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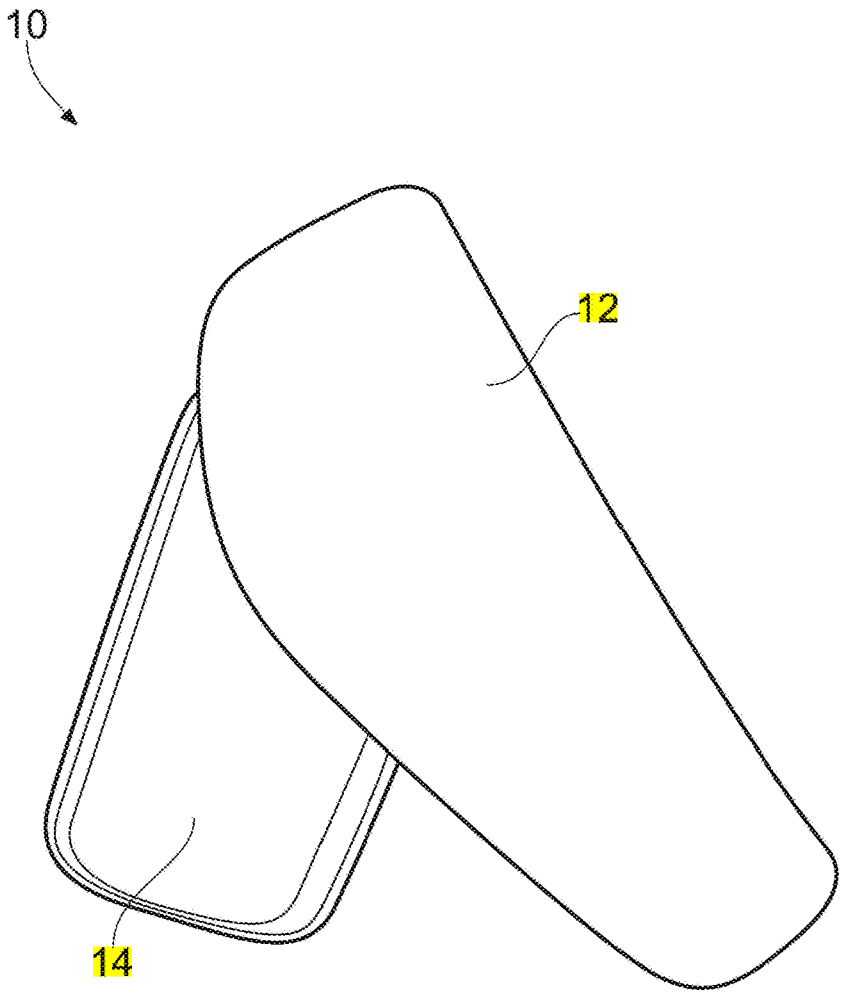

FIG. 1

18 01 21

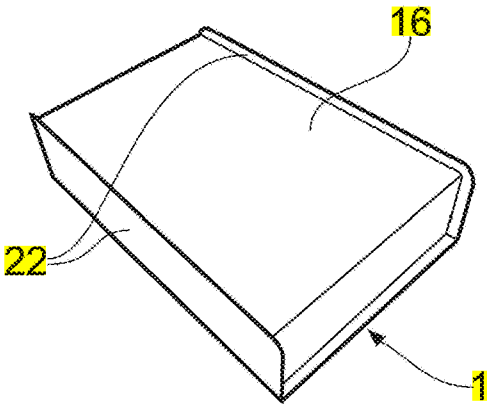

FIG. 2a

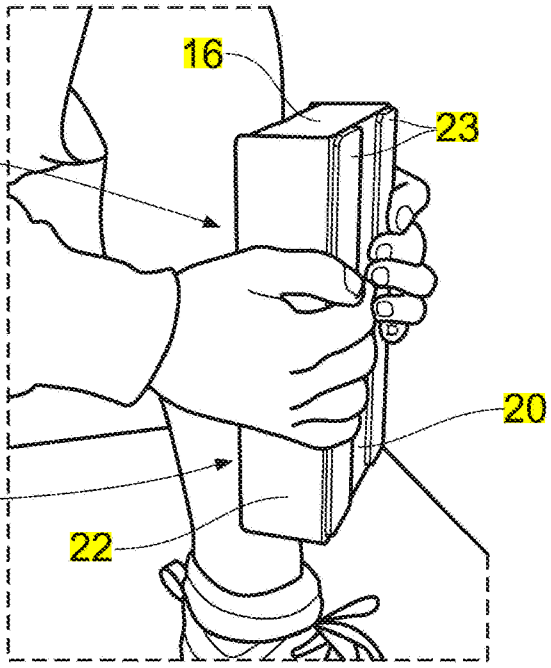

FIG. 2b

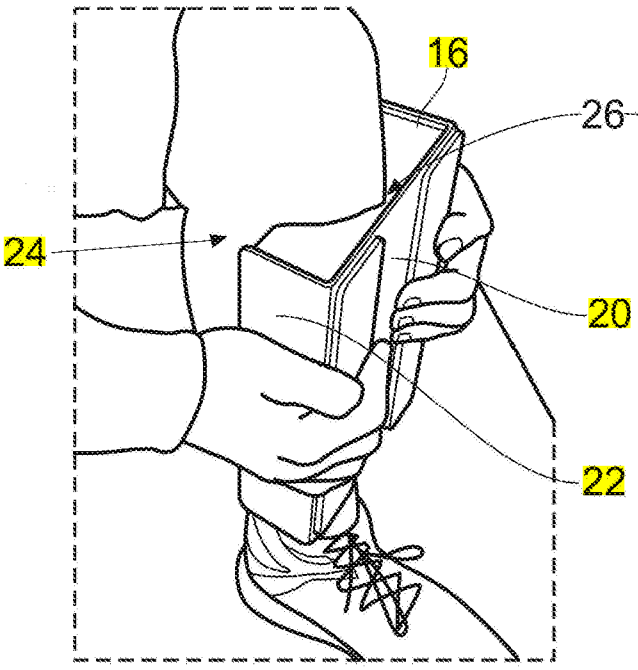

FIG. 2c

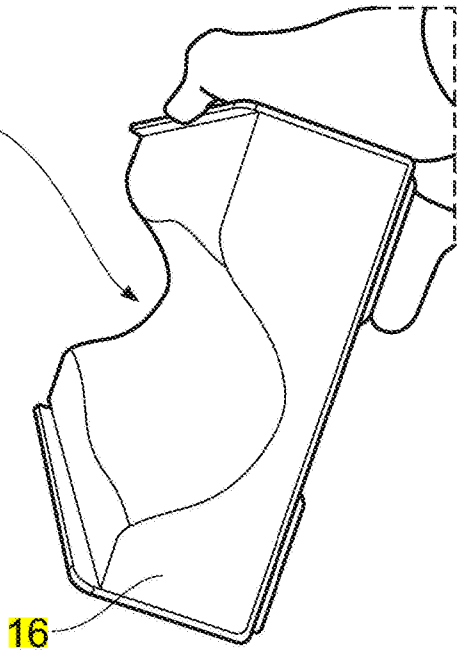

FIG. 2d

18 01 21

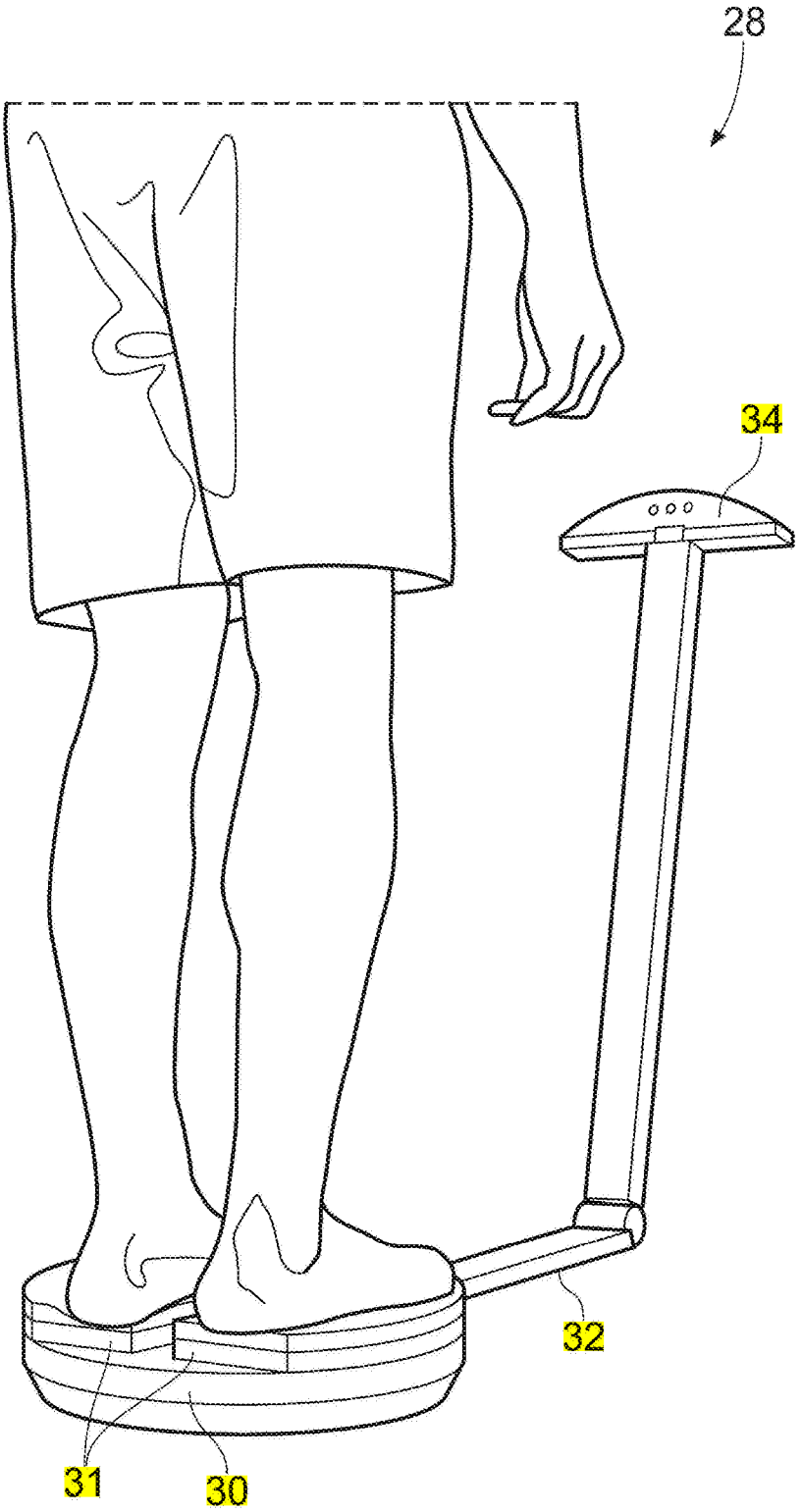

FIG. 3

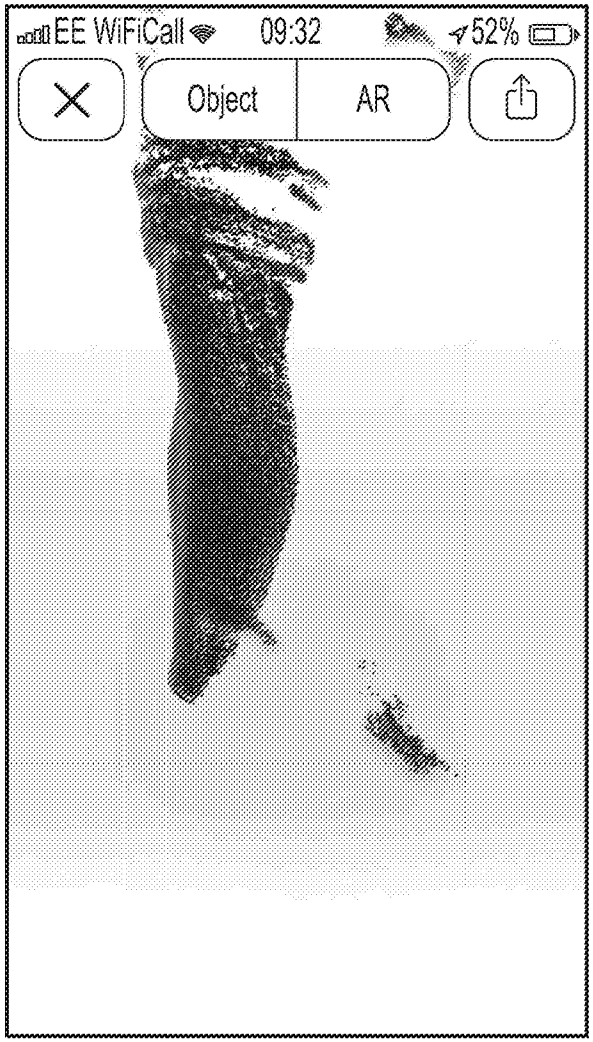

FIG. 4a

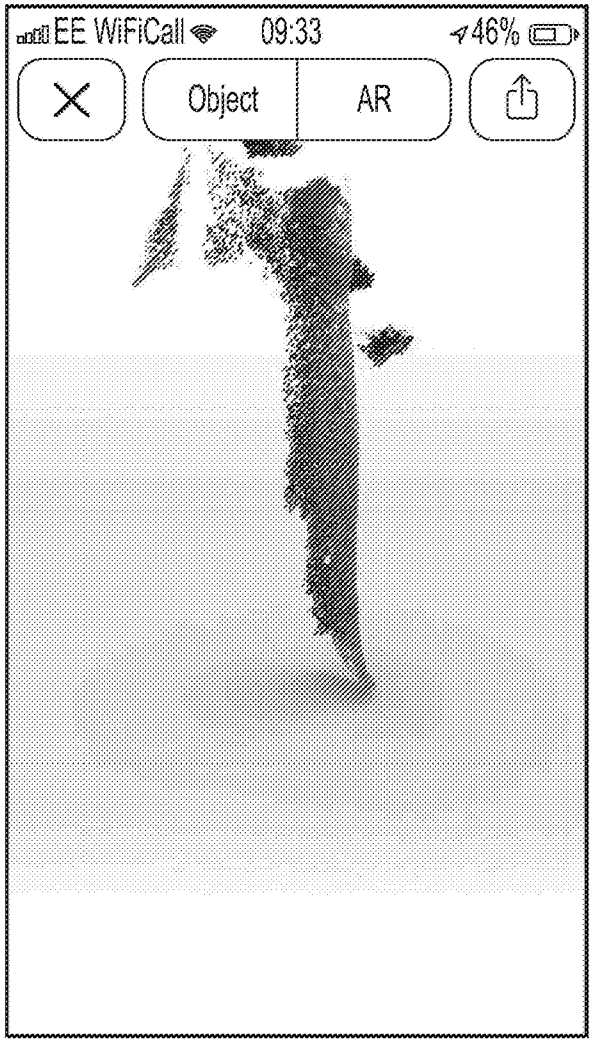

FIG. 4b

METHODS OF MANUFACTURING A GUARD TAILORED TO AN INDIVIDUAL'S BODY

The present invention generally relates to methods of manufacturing a guard tailored to a surface profile of an individual's body and to a guard tailored to the surface profile of an individual's body.

BACKGROUND TO THE INVENTION

Many contact or non-contact sports, at a professional or amateur level, require the use of guards to help prevent serious injury to vulnerable areas of the body. For example, shin guards are widely used to protect players' lower legs and shins from impacts during game play, for example, shin pads are used in football as kicking is used to advance the ball towards the goal. This can result in an increased risk of injury as players shins may receive impacts from other players.

Existing guards can be ill fitting, bulky and/or uncomfortable as they are mass produced in a limited number of standard sizes and to generic norms or average shapes. Individuals which differ from generic norms or average shapes may find that the protective guards are less comfortable to wear, impede movement, shift position easily and provide ineffective impact protection. This can be especially problematic for children and women as there are limited sizes and shapes available. Furthermore, as children grow, existing shin pads will fit worse.

To help ensure guards are held in position straps and/or adhesive tape are used to bind the guard tightly to the body. While this minimises undesired movement, it limits the flow of blood, and may allow the guard to shift to an uncomfortable position. Adhesive tapes can be particularly problematic as they do not stretch which requires them to be fitted in a constrictive manner. While straps can stretch, they tend to be overly constrictive as the unstretched state is significantly smaller than when in use.

Guards which can be adjusted for a better fit are known. For example, Tibtop (RTM) provide a shin guard in which two wing portions can be folded to better fit the shin. However, many of the same issues are still present as they are mass produced to

standard sizes and only allow the overall width of the shin pad to change. Furthermore, the shell of the shin pad maintains a standard concave shape.

It is an object of the present invention to reduce or substantially obviate the aforementioned problems.

STATEMENT OF INVENTION

According to a first aspect of the present invention there is provided a method of manufacturing a shin guard tailored to a portion of an individual's body as set out in claim 1. Optional features are set out in the dependent claims.

Using the disclosed method, it is possible to create a tailored protective guard which fits to the unique shape of a portion of the individual's body while improving impact protection. The tailored fit helps to prevent slippage of the protective guard during use which removes the need for additional adhesive tape or straps, improving blood flow during use. Furthermore, the tailored protective guard improves the comfort and mobility of the individual. The disclosed method improves access to well-fitting guards to a larger range of people.

The height and width of the shell are each independently tailored to the relevant part of the user's body.

By creating a positive mould and forming a shell through thermoforming, it is possible to quickly and cheaply produce guards tailored to an individual. The thermoplastic may include a copolymer.

The unitary shell is defined by a single shell sized and shaped to provide protection to the desired portion of the individual's body.

In some cases, the impact absorbing, or impact reducing, material may be applied to the rigid shell (that is, to the moulded portion of the thermoplastic sheet) prior to separating the shell from the rest of the sheet.

In the first aspect, the step of forming the tailored shell may comprise removing the rigid shell from the thermoformed sheet by cutting. After removing the rigid shell from the thermoformed sheet, the rigid shell may be reduced in size to user selected dimensions. Excess material may be removed to reduce the size by trimming using a cutting means, abrading using an abrasive, or other processes known to remove excess material.

The user selected dimensions may include at least a longitudinal dimension and a latitudinal dimension, the longitudinal dimension is the distance the guard will extend along the portion of the individual's body when fitted, the latitudinal dimension is the distance the guard will extend around the portion of the individual's body when fitted. The user selected dimensions should not be greater than the dimensions of the portion of the individual's body.

By customising the dimensions, such as size, length, width and/or overall area, of the tailored shell a greater range of individuals can be catered for. For example, taller players who have thinner shins will be able to have shin pads which are a narrower width when compared to the set standard sizes.

In the first aspect, prior to forming the rigid shell, at least a portion of the positive mould may be enlarged, or scaled up, to account for the thickness of the impact absorbing material. By doing so, once the shell has been formed, it is large enough to receive the impact absorbing material such that the surface profile which is scaled to fit the portion of the body that gave rise to the positive mould. In other words, the impact absorbing material has an irregular surface profile at the same scale as the body portion it is intended to fit, and the rigid shell has an irregular surface profile which matches and is equivalent to an enlargement of the surface profile of the impact absorbing material. The enlargement is fractional but contributes to an improved fit.

A flexible material capable of substantially conforming to the surface profile may be used to enlarge, or scale up, the positive mould. The flexible material may have a thickness which is approximately equal to or less than the thickness of the impact absorbing material to be used. The flexible material may be a fabric material or other material which can closely conform to the surface profile while allowing a gas to be

drawn through. The material used to enlarge, or scale up, the positive mould may be capable of stretching. The material may wrap around a portion of the mould.

When using a three-dimensional model, in the first aspect, the computer model may be enlarged or scaled by a predetermined value based on the intended thickness of the impact absorbing material to be used.

In the first aspect, the positive mould is created from a digital representation of at least the portion of the individual's body. The representation of at least the portion of the individual's body is a digital representation of the surface profile of at least the portion of the individual's body. The digital representation is captured by using an optical three-dimensional scanner. The scanner may be handheld or static. The scanner may be a smartphone with a camera and suitable installed software.

The optical three-dimensional scanner may directly scan at least the portion of the individual's body or it may scan a physical representation of at least the portion of the individual's body. For example, the physical impression may be scanned.

The use of a three-dimensional scanner allows for the necessary information to be digitised and stored. The stored digital information can be more easily accessed and transferred. The physical space required to store the digital scans is less than the physical impressions. The digital scans ensure that no accidental damage to the captured representation can easily occur.

In the first aspect, the captured data may be a point cloud or other digital representation of the surface profile of the portion of the individual's body. The captured data may be used to create a three-dimensional computer model representing the individual's body. The positive mould is then created by a computer controlled subtractive manufacturing process based on the three-dimensional representation of the individual's body. For example, a CNC machine, such as a milling machine, may mill a block of material based on the three-dimensional computer model.

The optical three-dimensional scanner may use known three-dimensional scanning techniques such as time-of-flight scanning, triangulation scanning and/or structured light scanning.

The optical three-dimensional scanner may be a handheld optical three-dimensional scanner.

The handheld device may be a smart device, such as a smart phone. The smart device may be an electronic device with a processor, memory and communication means allowing connection and communication with at least one other electronic device.

The smart device may comprise a structured light projector and at least one optical sensor. The structured light projector may project a pattern of light, such as parallel stripes, an array of dots or other common patterns, on to at least the portion of the individual's body. The pattern may change with time, for example the stripes may move in a predetermined direction.

By using a three-dimensional scanner, it is possible to capture the relevant three-dimensional geometric information required to build a three-dimensional computer model. By using a handheld scanner, it is possible to allow the individual, or an assistant within a shop or visiting a remote location such as a sport club, to capture the necessary information for later manufacturing the tailored guard.

A smart device allows for individuals to capture the necessary information using commonly owned devices. This would allow the individual to capture the representation at home and transmit the information to the manufacture or a remote server for later access by the manufacturer.

The first aspect may use a vacuum former to form the tailored shell.

An adhesive or glue may be used to bond the shell to the sheet of impact absorbing material. The adhesive may be a medical grade adhesive. The adhesive or glue may be a contact adhesive. An adhesive is considered to be a material or compound suitable for bonding two different surfaces of materials together. The bond is preferably permanent.

The impact absorbing material may be a strain rate dependent material. The impact absorbing material may be a foam material. The foam material may be a foam rubber. The foam material may be or include an elastomeric material. The impact absorbing material may include Poron XRD (RTM).

The impact absorbing material may include an antimicrobial additive or coating. For example, the Poron XRD (RTM) may include one of the antimicrobial technologies from Microban (RTM).

The impact absorbing material may be suitable for direct contact with human skin.

The impact absorbing material may be provided as a mid-layer between the inner surface of the guard and a further layer of material. The further layer of material may be or include a fabric suitable for wicking moisture away from the portion of the individual's body, such as polyester or wool, and/or providing comfort. The further layer of material may be applied to at least some of the surfaces of the impact absorbing material not in contact with the inner surface of the guard.

The adhesive or glue may be applied to the sheet of impact absorbing material or the inner surface of the rigid shell or both. The sheet of impact absorbing material may be placed against the inner surface of the rigid shell and pressure applied to the rigid shell and/or impact absorbing material. Pressure may be applied to substantially the whole surface area or a portion of the surface area of the rigid shell and/or impact absorbing material. Pressure may be applied by hand or a tool. The tool may include a roller. The tool assists in adhering the sheet of impact absorbing material to the inner surface of the rigid shell. Pressure may be applied until the glue has partially or fully set, for example.

In strain rate dependent materials, such as Poron XRD (RTM), the material is in a soft pliable state when at rest as it is above the glass transition temperature of urethane molecules. However, when stressed at a high rate, the glass transition temperature moves to a point the urethane momentarily freezes.

According to an unclaimed second aspect of the present invention there is provided a shin guard tailored to a surface profile of a portion of an individual's body manufactured by the method of the first aspect of the invention.

The irregular profile is a profile that complements the contours unique to a person's musculoskeletal structure in the respective part of the body, for example, the individual's shin having unique contours along its length and width created by the tibia and surrounding tissue.

The irregular inner surface of the guard, as well as the impact absorbing material applied to the inner surface of the guard, substantially corresponds to the surface profile of the individual's body by each effectively having a curvilinear line, when the guard or portion of the individual's body is viewed in cross section, which is substantially parallel to the other. Generally, this means that the surface profile of the guard, and the impact absorbing material when applied, must substantially match with the surface profile of the portion of the individual's body.

The irregular inner surface may be considered as a surface which does not consist solely or predominantly of a simple or regular concave face. Instead, it can include raised or recessed areas which follow the contours of a specific part of a specific person's body. The protective guard is a shin guard and the surface profile is a shin profile.

The protective guard may have a substantially uniform thickness. The protective guard may have a thickness between 10 mm and 2 mm, preferably between 5 mm and 2 mm and more preferably an approximate thickness of 3 mm.

In an unclaimed third aspect of the present invention there is provided a kit of parts comprising: at least one guard according to the unclaimed second aspect (or made by the method of the first aspect); and a guard retaining means for in use extending around the portion of the individual's body and holding the guard to the individual, the guard retaining means including a stretchable fabric material, the stretchable fabric material including a cohesive material so that the stretchable fabric material coheres to itself.

A stretchable fabric material with cohesive material can cohere (or stick) to itself and not adhere (or stick) well to hair, skin or other materials. In other words, the cohesive material has a high degree of cohesion with itself, for example by pressing the material together, and a comparatively low degree of attraction to other surfaces. The cohesive bond between one section of the material and another section of the same material is releasable, unlike the adhesive bond formed between the impact absorbing material and the shell,

The guard retaining means may be a strip of fabric with a predetermined length and predetermined width, the predetermined length being greater than the predetermined width. The guard retaining means may be rolled up. For example, the retaining means may be a cohesive bandage or covering.

The material may be incorporated in the fabric and/or be applied by a coating to the fabric. The fabric may include fragments of cohesive material, such as rubber, latex or other materials, incorporated into the fabric. The fabric may include threads of rubber, latex, or other cohesive materials.

The stretchable cohesive material allows for the amount of tension, when in use around the individual's body portion, to be adjusted according to personal preference. For example, the amount the fabric is stretched, when it is applied, can be reduced so as to limit constriction. Furthermore, as movement of the guard is limited due to the matching profiles the fabric material can act redundantly to assist in minimising movement.

The outer surface of the protective guard may include indicia display regions.

The kit may include a compressive sleeve. The sleeve may include a region configured to hold the guard to the portion of the individual's body. The region configured to hold the guard in position may be a pocket.

The kit may include a compression sock. A pocket for a guard may be provided at the front of the compression sock or compressive sleeve.

The region configured to hold the guard in position may include a material for increasing friction within that area. For example, the material may be a silicone. Silicone webbing may be included in the pocket or a surface of the retaining means for maintaining the guard in position. The material for increasing friction may be a material woven into the material of the retaining means or it may be applied to a surface of the retaining means. When applied to the surface of the retaining means, it may be patterned such as a webbed pattern.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the present invention, and to show more clearly how it may be carried into effect, reference will now be made by way of example only to the accompanying drawings, in which:

Figure 1 shows a view of a pair of tailored shin guards manufactured according to an embodiment of invention;

Figures 2a, 2b, 2c and 2d shows an impression of an individual's lower leg being taken according to an unclaimed embodiment of the invention;

Figure 3 shows an optical three-dimensional scanner being used to scan lower legs of an individual's according to an embodiment of the invention; and

Figures 4a and 4b show a graphical representation of three-dimensional geometric data according to an embodiment of the invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring firstly to Figure 1, a pair of tailored protective shin guards are generally indicated at 10. Each shin guard comprises a tailored shell 12 and a layer of impact absorbing foam 14. The tailored shell 12 has a thickness of 3 mm with an outer surface and inner surface. In other embodiments the thickness of the tailored shell and/or the impact absorbing foam can vary based on sporting requirements and the individual's

preferences. The impact absorbing foam 14 is bonded to the inner surface of the tailored shell 12.

Each tailored shell 12 is shaped during manufacture based on a representation of the shin it will be located on. It is shaped such that it will conform closely, in use, to the surface profile of said shin. This allows the tailored shin guards to match the contours of the shin so as to run substantially parallel to the surface profile over the desired region of protection. The surface profile of the individual's shin, or other location onto which the protective guard is to be located, is dependent upon the local musculoskeletal structure of the individual.

The tailored shell 12 can be sized to the individual's requirements providing a non-set range of sizes (in both height and width), unlike the set number of standard sizes offered e.g. S, M, L & XL. The shape of the periphery of the tailored shell can also be customised based on the individual's choices. The aesthetics of the tailored shell may also be customised through applying designs or colour to the shell or placing branding within indicia display areas.

Embodiments of the first aspect of the invention will now be discussed. A method of manufacturing tailored protective guards, such as those shown in Figure 1, comprises the steps of creating a positive mould of a portion of an individual's body, forming a tailored shell and applying an impact absorbing foam to the tailored shell.

In one embodiment, the step of creating a positive mould is achieved by using medical impression foam.

Figures 2a, 2b, 2c and 2d generally show an impressioning kit and the process of making a shin impression using said kit. The impression kit comprises a block of impression foam 16 contained in an impression tool 18 made from metal, plastic or other suitably rigid material. Figure 2a shows the impression kit prior to an impression being formed and Figure 2d shows the impression kit after an impression is formed.

The impression tool 18 has a rectangular backplate 20 with two side walls 22 extending substantially perpendicular from the backplate 20. A region for receiving the

impression foam 16 is defined by at least a portion of the backplate 20 and at least a portion of the two side walls. The size and shape of the impression tool is predetermined based on the type of protective guard required and the part of the individual's body. The backplate 20 is used to distribute the force applied by the individual or assistant.

The impression tool 18 comprises two finger grip regions 23. In the current embodiment, the finger grip regions 23 extend along substantially the length of the backplate 20 and extend approximately one third of the width of the backplate 20. The finger grip regions 23 are formed by a pad of compressible material, such as foam, attached to a surface of the backplate 20. The two finger grip regions can act as an alignment means. Each foam pad is adhered to the backplate 20 so that the central third of the backplate is not covered. This allows the individual or assistant to approximately align the crest of the shin with the centre of the impression tool 18.

As shown in figures 2b and 2c, the individual, or an assistant, aligns the crest of the shin to the central region of the impression kit 18, places the impression kit into contact with the desired area on the individual's body 24 and applies a force to the impression tool 18 towards the desired area of the individual's body 24. This causes the impression foam 16 to destructively compress creating an impression containing the surface profile of the desired area of the individual's body between the backplate 20 and the desired area of the individual's body 24.

In some embodiments, a surface of the backplate 20 is textured or includes an adhesive to secure the impression foam 16 within the receiving space of the impression tool 18.

In other embodiments, the side walls 22 may flex slightly allowing contact with the impression foam 16. The flexing side walls 22 will secure the impression foam within the receiving space when the impression tool 18 is handled by the user.

In some embodiments, the impression tool 18 containing the impression foam 16 is supplied to an individual through an online marketplace or in a physical store. Alternatively, an assistant can travel to the individual to capture the impression. The impression tool may be provided with a cover or box to protect the impression foam 16 during transport. Alternatively, the impression tool 18 may be constructed in such a

way to fold so as to prevent the impression foam 16 from being further crushed once an impression has been taken. The individual is provided with instructions on how to take an impression using the foam. Once an impression has been taken it is returned so that a positive mould can be created.

In the current embodiment, a liquid plaster, or similarly suitable casting medium, is poured into the impression 26 to create a positive of the desired area of the individual's body. Once the casting material has hardened, the positive is removed and smoothed.

In an alternative embodiment using the impression kit, a handheld optical three-dimensional scanner, such as those discussed below, is used to scan the impression with the resulting data to be used to generate a three-dimensional computer model of the desired area of the individual's body. A CNC milling machine is used to mill a block of material, preferably a polymer, into the positive mould of the desired area of the individual's body based on the three-dimensional computer model.

In an alternative embodiment, the step of creating a positive mould is achieved by using an additive manufacturing technique, such as three-dimensional printing, to construct the positive based on a three-dimensional computer model of the desired location of the individual's body. The three-dimensional computer model is created by using a three-dimensional scanner.

Figure 3 shows a stand-on optical three-dimensional scanner 28 which can be used in some embodiments of the invention to generate a data file containing three-dimensional geometric data of an individual's lower legs. The stand-on optical three-dimensional scanner 28 comprises a base 30 with foot positions 31, an adjustable arm 32 extending from the base 30, and an optical scanner 34. An individual locates their feet on the identified foot positions on the base 30 and commences a three-dimensional scan. The base 30 may also comprise a motorised turntable to rotate the user. Alternatively, the adjustable arm 32 may rotate about the base 30. The stand-on optical three-dimensional scanner 28 generates a point cloud of the lower legs including the shins. Similar stand-on or non-handheld three-dimensional scanners, are known to the skilled person and would be suitable.

In other embodiments, a handheld optical three-dimensional scanner is used to capture the necessary three-dimensional data representing a portion of the individual's body. There are a number of handheld optical three-dimensional scanners known to the skilled person which use different mechanisms and techniques to capture the three-dimensional geometric data which would be suitable for use in the disclosed methods, for example structured light, modulated light, laser triangulation or stereoscopic images.

In the preferred embodiment, the handheld device may be a smart device, such as a smartphone or tablet, which uses the existing imaging components to perform the three-dimensional scanning. For example, the smart device may be an iPhone (RTM) which comprises the Apple (RTM) TrueDepth (RTM) camera. The three-dimensional scanning is performed by utilising the plurality of cameras and structured light projector. The smart device is moved through a plurality of positions such that a series of images of the individual's body is captured. Processing is carried out to generate a point cloud of the individual's body. Figures 4a and 4b show an example of a point cloud generated by using an application run on a smart device.

The process of scanning the desired area of an individual's body can be performed by the individual themselves using smart devices, or by an assistant within a shop or at an alternative location such as a sporting ground.

A three-dimensional computer model of the portion of the individual's body is created from the point cloud. The three-dimensional model is then used to create the positive mould of the individual's body by a CNC machine milling a block of material or by a three-dimensional printer constructing the positive mould.

Once the positive mould of the individual's body has been created, by any of the above embodiments, it is possible to form the tailored shell. In the current embodiment, a vacuum forming method is used to form a polypropylene copolymer sheet over the positive mould. The tailored shell is removed from the positive mould and the excess polypropylene copolymer removed. The tailored shell also undergoes the process of smoothing and finishing.

Once the tailored shell has been formed, sized, smoothed and finished, impact absorbing foam is secured to its inner surface. A layer of medical grade adhesive, suitable for adhering different materials together, is applied to the inner surface. A sheet of impact absorbing foam is applied to the medical grade adhesive. The sheet of impact absorbing foam is trimmed so as to align with the periphery of the tailored shell.

Embodiments of the second aspect of the invention will now be discussed. The second aspect of the invention does not include creating a positive mould of the individual's body and instead uses three-dimensional scanning techniques and resultant three-dimensional computer models discussed above to create the tailored shell through additive or subtractive manufacturing processes.

A method of manufacturing tailored protective guards, such as those shown in Figure 1, comprise the steps of generating a point cloud representation of the individual's body by using a three-dimensional scanner, creating a three-dimensional computer model, using the three-dimensional computer model in a computer controlled manufacturing process to create the tailored shell, and applying an impact absorbing material to the tailored shell.

The point cloud representation of the individual's body is the basis for a three-dimensional model representing at least the portion of the individual's body. A three-dimensional model of the tailored shell is created based on the three-dimensional model of the individual's body. The three-dimensional model of the tailored shell is used by the computer-controlled manufacturing processes.

In one embodiment, an additive manufacturing means, such as a three-dimensional printer, is used to create the tailored shell based on the three-dimensional computer model. In another embodiment, a subtractive manufacturing means, such as a CNC milling machine, is used to create the tailored shell based on the three-dimensional computer model.

Once the tailored shell has been created from either the additive manufacturing means or subtractive manufacturing means it is smoothed and finished, the impact absorbing foam is secured to its inner surface. A layer of high strength medical grade adhesive,

suitable for adhering different materials together, is applied to the inner surface. A sheet of impact absorbing foam is applied to the medical grade adhesive. The sheet of impact absorbing foam is trimmed so as to align with the periphery of the tailored shell.

Once finished, the tailored protective guards are packaged for delivery to the individual. Compressive sleeves of a suitable size for the individual's body are packaged with the tailored protective guards. Each compressive sleeve includes a compartment for containing the tailored protective guard in use. In some embodiments, the or each compressive sleeve includes a silicon webbing to securing the tailored protective guard.

The embodiments described above are provided by way of example only, and various changes and modifications will be apparent to persons skilled in the art without departing from the scope of the present invention as defined by the appended claims.

CLAIMS

1. A method of manufacturing a shin guard tailored to a portion of an individual's body including a shin profile, the tailored guard comprising a rigid shell and an impact absorbing material of substantially uniform thickness, the rigid shell including a substantially concave inner surface shaped to substantially correspond to the shin profile, the method comprising the steps of:

capturing a representation of at least the portion of the individual's body using an optical three-dimensional scanner to create a three-dimensional computer model of at least the portion of the individual's body, the representation including a surface which corresponds to the shin profile of the portion of the individual's body;

based on the three-dimensional computer model, using a subtractive manufacturing process to create a positive mould from the representation;

forming the rigid shell by:

thermoforming a sheet of thermoplastic to the positive mould;

isolating or separating the rigid shell from the thermoformed sheet; and

applying the impact absorbing material to the inner surface of the rigid shell.

2. A method of manufacturing a tailored shin guard as claimed in claim 1, in which a vacuum former is used to thermoform the sheet of thermoplastic.

3. A method of manufacturing a shin guard as claimed in claim 1 or claim 2, in which a smart device comprises the optical three-dimensional scanner, the optical three-dimensional scanner comprising a structured light projector and an optical sensor.

4. A method of manufacturing a shin guard as claimed in any preceding claim, in which the three-dimensional scanner scans part of the individual's body.

5. A method of manufacturing a shin guard as claimed in any preceding claim, in which the three-dimensional scanner is handheld.

6. A method of manufacturing a shin guard as claimed in any preceding claim, in which the three-dimensional computer model is enlarged or scaled by a predetermined value based on the intended thickness of the impact absorbing material to be used.

7. A method of manufacturing a shin guard as claimed in any preceding claim, in which the rigid shell has predetermined dimensions based on user selection and dimensions of the portion of the individual's body.

8. A method of manufacturing a shin guard as claimed in any preceding claim, in which an adhesive is used to bond the impact absorbing material to the inner surface of the shell.

9. A method of manufacturing a shin guard as claimed in any preceding claim, in which the impact absorbing material is a strain dependent material.

10. A method of manufacturing a shin guard as claimed in any preceding claim, in which the impact absorbing material is a foam.

11. A method of manufacturing a shin guard in any preceding claim in which the impact absorbing material is a urethane.

12. A method of manufacturing a shin guard in any preceding claim, in which the protective shin guard has an approximate thickness of 3 mm.