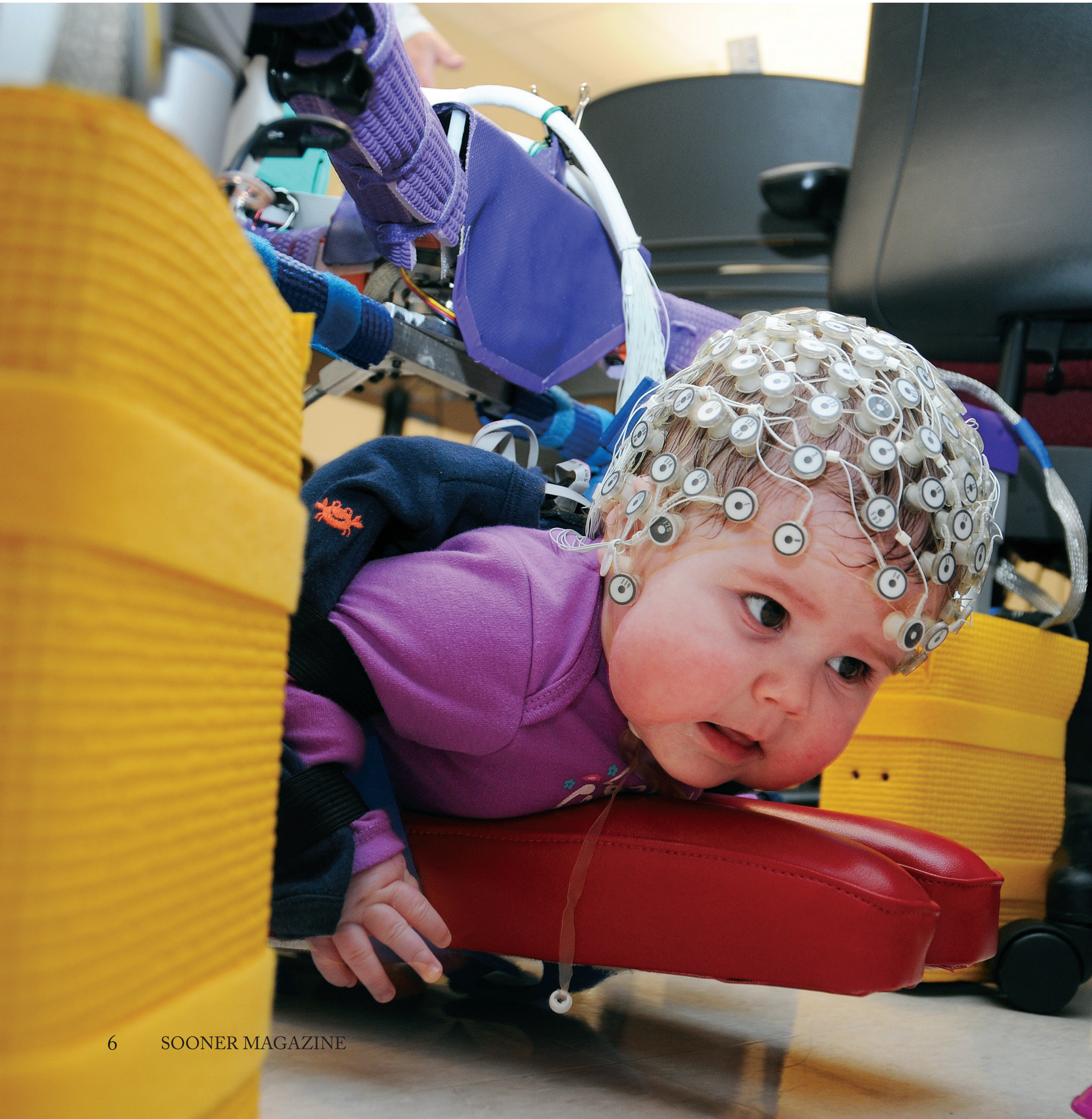
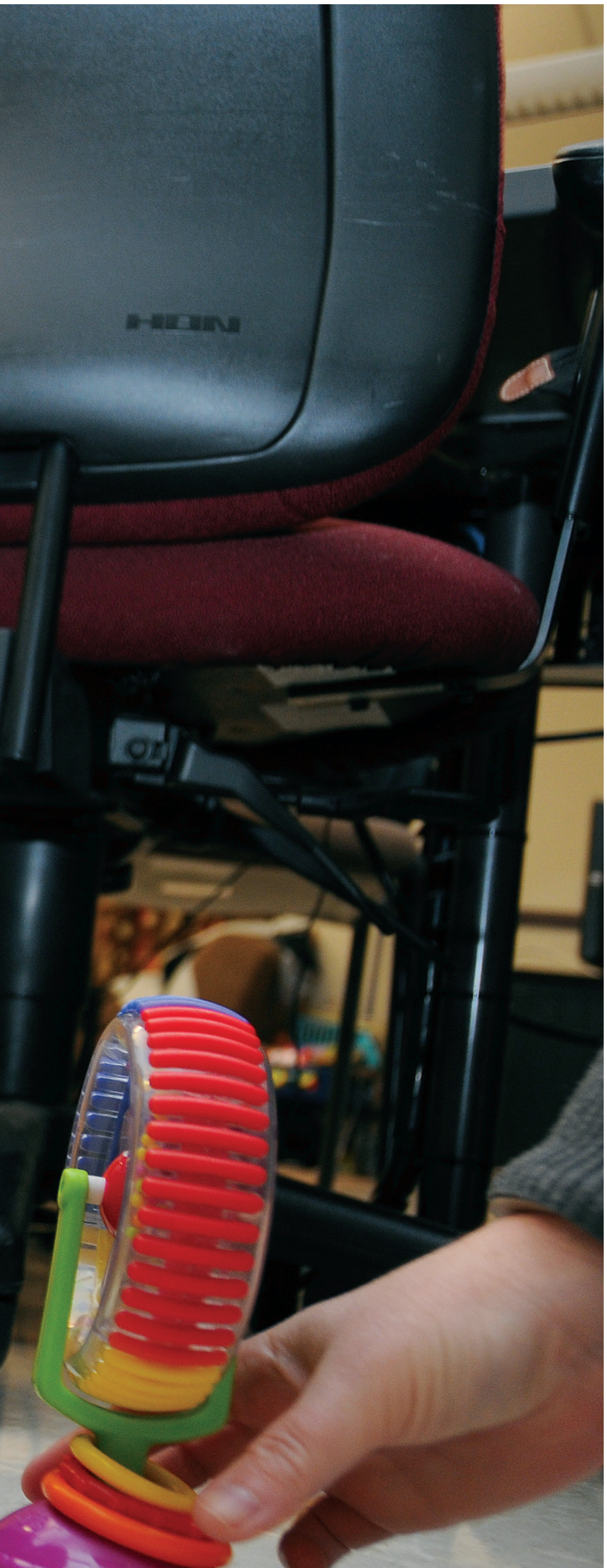
Mind Over



Matter

By April Wilkerson
Photos by Hugh Scott



A ROBOTIC "ONESIE" AND A DEDICATED PHYSICAL THERAPIST ARE GIVING LESSONS IN LOCOMOTION TO BABIES AT RISK FOR CEREBRAL PALSY.

One of the most delightful times of infants' lives is when they begin deliberately kicking their legs and moving their arms – important movements that prepare them for crawling and walking.

As babies become more mobile, it's not only their motor skills that are developing, however. Such movements are closely linked to cognitive development – as infants move, their brains are sending signals and forming connections that will serve them their entire lives. Spatial cognition, depth perception and the basis for problem solving all start to form because children are able to move and experience the environment around them.

But for infants who are at risk of developing cerebral palsy or other developmental disabilities, movement doesn't come naturally or easily; consequently, they miss out on the experiences that spur their development.

A physical therapist and researcher in the College of Allied Health at OU Health Sciences Center, Thubi Kolobe, Ph.D., has a passion for helping those babies, and her team's novel approach has made significant strides toward her goal. They have created a high-tech device called the Self-Initiated Prone Progression Crawler (SIPPC, pronounced "sip-see") that helps babies at risk for cerebral palsy or severe developmental delays achieve the movements so crucial to their development.

Although it may look like play, seven-month-old Olivia Rodriguez, daughter of Joey Rodriguez and Christina King-Rodriguez, is testing an elaborate wireless robotic system for an interdisciplinary team of OU physical therapists and engineers. The team can take what they learn from babies like Olivia, who are developing normally, and use it to help babies with cerebral palsy.

> “If babies don’t have success in moving, they stop. They don’t understand – they’ve never moved before.”

“The most active part of the brain’s development is formation of synaptic connections that occur between 2 months and 8 months,” Kolobe said. “Typically developing babies are kicking and moving, and eventually they crawl because their brains have made those connections. But infants at risk for cerebral palsy often develop what we call ‘learned non-use/disuse’ – if they can’t do something, they stop trying. There is a ‘pruning off’ that occurs in the brain and some pathways simply don’t develop.”

The foundation for Kolobe’s current work was laid years ago when she was a faculty member and researcher at the University of Illinois in Chicago. There, she and a team developed a movement assessment for premature infants who were in the neonatal intensive care unit. Called the Test of Infant Motor Performance, the TIMP evaluated infants’ functional movements, with the goal of predicting earlier who would likely develop cerebral palsy or severe developmental delays. Her team gained funding from the National Institutes of Health for a study that followed babies from the time they were still in the NICU until they were 5 years old. Her findings were significant: In 92 percent of the cases, TIMP allowed her team to correctly identify at 3 months of age premature babies who would develop typically. It also allowed them to pinpoint 3-month-old babies who would likely develop cerebral palsy or severe developmental delays in 76 percent of the cases.

Her discovery was significant because she was keenly aware of the precious window of time when babies’ brains develop in conjunction with their movements. Cerebral palsy is not clinically diagnosed by a physician until the baby is at least 12 months old, sometimes later. By that time, babies with cerebral palsy have already slipped far behind their typically developing peers and may not even begin crawling until 2 years of age, if at all.

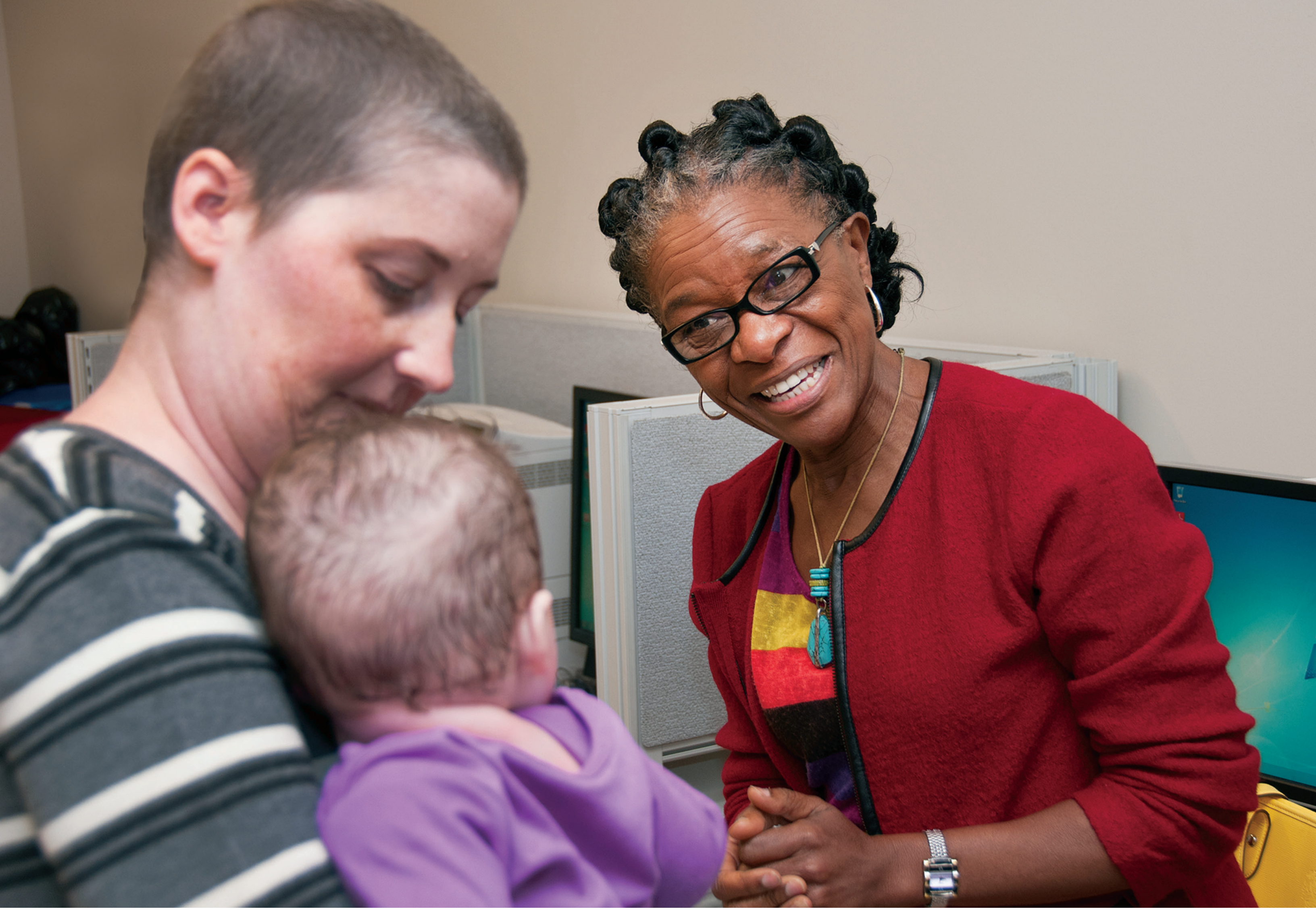
“Babies are not like adult patients who have a stroke and are trying to regain the movement they lost,” Kolobe said. “If babies don’t have success in moving, they stop. They don’t understand – they’ve never moved before.”

Test driver Ryan Thomas, son of Renee and Shoun Thomas, clutches a toy he retrieved by negotiating the souped-up SIPPC skateboard across the floor of Dr. Kolobe’s lab in the College of Allied Health.

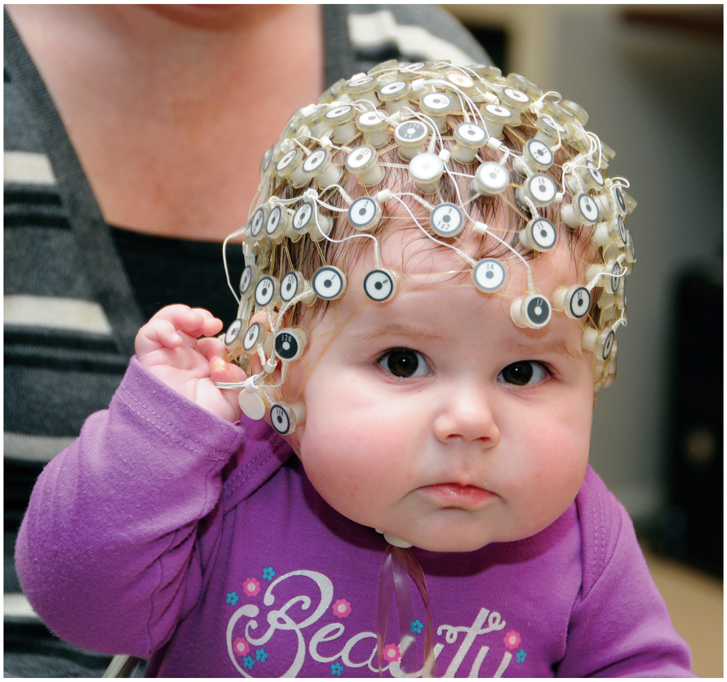
By the time she arrived at the OU Health Sciences Center in 2003, Kolobe had brainstormed a device to help these infants. With a colleague at Virginia Commonwealth University, she developed the first SIPPC, a motorized skateboard-like device. Babies lay on their stomachs and used the device to help them move across the floor and explore their environment. The initial version of the SIPPC only responded to the baby’s efforts. Since that time, Kolobe and her team have greatly refined the SIPPC to the cutting-edge device it is today, and they have obtained national funding to continue studying its effectiveness.

Today’s SIPPC is an elaborate wireless robotic system that has been developed through an interdisciplinary collaboration with faculty members on the OU Norman campus, including Ph.Ds Andrew Fagg, David Miller and Lei Ding, all faculty in the Biomedical Engineering Center in the Gallogly College of Engineering.

Babies still lie prone on the SIPPC, but they do so wearing a “high-tech onesie,” a kinematic capture suit with 12 sensors that gather information 50 times a second. The suit allows researchers to see, in real time, what movements the babies are



Dr. Kolobe, right, chats with Olivia Rodriguez and mom Christina before the infant dons the robotic onesie and special headgear needed to capture movement and brain activity while using the SIPPC. Kolobe's research in early movement and cognition has earned her a grant from the National Science Foundation.

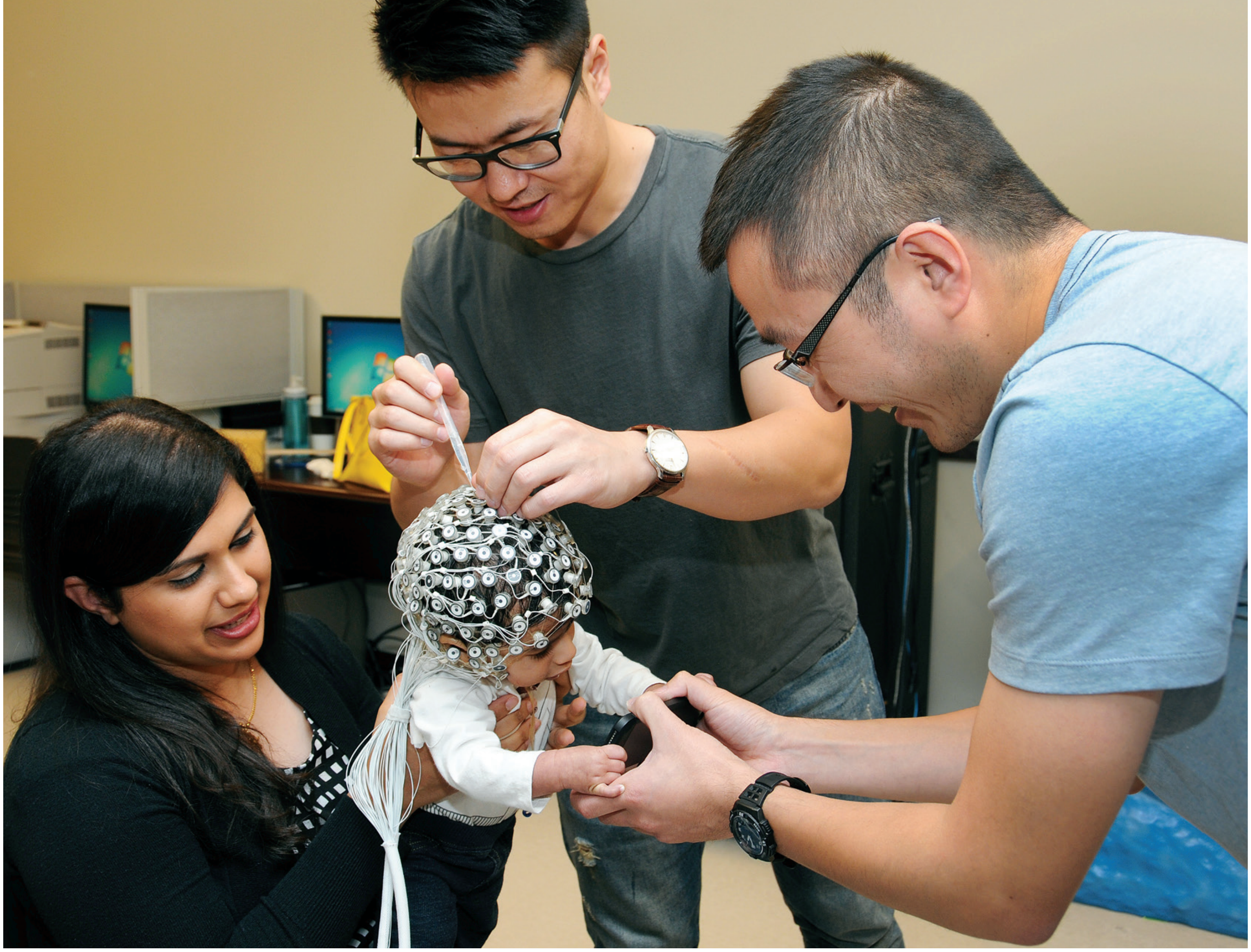


Dr. Kolobe added Olivia's fancy EEG headgear to capture brain activity that researchers can observe in real time while the infant moves with the SIPPC.

making with their arms and legs. A three-dimensional skeletal representation provides a picture of the movements the baby is trying to make, such as pulling her hands forward or kicking her legs. Cameras mounted on the SIPPC capture the picture of the baby and what each of her limbs is doing at a given time.

The information gathered by the suit and the baby's motions is important because, through a complex algorithm written for the SIPPC, it is used to help the babies to move.

"We can recognize, for example, when babies are trying to reach their hands out to pull themselves forward," Fagg said. "But it doesn't require the infants to actually have their hands in contact with the ground – as they make the gesture, the robot recognizes it and responds by moving the infant forward. The idea is to reward the baby with movement. When infants are surprised in that way, they're driven to try to figure out if they had something to do with the surprising event. We call it 'motor babbling,' not unlike vocal babbling, and this process



Renee Thomas holds her son, Ryan, as Ran Xiao, a doctoral engineering student, checks Ryan's EEG head gear in preparation for a turn on the SIPPC. Chuang Li, graduate research assistant, provides distraction with every modern infant's favorite toy—a cell phone

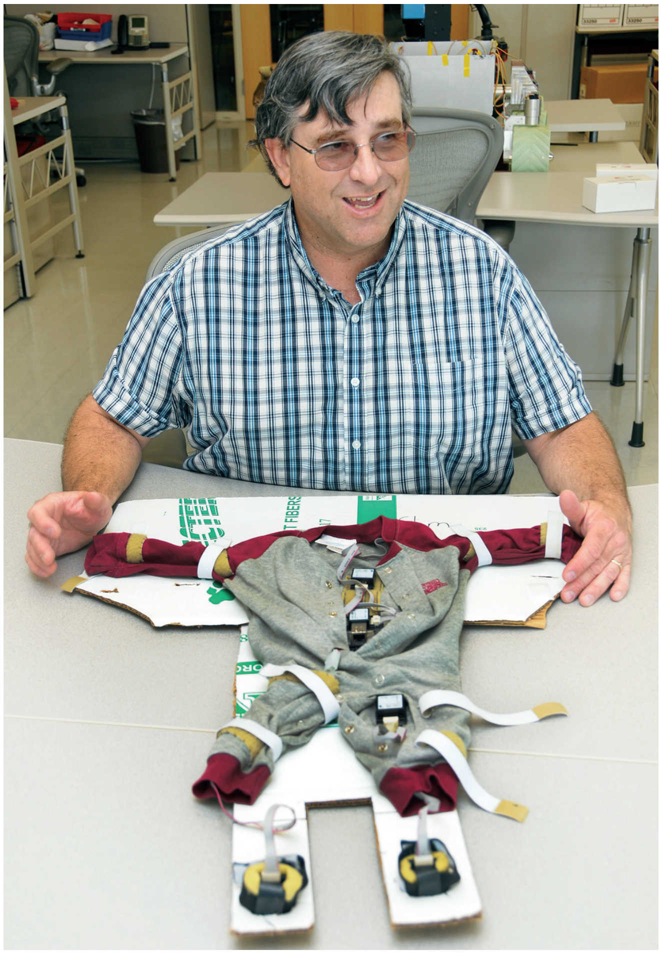
gives way to more intentional movement. They try things out to see what the effects are. Over time, they start to develop an internal model of what will happen if they move their bodies a certain way. We want them to ultimately learn motor skills that will be useful when they're not using the robot."

The SIPPC, in combination with the kinematic capture suit, has allowed the research team to study whether learning can be accelerated for children who are *at risk* of cerebral palsy, a disorder that is not officially diagnosed until 12 months of age when it's too late for the SIPPC to do much good. It is a question that researchers had not been able to ask until the technology developed by Kolobe's team made it possible.

"We want to see if we can stop learned non-use/disuse and introduce success," Kolobe said. "We believe that the babies need to be successful very early so that they can repeat the successes until such time the brain has formed enough connections to allow them to drive the SIPPC on their own."

Recently, Kolobe's team has added another element to the research–a net worn on the babies' heads with dozens of

Seven-month-old Ryan gets a cuddle from his mom before donning his suit and headgear in the SIPPC lab. Like Olivia, Ryan is helping researchers get a baseline for infants who are developing at normal rates to help children who may be at risk for cerebral palsy or other developmental delays.



Dr. Andrew Fagg, associate professor of computer science and bioengineering, explains the robotic "onesie" featuring 12 sensors that gather information 50 times a second from infants as they move.

"WE WANT TO SEE IF WE CAN STOP LEARNED NON-USE/DISUSE AND INTRODUCE SUCCESS."

sensors that capture the electrical activity of the brain as the babies move on the SIPPC. Research had been showing the value of the SIPPC and the suit, but Kolobe wanted to take the project a step further to capture what was happening in the brain when children were learning to move. The head net uses EEG to view signals in the baby's brain and allows the team to study changes in those signals over time. This element of Kolobe's study is groundbreaking in terms of the data it will generate.

"We've always talked about the brain – does it show connections when the babies are learning?" Kolobe said. "I wanted to introduce brain imaging but there wasn't anything you could use for infants, except the MRI, but that is used when they are stationary. We wanted to be able to see the electrical transmissions of the brain in real time."

The research is ongoing, but Kolobe is gratified by its progress and the potential for the SIPPC to help babies at risk for cerebral palsy. Her ultimate goal is to mass produce the SIPPC so they are available for parents to rent or purchase for use at home. The computer program would be developed for a smartphone app that would guide the device at home. During visits to a physical therapist, progress would be evaluated and the program would be customized according to the baby's needs – continuing to reward with movement but challenging the baby to do more and more as time goes by. The team's current grant from the National Science Foundation allows the team to tailor the robotic system to the baby's ability and to reduce the amount of assistance as the baby becomes more competent.

Kolobe's project is an exciting component of the Department of Rehabilitation Sciences in the College of Allied Health. Department Chair Martha Ferretti, PT, MPH, said the department has a history of studying early movement and cognition; Kolobe's work is one of several projects that speak to an exciting future for physical therapists and occupational therapists in that realm. Kolobe also has championed interdisciplinary collaboration, a growing movement in academic health profession settings.

"She's a great role model for involving people from several disciplines, such as engineers and computer scientists," Ferretti said. "Everyone speaks a different language and has a different understanding of the human system, but everyone has the same vision. None of us can do this alone, nor should we when working with humans because there are so many aspects of life that are important, and we all bring our unique perspectives to the work."

April Wilkerson is editor of OU Medicine, *the official publication of the College of Medicine at the OU Health Sciences Center in Oklahoma City.*