



Testing children's footwear

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IMAGE: SHUTTERSTOCK / MONKEY BUSINESS

The primary purpose of footwear is to protect the foot. This is achieved in a number of ways, the most fundamental of which begins with the sole providing a barrier against the ground and any objects that might cause cuts and other damage. This ground protection also adds a degree of impact and pressure reduction as well as offering traction. In closed footwear the upper offers insulation against cold and damp conditions. However, there are certain aspects that, if not correct, can lead to damage and poor foot health. Nowhere should this be taken more seriously than in footwear for children. There is an unfortunate tendency to overlook their importance because their feet grow

faster than shoes will wear and, as such, cheaper options are looked on more favourably than for adults' footwear where durability and quality become more cost effective. It is perhaps more important that children's footwear maintains a certain level of performance as damage to the still developing foot can lead to irreversible conditions in the adult foot later in life.

FITTING

The first step when considering children's footwear is size and shape. It is well known that poor fitting footwear can distort the shape of the foot and in young children, where the bones are still developing, this can lead to significant damage. It can permanently distort its shape and contribute to

altered gait patterns, misalignment of the natural mechanical motion of the foot and leg, strain in ligaments and muscles, and aching or pain. 'Growing room' is essential in order to prevent the cramping and distortion of the foot. On the other hand, allowing too much additional space is also problematic. A foot given too much space will move within the shoe causing blisters or difficulty in walking. Too much toe allowance can be a tripping hazard and gait will again develop in order to compensate.

Not only is a child's foot smaller than that of an adult, it also differs in proportionality. For example, smaller feet have a larger joint girth to foot length ratio, meaning that smaller sizes tend to be proportionally wider.

This holds true for children's feet but with a different ratio to that found in adult feet. Understanding these differences is key to producing footwear that offers optimal fit and comfort, and minimises the risk of distortion and foot damage. SATRA has dedicated significant resources to conducting foot dimension studies to assist the industry in this area. The use of 3D scanning has resulted in a substantial database of 3D foot images from which a multitude of dimensions and shape assessments can be taken. This, alongside methods of assessing last shape such as SATRA TM253 (Children's last assessment), and fit assessments, SATRA TP4 (Assessment of fit in footwear) can offer substantial support in achieving good fit.

Compounding the problem of fitting footwear comfortably and other comfort issues, is the fact that children sometimes struggle to assess discomfort and pain and may perceive it differently to adults. They certainly lack the experience to understand that a small amount of immediate discomfort that is not registering as pain, may lead to greater damage later on, such as pressure leading to blisters. When they are aware of discomfort, they may lack the ability to effectively communicate this in order to improve things. Delay in identifying and rectifying causes of discomfort may significantly increase the risk of damage.

THERMAL PROPERTIES

In addition to fitting characteristics, the difference in shape between the adult and child foot has another significant effect. Smaller feet have a larger surface area to volume ratio, so children's feet will lose heat faster than those of an adult. Children also have less subcutaneous fat with which to insulate themselves which also promotes higher heat loss. In very young children below the age of two, their bodies have yet to learn how to control their temperature effectively and it takes time for them to develop the regulation available to adults. While children tend to be more active than adults, there is still an increased risk of excessive heat loss, discomfort and, in the extremes, hypothermia and frostbite. In cold conditions it is therefore essential that children's footwear offers good thermal insulation.



Fitting children's footwear properly is essential for both comfort and foot health.

IMAGE: SATRA

The standard test for determining thermal insulation is SATRA TM436 (Determination of whole shoe thermal insulation value and cold rating). This can be performed on UK adult sizes 9, 7, 4, 1 and UK children's size 10. Typically, children as young as 2 are already wearing UK child size 6 and will have reached the average adult size of UK 6 for women and UK 9 for men by the time they are 13 (girls) and 15 (boys), though the foot is still developing in other ways up to the age of 20. The cold rating test employs a heated foot form at a constant temperature to establish the energy loss through the footwear. This is used to calculate a thermal insulation value and indicate at what temperatures and activity levels the footwear will feel comfortable. Children's footwear designed and marketed for cold conditions must be able to offer a suitable level of protection otherwise there is risk of discomfort and possible damage. Alternatively, footwear

designed for warm conditions needs to have a low thermal insulation value and high breathability for comfort.

The heated foot form used in cold rating is also fitted with water pipes that mimic the excretion of sweat from the foot at a realistic rate. By monitoring the input of sweat and the mass gain of the footwear, its effectiveness in managing moisture can be determined—SATRA TM376 (Advanced moisture management). While it is important that footwear has appropriate thermal insulation to keep the foot warm and healthy, increased insulation tends to restrict the movement of sweat from the foot. Footwear with good moisture management is often described as 'breathable' and is an assessment of how easily liquid can migrate through the materials and evaporate to the atmosphere. Moisture management is usually measured under standard laboratory conditions of 23°C plus or minus 2°C and 50% plus or minus 5% RH.

However, these conditions mimic a fair day in a cooler climate and favour the evaporation process being assessed in breathability. To understand how footwear will perform for moisture management in the conditions they are likely to encounter in real wear, it is important to test them in more challenging environments. Breathability can be tested in a range of climates ranging from -10°C to 45°C and 10% RH to 99% RH. Whilst there are conflicting opinions in the scientific community on the sweat rate in children versus that seen in adults, children do still sweat and are also generally more active than adults. That sweat rate will lead to dampness and moisture build-up in footwear with poor breathability. These warm, moist conditions are ideal for the growth of micro-organisms which can be linked to foot infections.

WATER RESISTANCE

While footwear will always have to contend with internal moisture as a result of perspiration, external water sources may also be an issue. As with the build-up of perspiration, water introduced from outside the footwear will lead to discomfort and damage. The risk of blisters is significantly increased in damp footwear and wet materials have a drastically reduced thermal insulation value, increasing the risk of excessive heat loss. Again, children are more prone to damp footwear, partly because a lack of foresight precludes them from avoiding getting their shoes wet and partly because they inevitably like to play in puddles.

Resistance to water penetration can be tested with a simple experiment of placing footwear in water and monitoring for water ingress. In most cases children's footwear need only prevent water uptake through the sole, making no claim that the footwear as a whole offers water resistance. In this case, the drying time of the footwear is probably of more interest than water resistance. However, footwear designed and marketed as water resistant and, in the extreme to be waterproof, will need vigorous testing to validate these claims. Child sizes as low as UK children's size 8 can be tested to SATRA TM230 (Dynamic



Test equipment for TM376 and TM230.

IMAGE: SATRA

water penetration).

This test uses a flexing foot form offering realistic creasing of the upper and suspended in a body of water. The act of flexing accounts for any damage that may lead to water penetration as a result of natural flexing during wear. An alternative test to quickly assess footwear for manufacturing faults is SATRA TM444 (Centrifuge). This is a 10-minute test that uses pressurised water to quickly identify if the construction or materials are likely to withstand more demanding tests or if there is a fault that would cause the footwear to leak. This is an ideal, non-destructive, end of line test that can be used as part of a quality procedure to identify faults.

As mentioned, children do not tend to end up in clean, laboratory grade water when they play. An addition to the standard dynamic water penetration test is to add silt to the water in order to more closely mimic muddy water found in streams or grit

and sand in water found at the beach: SATRA TM446 (Resistance to waterborne abrasive particulate). The addition of an abrasive particulate to the test not only better simulates dirty water, but also introduces a new form of damage to the footwear. While flexing the silt will settle into the materials of the shoe and produce an abrasive effect more indicative of the harsher conditions to which footwear may be exposed.

SLIP RESISTANCE

SATRA TM 144 Friction (slip resistance) of footwear and floor coverings is recognised worldwide as the preferred assessment for the coefficient of friction in footwear. Under a known load, the test footwear is pressed against one of several standard floor surfaces and the force required to slide them against each other is recorded. Contaminants can be added to the test and more extreme surfaces, including ice and, more recently, a

simulated mud are also available. Slip is one of the most important safety critical tests for footwear. A slip can happen in any conditions and, without suitable grip, footwear is not only failing to reduce risk, but introducing a new risk to the wearer.

Young children, have yet to develop the natural adult gait consisting of heel strike, stance phase and toe off, tending to have a more plodding pattern with a flatter impact. In very young children standard gait has no bearing as they are still learning to walk. In these cases, static friction plays a much greater role in footwear and floor interaction, while in adult gait dynamic slip becomes more relevant. While the very young may not be walking, risk of footwear slip is still important. For toddlers learning how to stand there is a risk that footwear with no traction will slip out beneath them as they are pulling themselves up against furniture. This type of slip can easily lead to head or face impact with the furniture.

NOVELTY FOOTWEAR

This article has focused primarily on the physical functionality of children's footwear, however, there are many other factors affecting testing of children's footwear that are not immediately obvious because they are rarely a concern in adult footwear. This class of testing is a result of children's products often containing novelty functions or aesthetics to be more appealing to the young audience. The most common novelty of concern is accessories such as bows, beads, buckles and other adornments. These can be tested for the strength of their attachment using SATRA TM117 (Attachment strength of decorative bows) as any adornment that can be removed easily may present a choking hazard. Adornments that are removable should be tested for their choking hazard under EN71 Safety of toys (Part 1 Mechanical and physical properties).

With very young children there is also a high risk that footwear will come in to contact with the mouth and, aside from possible choking, this also presents a risk of chemicals leaching from materials and being ingested. REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals) is the European Union



With young children there is a risk of footwear coming into contact with the mouth.

IMAGE: SATRA

regulation concerning restricted substances and again EN71 Safety of toys series covers testing for a number of chemicals (Part 3 – Migration of certain elements). Treating novelty footwear as if they were toys is a common practice and demonstrates a need for due diligence. Other aspects of concern are flammability of materials EN71 (Part 2 Flammability) and tripping hazards of novelty attachments. A good example of both of these would be fluffy bunny slippers with long ears.

One final, major concern is electronics in footwear for which three directives are applicable: the Waste Electrical and Electronic Equipment (WEEE) directive 2017/699, Restriction of Hazardous Substances in electrical and electronic equipment (RoHS) and the batteries directive 2006/66/EC. These directives relate to the disposal, chemical content and labelling of electronics. For the functionality of electronics in footwear it is advised to

perform life cycle and ageing tests on footwear. SATRA TM362 (Abrasion resistance of soles) uses a biomechanical walking machine to realistically recreate actual wear. Applying this test to footwear containing electronics can not only determine possible failure in wear but also predict if they will become exposed or damaged to an extent that poses a risk.

Children's footwear offers the same protection and presents the same risks—if not more—as adult footwear but, because of its shorter functional lifespan compared to adult footwear, basic testing is sometimes dismissed. Children's footwear should be considered for the same range of testing that would be appropriate for standard adult footwear, particularly with respect to safety aspects. Other more specialist and novelty footwear should be considered as toys and tested under the EN71 Safety of toys series. 