



## WHAT HAPPENS TO BABIES' FEET WHEN THEY ARE LEARNING TO WALK?

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### YOUNG REVIEWERS:



CARYS

AGE: 13



MARTIN

AGE: 13

Learning to walk is complicated and starts when we are very young. It takes lots of practice and typically begins with just a few steps. We conducted an experiment to understand more about what happens to babies' feet when they first start walking. In our experiment, we compared how babies' feet interact with the ground at two stages: First, when the babies just start walking (age 13 months); and second, when they are more confident walkers (age 16 months). We recorded pressures under their feet when they moved and used videos to help us understand if the children were walking in a straight line or turning. Confident walkers took more steps than new walkers and more of these were turning steps. This tells us that confident walkers were practicing more complicated movements. The pressure under the feet changed once babies were walking confidently. Pressure changes depended on the direction of the step.

## HOW DID YOU LEARN TO WALK?

You probably can not remember when you started walking, or how you learned to walk. Most babies learn to walk when they are very young—somewhere between 10 and 16 months [1]. Before they start walking, babies practice movements like crawling, shuffling about on their bums, and standing. Learning to walk is an important stage of development and lets children explore the world around them and do fun stuff. When babies first start walking, they hold their hands up high and place their feet wide apart, to help with balance [2]. This is very different from the way older children and adults walk.

The feet are very important as they provide the foundations for walking. When babies are born, the bones in their feet are small and soft. This changes as the bones grow and respond to the forces children experience underneath their feet. We all have unique walking styles, and this means that the forces on our feet are also unique. Scientists are interested in measuring what happens under our feet when we walk, and they use equipment to measure pressure on the soles of the feet, which is called **plantar pressure**. Measuring plantar pressure can tell scientists a lot about how babies learn to walk and what it means for their small feet.

## WHAT IS PLANTAR PRESSURE?

Although walking does not seem complicated, there is lots that needs to happen. Every time a person's feet land on the ground, there is an opposite reaction, or force, from the ground across the surface of the feet—the **ground reaction force**. When a force is applied across an area, it is called pressure. Feet have an important role in responding to these forces. Activities like running and jumping increase the forces on the body. When someone's foot lands on the ground, the force that their body experiences is spread across the soles of the feet, known as the **plantar surface**. To measure pressures under the feet, researchers use a piece of equipment called a **pressure platform** (Figure 1). The pressure platform measures the area of the feet (determined by their size and shape) and the ground reaction force acting on them. The pressure platform is made of lots of small, square sensors in a grid pattern, which all measure forces that act upon the feet [3]. For our experiment, we wanted to understand what happens under the feet when babies learn to walk. Can you imagine the fun we had?

## MEASURING PLANTAR PRESSURE IN BABIES

In our study, we created a laboratory that we called the "baby space." It was a room filled with toys and our equipment, including our pressure platform. We asked parents of young babies to take part in our experiment. The babies came to our baby space twice: the first visit was when the babies were taking their first steps as new walkers,

### PLANTAR PRESSURE

The pressure (force divided by area) on the sole of the foot.

### GROUND REACTION FORCE

The equal and opposite force from the ground acting on the sole of the foot.

### PLANTAR SURFACE

The sole of the foot.

### PRESSURE PLATFORM

A platform made up of thousands of small sensors in a grid which measure the forces being applied to the feet.

### Figure 1

When a baby walks over the pressure platform, a ground reaction force is produced and the sensors in the platform measure the pressure beneath each footstep.

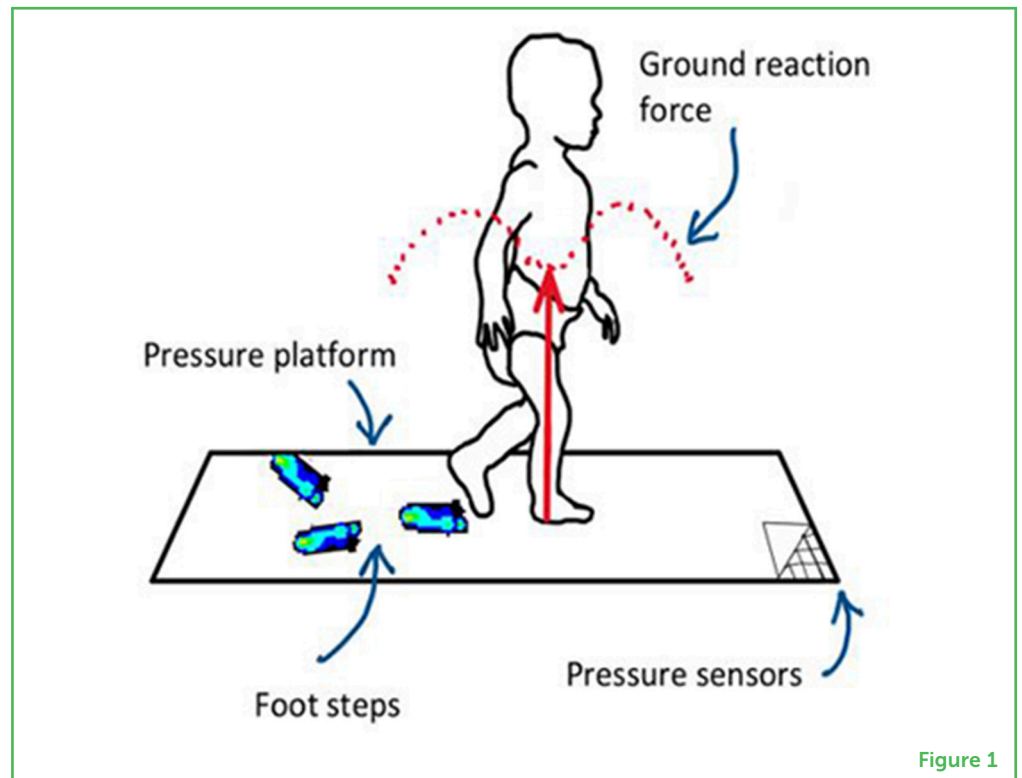


Figure 1

and the second visit was when they were more confident with walking and were balanced, stable walkers.

We measured the babies' feet as they moved around the baby space. We allowed the babies to move independently—we did not hold their hands or direct their movements. This is important because we know that babies do not walk in straight lines at home. We also encouraged the babies to walk between the researcher and their parents, carrying small toys between them. As the babies walked, we recorded the pressure under their feet, and we also used video cameras to record their movements. This let us describe how the babies were walking and in which direction.

Overall, 57 babies took part in our experiment, and we had more than 3,000 footsteps to count, describe, and analyze! This was really difficult—some babies walked forward, whereas some turned in various directions. Our analysis allowed us to describe how the pressures underneath the babies' feet changed.

## WHAT DID THIS TELL US ABOUT BABIES LEARNING TO WALK?

We found that confident walkers took more steps during their visits to the baby space. Confident walkers also turned more than twice as often as the new walkers. We took a more detailed look at the pressures on the feet by dividing the feet into eight different regions,

so that we could understand where the force was being applied (Figure 2).

### Figure 2

To analyse our data, we divided the foot up into eight regions and looked at the pressures in each. The color key shows the range of pressures from low (black) to high (red) in each foot region.

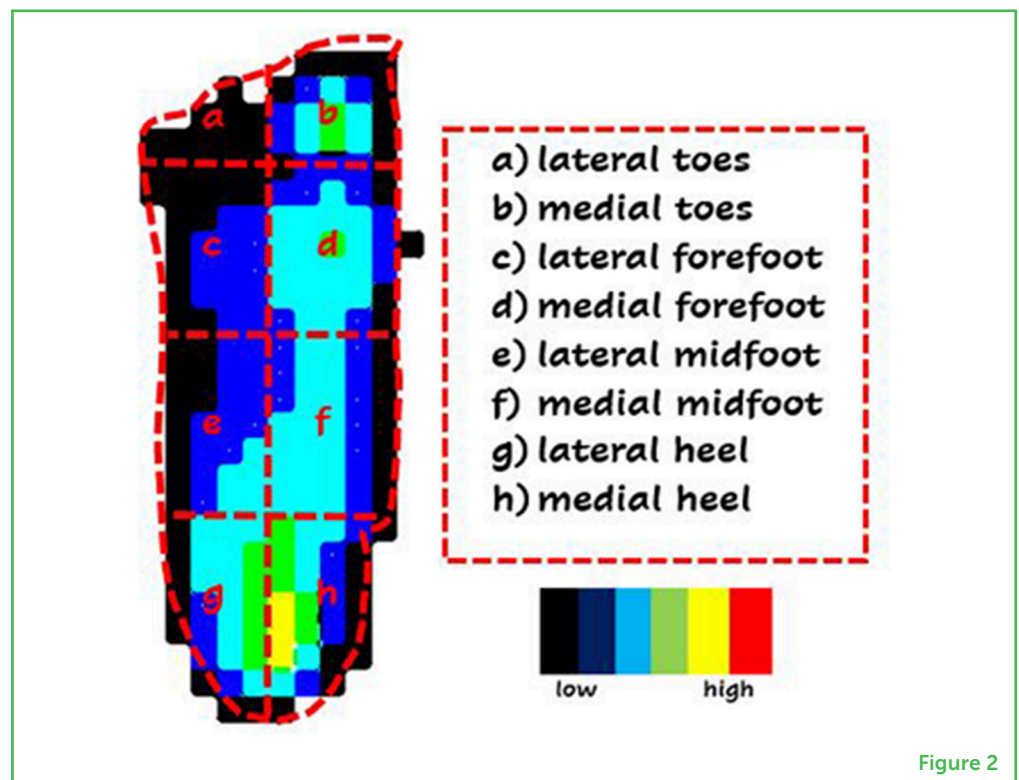


Figure 2

We found that pressures changed as babies became more experienced at walking (Figure 3). When walking in a straight line, confident walkers had higher pressures on the inside of the heel (medial heel, region h from Figure 2) and the outside of their forefoot (lateral forefoot, region c). Once they walked more confidently, the time babies spent with their feet on the floor decreased (this is known as the **step cycle**). We also found that, as the babies became more confident, they used different parts of their feet to walk. When they first started to walk, they used the front and middle parts of their feet more often. Once confident, they used the areas in the midfoot less (region f) and they used their heels more often.

Changes in the turning steps were different than changes in the straight steps. We did not see differences in pressure in the turning steps between new walkers and confident walkers, but we did see differences in the step cycle. When turning inwards (toward the inside of the foot), the forefoot regions (c and d) spent less time in contact with the floor in confident walkers.

### WHY IS THIS IMPORTANT?

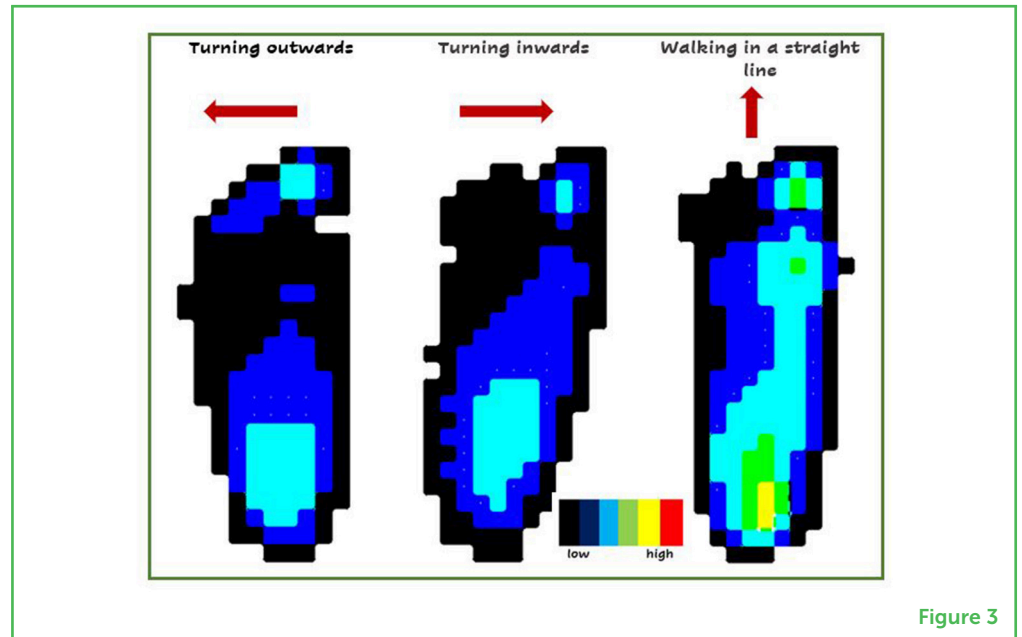
Our research explored what happens to the feet when babies are learning to walk. We found that pressures are reduced in the midfoot

### STEP CYCLE

The time spent with the foot in contact with the floor (rather than up in the air) when we walk.

### Figure 3

In a confidently walking baby, the pressures experienced by various foot regions differ depending on the direction of walking.



area in confident walkers. Also, the amount of the midfoot area contacting the floor is reduced in confident walkers, despite the fact that their feet had grown since they were new walkers. In confident walkers, steps were quicker and many areas of the foot spent less time touching the floor. This work helps us to understand the role of early walking experiences and could help health professionals, like **podiatrists**, to understand what the feet are expected to do during this early age. This information is particularly important for health care professionals working with children who have problems with their feet, including those children who walk only on their toes or those who have painful flat feet. We also found that pressures differ depending on the direction of walking, so researchers or podiatrists who only look at walking in a straight line are missing important information about the function of the foot. Finally, we would expect that children who have difficulty walking, or those who have sore feet, would have pressures different from children without foot issues. This is our next project!

### PODIATRIST

A healthcare professional who focusses on care of the foot, ankle, and leg.

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## REFERENCES

1. WHO Multicentre Growth Reference Study Group. 2006. WHO motor development study: Windows of achievement for six gross motor development milestones. *Acta Paediatr*. 450:86–95. doi: 10.1111/j.1651-2227.2006.tb02379.x
2. Kubo, M., and Ulrich, B. 2006. A biomechanical analysis of the “high guard” position of arms during walking in toddlers. *Infant Behav. Dev.* 29:509–17. doi: 10.1016/j.infbeh.2006.05.001
3. Razak, A. H., Zayegh, A., Begg, R. K., and Wahab, Y. 2012. Foot plantar pressure measurement system: A review. *Sensors*. 12:9884–912. doi: 10.3390/s120709884

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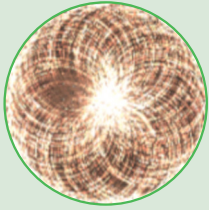
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## YOUNG REVIEWERS

**CARYS, AGE: 13**

Hi, I am Carys. I like singing in St. Thomas Church Choir in Salisbury.



**MARTIN, AGE: 13**

I love to play games with my family and go on walks or bike rides. I like to go to the bike park near my home, or any other park with my family. I love to play video games. Some of my favorite video games are Clash Royale, Minecraft, and Bloons TD Battles 2.

**AUTHORS****CARINA PRICE**

Carina is a researcher who works at the University of Salford, near Manchester, in the UK. She studied sport biomechanics and has a keen interest in feet and footwear and their role in supporting our movement. She tries to understand how changing features of shoes changes the way we walk. \*[c.l.price@salford.ac.uk](mailto:c.l.price@salford.ac.uk)

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Stewart is a senior lecturer who works at Kings College London. He is a podiatrist and has spent many years helping children and young people with foot and ankle problems. His research focuses on understanding more about children's feet.

