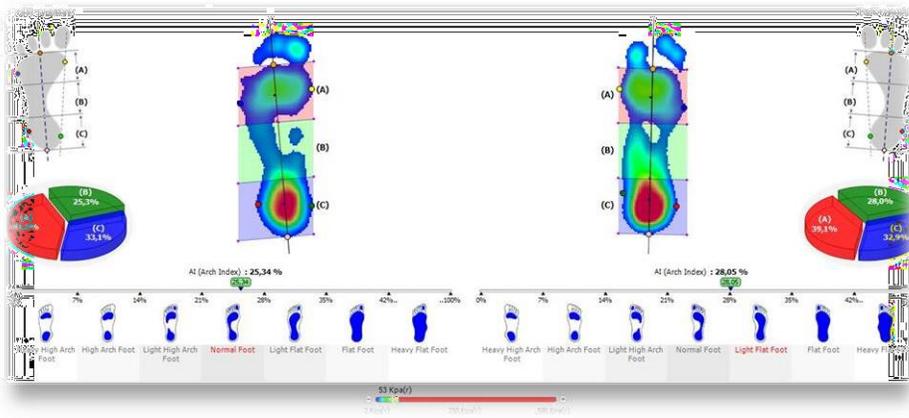


Figure (11): Foot Pressure Mapping, with the division of the foot into three main areas and an indication of the type of arch of the foot.

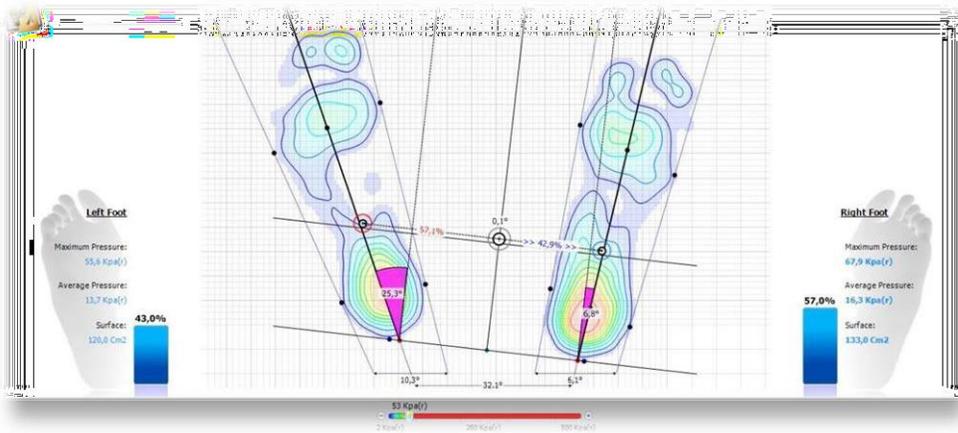


Figure (12): Foot Pressure Mapping with foot axis and COP.

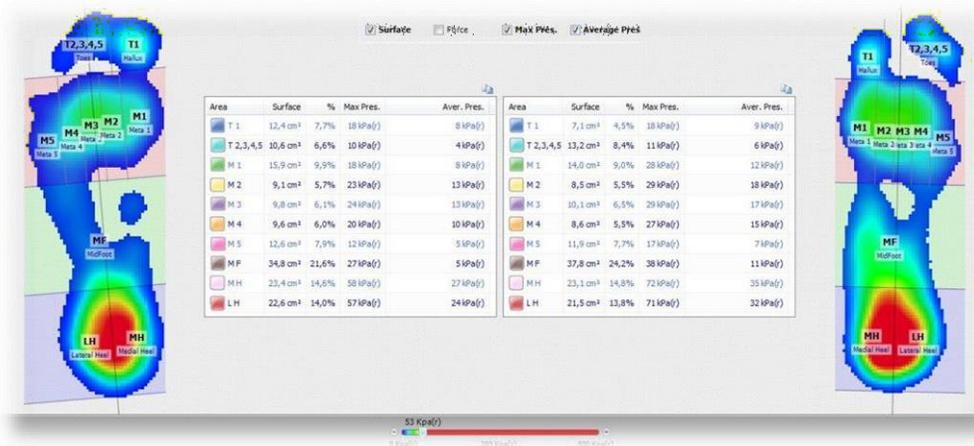


Figure (13): foot pressure mapping.

## Result

The mean bar plot and standard deviation bar plot:

Subject 1

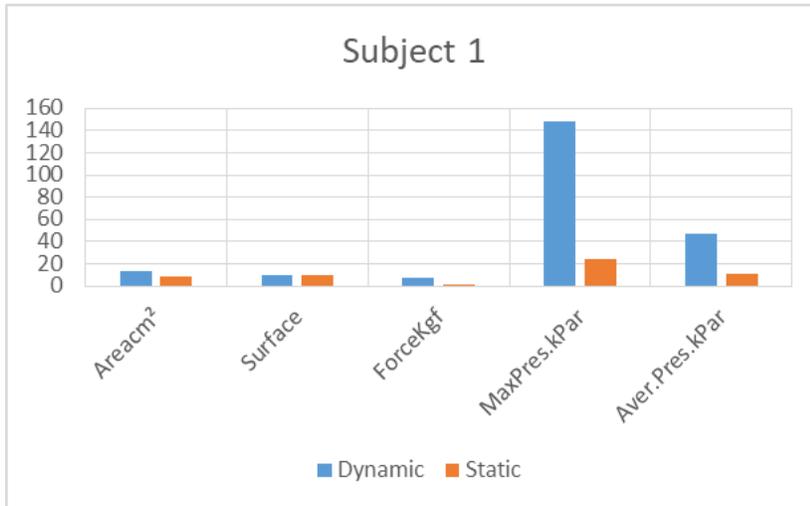


Figure (14): Mean bar plot.

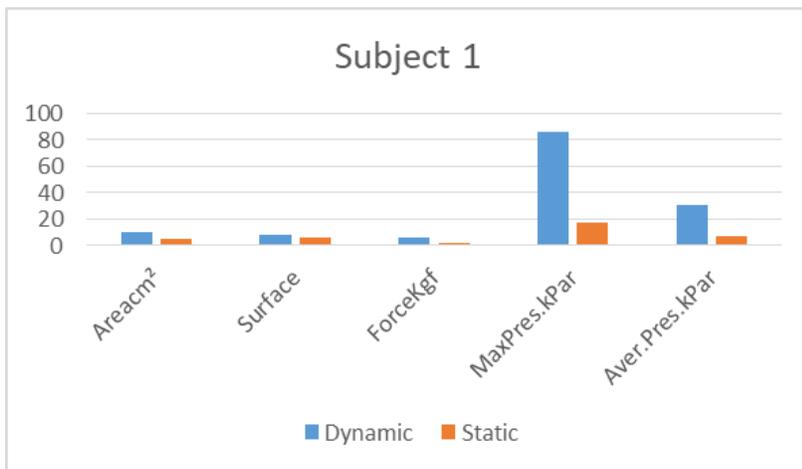


Figure (15): Standard deviation bar plot

This results is due to heavy high arch feet in static state and normal feet in dynamic state

Subject 2

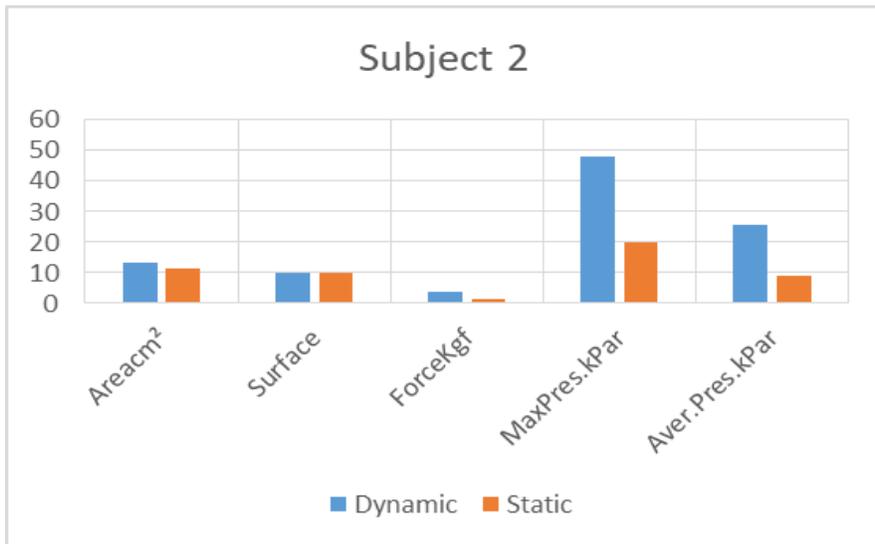


Figure (16): Mean bar plot.

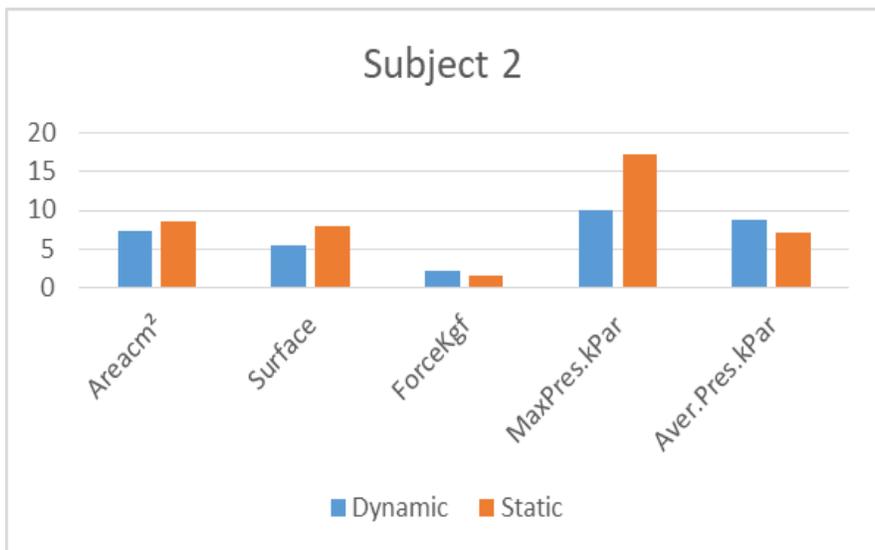


Figure (17): Standard deviation bar plot

This results is due to light flat feet in static state and normal left foot and flat right foot in dynamic state

Subject 3

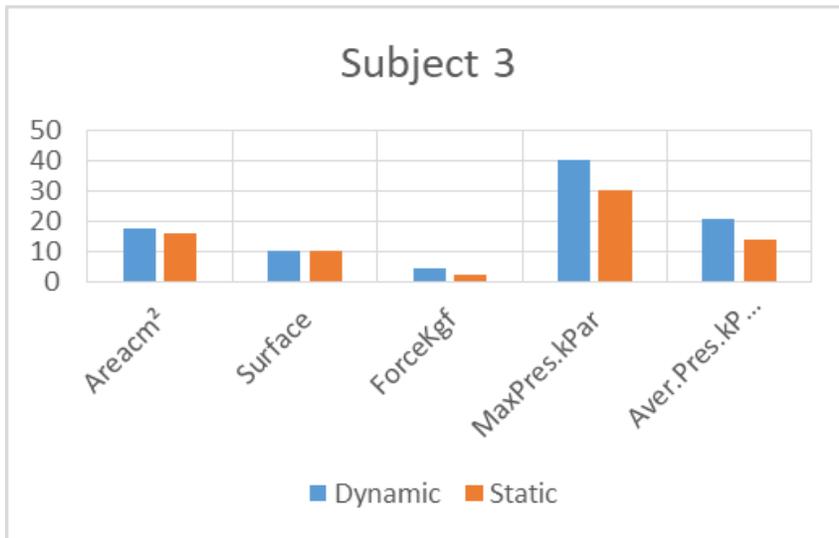


Figure (18): Mean bar plot.

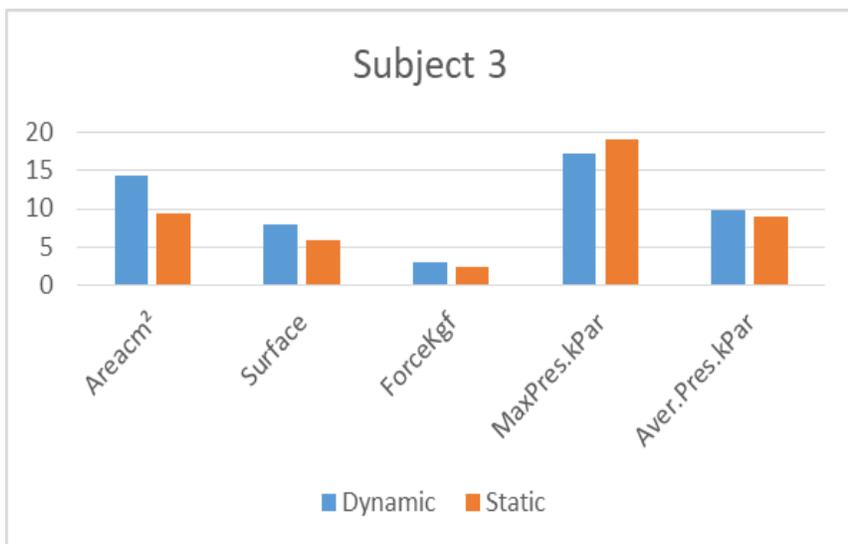


Figure (19): Standard deviation bar plot

This results is due to normal left foot and light flat foot in static state and light flat feet in dynamic state.

### Conclusions

In this work, we analyzed the distribution of foot pressure for children aged 5-15 years, depending on the tactilus device, which gave very accurate results in the case of standing and also during walking, which was difficult to obtain in advance from other methods. It aims to determine the type of the foot, the distribution of pressure and the identification of the contact areas of the foot with the ground. It also made it possible to find maximum foot pressure, average foot pressure, surface area, forces and time contact, as from this data it is possible to diagnose diseases and find solutions. The ideal solution to foot problems (flat foot, high arch foot) is the design of insoles suitable for each case according to the pressure areas and their distribution. Pain in the leg and back caused by the absence of an arch in the foot. In the case of high arch, the insole is also designed based on high pressure areas, which reduces pressure and gives a feeling of comfort to the person.

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