Title: KNITTED COMPRESSION SLEEVE

Abstract: According to an aspect of the present invention, there is provided a knitted compression sleeve for compressing a body part of a user, the knitted compression sleeve comprising at least two electrodes located on an internal side of the knitted compression sleeve, conductive pathways integrally formed with the knitted compression sleeve, a conductive pathway being in electrical connection with each electrode, and wherein the electrodes are positioned such that, in use, the electrodes are able to stimulate a muscle constituting the body part of the user, or are able to detect electrical activity within a muscle constituting the body part of the user.
Knitted Compression Sleeve

The present invention relates to a knitted compression sleeve.

It is known to provide a compression sleeve (sometimes referred to as a compression bandage, support, or brace or the like) to assist in the rehabilitation or prevention of injury (or further injury) of a body part of a user of the compression sleeve. The compression sleeve may, for example, maintain certain components of the body part in place, which may speed up a rehabilitation process. The compression sleeve may perhaps also provide some insulation or heat to the body part. In some instances, the compression sleeve may include one or more rods which may provide support to the body part. No other rehabilitation measures are provided by known compression sleeves.

It is desirable to provide a compression sleeve which obviates or mitigates a problem of existing compression sleeves, whether identified herein or elsewhere. Alternatively or additionally, it is desirable to provide a compression sleeve which serves as an alternative to existing compression sleeves. Alternatively or additionally, it is desirable to provide a compression sleeve which has, or has the ability to provide, additional functionality in comparison with existing compression sleeves.

According to an aspect of the present invention, there is provided a knitted compression sleeve for compressing a body part of a user, the knitted compression sleeve comprising: at least two electrodes located on an internal side of the knitted compression sleeve (i.e. a side of the sleeve that would, in use, face the body part of the user); conductive pathways integrally formed with the knitted compression sleeve, a conductive pathway being in electrical connection with each of the at least two electrodes; and wherein the at least two electrodes are positioned such that, in use, the electrodes are able to stimulate a muscle constituting the body part of the user, or are able to detect electrical activity within a muscle constituting the body part of the user.

The at least two electrodes may be integral to the knitted compression sleeve (e.g. formed integrally with the sleeve during knitting).

The knitted compression sleeve may further comprise indicators on an external side of the knitted compression sleeve, the indicators indicating a location of at least one of the electrodes.
The knitted compression sleeve may further comprise apertures on an external side of the knitted compression sleeve, a location of the apertures coinciding with a location of the at least two electrodes. The apertures may be sealable apertures.

A pocket may be formed between each electrode of the at least two electrodes and the internal side of the knitted compression sleeve. A compressible insert may be provided or providable in each pocket.

The at least two electrodes may comprise a pair of electrodes. The at least two electrodes may comprise two or more pairs of electrodes.

Each electrode may measure 5mm or more across.

The knitted compression sleeve may be formed with a substantially tubular shape. The knitted compression sleeve may be formable into a substantially tubular shape. In general, the knitted compression sleeve may be formed to, or may be formable to, conform to a shape of the body part, and may be non-tubular. The knitted compression sleeve could be formed, for example, in a planar (e.g. flat) manner, and then wrapped around a body part in use and secured with a fastening arrangement.

A pressure of compression providable by the knitted compression sleeve may be controlled by controlling one or dimensions of the sleeve during manufacture, or by controlling one or dimensions of the sleeve when in-situ around the body part.

The electrodes are, in use, configured to stimulate a muscle constituting the body part of the user, or configured to detect electrical activity within a muscle constituting the body part of the user.

The electrodes may be configured (e.g. shaped, or shaped in use) to present a substantially convex outer surface (e.g. a surface for contacting a body part of a user).

Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying figures, in which:

Figure 1 schematically depicts a perspective view of a knitted compression sleeve in accordance with an embodiment of the present invention;
Figure 2 schematically depicts a part cut-away view of the knitted compression sleeve of Figure 1; and

Figure 3 schematically depicts a side-on view of part of a knitted compression sleeve in accordance with another embodiment of the present invention, which includes optional features that may be used in connection with the knitted compression sleeve of Figures 1 and 2.

The accompanying Figures have not necessarily been drawn to any particular scale. Like features appearing in different Figures have been given the same reference numerals, for consistency and clarity.

Figure 1 schematically depicts a perspective view of a knitted compression sleeve for compressing a body part of a user of the knitted compression sleeve, in accordance with an embodiment of the present invention. In particular, Figure 1 schematically depicts a knitted compression sleeve which serves as a knee brace (or in other words, a knee support or the like).

Referring now to Figure 1, the knitted compression sleeve 2 comprises one or more knitted layers 4. The knitted compression sleeve 2 is formed into a substantially tubular shape during manufacture. The tubular nature of the knitted compression sleeve 2 provides openings 5 for insertion or removal of the body part of the user. In other embodiments, the knitted compression sleeve may be formable into a substantially tubular shape, for example, by wrapping the one or more knitted layers around a body part of the user and securing the knitted layers around the body part using one or more fastening arrangements, such as a hook and eye fastening arrangement, a strap and buckle fastening arrangement, or the like. The knitted compression sleeve could be formed, for example, in a planar (e.g. flat) manner, and then wrapped around a body part in use and secured with fastening arrangements.

The knitted compression sleeve may be formed to, or be formable to, conform substantially to a shape of the body part. For example, referring to Figure 1, the knitted compression sleeve 2, serving as a knee brace, has a slightly enlarged upper region to extend, in use, around a portion of a leg above the knee, and a relatively reduced in size lower region to extend, in use, about a portion of the leg below the knee.
Figure 2 schematically depicts a cut-away view of an internal side of the knitted compression sleeve of Figure 1. Figures 1 and 2 will now be referred to in combination.

The knitted compression sleeve 2 comprises a pair of electrodes 6 located on an internal side of the knitted compression sleeve 2 (i.e. a side of the sleeve that would, in use, face the body part of the user). A further pair of electrodes 8 are also provided on an internal side of the knitted compression sleeve 2. The electrodes 6, 8 may be formed from conductive yarn or the like, and may be provided by knitting such yarn.

The electrodes may be any suitable size. For example, the electrodes may measure 5mm across or more, 10mm across or more or 20mm across or more. The electrodes may for example measure 50mm across or less. Although the electrodes 6, 8 all have the same size in Figure 2, different electrodes may have different sizes. For example, an electrode which is used to detect movement of a muscle may be larger than an electrode which is used to supply stimulation to a muscle (it may be desirable to detect the movement using signals gathered over the larger electrode area).

Conductive pathways 10 are provided, and each of the pathways 10 are integrally formed with the knitted compression sleeve 2. For example, as the compression sleeve is knitted, one or more conductive yarns or strands or the like may be used in the knitting process to form the conductive pathways 10. Each electrode of the pairs of electrodes 6, 8 is in electrical connection with a conductive pathway 10, so that in use appropriate electrical signals can be transmitted to or from the pairs of electrodes 6, 8 via the conductive pathways 10.

The conductive pathways 10 may extend in any convenient direction. In one example, the conductive pathways may extend towards a common area, region or point. This may make it easier to connect the conductive pathways 10 to further electrical equipment.

An advantageous way of providing the integrally formed conductive pathways 10 is disclosed, for example, in WO2007/036746. WO2007/036746 discloses a method of knitting a garment (which may include a compression sleeve) having a definable axis, with conductive pathways defined by distinctive (e.g. conductive) yarns or the like extending substantially parallel to that axis. Knitting is conducted with knitted rows or courses being formed in a direction parallel to the axis, with the distinctive (e.g. conductive) yarns or the like being incorporated in series to define the conductive
pathways as the garment is formed. Since the pathways are substantially parallel, each pathway is concluded before a subsequent pathway or other yarn must be commenced, which enables the same yarn feeder to be used for each conductive pathway. Not only does this result in a substantial saving of equipment, but also in space.

The pairs of electrodes 6, 8 may also be integral to (e.g. integrally formed with) the knitted compression sleeve 2. For instance, the pairs of electrodes 6, 8 may be provided during the manufacture of the knitted compression sleeve (e.g. by knitting) or may be attached to the compression sleeve by appropriate stitching or the like during manufacture of the knitted compression sleeve 2.

The pairs of electrodes 6, 8 of the knitted compression sleeve 2 are deliberately positioned on the internal side of the compression sleeve such that, in use, the electrodes 6, 8 are able to be in electrical connection with and stimulate a muscle constituting the body part of the user that is in contact with the electrodes 6, 8. It will be appreciated that the electrodes 6, 8 are thus not randomly distributed, or distributed with no thought as to the specific location of the electrodes 6, 8. In contrast, the electrodes 6, 8 are specifically located such that when the compression sleeve is in-situ and surrounding a body part of the user, the electrodes 6, 8 are appropriately located to stimulate a muscle and, for example, detect electrical activity within or of that muscle.

The required locations of the electrodes may vary depending on the size of the user, for example depending on the size of the body part of the user, and the knitted compression sleeve can be designed and manufactured accordingly to meet these requirements.

The electrodes, being appropriately located for stimulation of a muscle of a user, can alternatively or additionally be used to detect (i.e. sense) electrical activity of or within that muscle. Thus, the electrodes can be used to both sense electrical activity within the muscle, and also to stimulate activity of the muscle. Sensing and stimulation may be undertaken by different pairs of electrodes, or by the same electrodes in series (e.g. sense then stimulate, or stimulate then sense). The electrodes may also be used to provide a degree of pain relief, for example by appropriate stimulation of nerves or muscles.
An external side of the knitted compression sleeve 2 may be provided with indicators 12. The indicators indicate a location of at least one of the electrodes 6, 8 on the internal side of the knitted compression sleeve 2. The indication may be in the form of an arrow or other marker pointing towards the appropriate location, or the indicator may directly coincide with the location. The indicators 12 are provided so that the user, or whoever is applying the knitted compression sleeve to the user, can ensure that the electrodes 6, 8 are appropriately positioned relative to respective muscles, so that stimulation or detection may be successful.

In use, when the knitted compression sleeve 2 is in-situ (e.g. surrounding and compressing a body part of a user), the electrodes 6, 8 will be appropriately located relative to one or more muscles of that body part so that the one or more muscles may be stimulated, or the electrical activity of those one or more muscles detected. The conductive pathways 10 may transmit detected electrical signals from the electrodes 6, 8 to further electrical equipment (not shown), and/or the conductive pathways 10 may transmit generated electrical signals from to further electrical equipment to the electrodes 6, 8. The further electrical equipment may be, for example, a signal processor, a single detector, a signal generator, a computer, a power supply, or the like. A wired or wireless transmitter may be in connection with the conductive pathways to transmit one or more signals to and from the further electrical equipment. The knitted compression sleeve and one or more pieces of further electrical equipment may together form a rehabilitation system, and/or a stimulation system, and/or a detection system.

During rehabilitation, for example, a user may use the respective body part that is supported by the knitted compression sleeve. For example, the body part may be a knee. The knee may be bent. Bending of the knee will generate electrical signals within one or more muscles which can be sensed (or in other words detected) using the electrodes 6, 8. Detection may be used, for example, to determine that the knee has only been bent to 50% of its normal range of flexibility. Next, using the same or different electrodes 6, 8 an electrical signal may be sent via conductive pathways 10 to respective electrodes 6, 8 to stimulate one or more muscles and cause movement (e.g. contraction or relaxation) of the muscle and thus bending of the knee. Stimulated bending of the knee may improve the flexibility or range of flexibility of the knee, and thus assist in the rehabilitation of the knee.
Electrodes of a pair of electrodes may be located at either end of a muscle in order to stimulate, via electrical signals, movement (e.g. contraction or relaxation) of that muscle. The electrodes may be located in other positions, so long as they are in positions which allow the electrodes to stimulate the muscle and, for example, generate movement in or of the muscle. For example, an electrode may be located at or adjacent to nerve ends of nerves associated with a muscle to be stimulated, such that electrical signals from the electrode may pass into the nerves.

A muscle or a muscle group may be stimulated. An electrode which is used to stimulate a muscle group may in some instances be larger than an electrode which is used to stimulate a muscle.

A single pair of electrodes may be provided, and may be sufficient. Alternatively, two or more pairs of electrodes may be provided. The two or more pairs of electrodes may be used to apply the electrical stimulation more accurately, or with a greater degree of control (e.g. via appropriate choice of the electrodes used).

In a further example, three electrodes may be provided instead of a pair of electrodes. The first and second electrodes may provide a simulating electrical signal to a muscle, and the third electrode may sense movement of the muscle. Alternatively, the first and third electrodes may provide a stimulating electrical signal to the muscle, and the second electrode may sense movement of the muscle. Any other combination of stimulation and sensing may be provided by the three electrodes. The three electrodes may be provided in a row, or in any other arrangement.

In a further example, four or more electrodes may be provided instead of a pair of electrodes.

At least two electrodes may be required in the knitted compression sleeve in order to couple a simulating electrical signal into and out of a muscle. More than two electrodes may be provided. It is not necessary that the electrodes be provided in pairs.

The choice of electrodes used may depend on, for example, the size of the body part of the user, or the desired application of electrical signal to particular parts of the muscle of the user (e.g. location or area of application). Integrally formed conductive pathways will be provided in the knitted compression sleeve which provide electrical connections to each electrode.
Figure 3 schematically depicts a side-on view of a part of a knitted compression sleeve in accordance with another embodiment of the present invention. Figure 3 schematically depicts various optional features which may be incorporated, either in isolation or combination, with one or more features discussed above in relation to Figures 1 and 2.

Referring to Figure 3, the knitted compression sleeve comprises one or more knitted layers 4. An electrode 6 is shown as being attached to, and for example formed integrally with, the knitted layers 4. A pocket 14 is formed between the electrode 6 and the knitted layers 4 (i.e. between the electrode 6 and an internal side of the knitted compression sleeve). The pocket 14 could be formed by ensuring that the electrode 6 is not, in its entirety, pulled against or attached to the internal side of the knitted compression sleeve, but instead includes some slack (e.g. between points of attachment to the knitted layers 4). The pocket 14 may be used to accommodate a compressible insert 16 (e.g. foam or the like). The compressible insert 16 may, in use, ensure that a better contact is made between the electrode 14 and the body part of the user. Being compressible, the insert 16 should cause the user little or no discomfort.

When stimulating muscles using electricity, it is advisable to use an electrically conductive fluid such as a gel or the like between an electrode and the user's skin, in order to dissipate electrical current and prevent burning of the user's skin. Thus, in accordance with an embodiment of the present invention, one or more apertures 18 may be provided on an external side of the knitted compression sleeve, the location of the one or more apertures 18 coinciding with the location of the electrode or electrodes 6. The electrically conductive fluid (e.g. a gel or the like) may be inserted (for example) by injection or any other appropriate manner through the aperture 18 and either directly into or onto the electrode 6, or into a pocket 14 formed between the electrode 6 and the internal side of the knitted compression sleeve, or into a compressible insert 16 located in the pocket 14. The compressible insert 16 may assist in at least partially retaining in position the electrically conductive fluid, prolonging the time before further fluid is required. The apertures 18 may be at least partially sealable (e.g. self-sealing) apertures, to prevent escape of the electrically conductive fluid through the aperture 18.

A suitable electrode structure for use in the knitted compression sleeve may be as substantially shown in WO/2007/036741. WO/2007/036741 discloses an electrode structure suitable for monitoring or stimulating activity at a body surface. The structure
comprises a contact membrane (e.g. for receiving and/or transmitting electrical signals) and a cover membrane. The contact membrane is attached to the cover membrane around its periphery such that at least one of the membranes forms a convex outer surface. The cover membrane is adapted for extension over a body surface to project the contact membrane against a body surface beneath it. The cover membrane may be, for example, a part of the material forming the knitted compression sleeve. Because one of the membranes form a convex outer surface, when the cover membrane is extended over a body surface, this will ensure that the contact membrane is urged against the body surface for monitoring or stimulation of activity. This may improve signal to noise ratio, signal consistency, or the like. The formation of the convex outer surface can be accomplished by a manner in which two membranes of different elastic modulus are attached to each other. A substantially similar effect can be achieved in a single knitted fabric having a contact side and a cover side, by increasing the stitch density on the contact side relative to the cover side over an area thereof which forms a convex surface on the contact side. In summary, it may be beneficial to provide an electrode or electrode structure which comprises a convex outer surface.

The use of a knitted compression sleeve is particularly advantageous, since the knitting process allows the conductive pathways required to electrically stimulate or electrically detect activity within a muscle to be integrally provided in the knitting compression sleeve. This avoids the need to provide and attach wires or the like after manufacture of a compression sleeve. This makes the manufacturing process easier and cheaper, and should also mean that the compression sleeve is more robust, since it is more difficult to detach or damage integrally formed conductive pathways.

A pressure of compression provideable or provided by the knitted compression sleeve may be controlled by controlling one or more dimensions of the knitted compression sleeve during manufacture, or by controlling one or more dimensions of the sleeve when in-situ around the body part (e.g. by changing the degree of interaction or extension or co-operation between hook and eyes, or straps and buckles, or the like).

The knitted compression sleeve may be shaped to fit a body part. The thickness of the knitted compression sleeve may vary. For example, the thickness of the knitted compression sleeve may be less than an average thickness of the knitted compression sleeve at a location which will be on the inner side of a joint during use (thereby allowing greater freedom of movement of the joint than would otherwise be the case).
The knitted compression sleeve according to the present invention is not limited to serving as a knee braces, but may also find application in the compression of any one or more of a number of body parts of a user.

The knitted compression sleeve may include one or more rods which are arranged to provide lateral or longitudinal support to a body part of the user (e.g. a knee). The knitted compression sleeve may include one or more pockets which are configured to receive the rod or rods.

The direction of knitting which is used to form the knitted compression sleeve may be any suitable direction. The direction of knitting may for example be chosen in order to accommodate the placing of electrodes, and/or to accommodate the conductive pathways which connect the electrodes to further electrical equipment.

It will be appreciated by a person skilled in the art that various modifications be made to the embodiments described herein, and without departing from the invention as defined by the claims that follow.
CLAIMS:

1. A knitted compression sleeve for compressing a body part of a user, the knitted compression sleeve comprising:
   at least two electrodes located on an internal side of the knitted compression sleeve;
   conductive pathways integrally formed with the knitted compression sleeve, a conductive pathway being in electrical connection with each of the at least two electrodes; and
   wherein the at least two electrodes are positioned such that, in use, the electrodes are able to stimulate a muscle constituting the body part of the user, or are able to detect electrical activity within a muscle constituting the body part of the user.

2. The knitted compression sleeve of claim 1, wherein the at least two electrodes are integral to the knitted compression sleeve.

3. The knitted compression sleeve of claim 1 or claim 2, further comprising indicators on an external side of the knitted compression sleeve, the indicators indicating a location of at least one of the electrodes.

4. The knitted compression sleeve of any preceding claim, further comprising apertures on an external side of the knitted compression sleeve, a location of the apertures coinciding with a location of the at least two electrodes.

5. The knitted compression sleeve of claim 4, wherein the apertures are sealable apertures.

6. The knitted compression sleeve of any preceding claim, wherein a pocket is formed between each electrode of the at least two electrodes and the internal side of the knitted compression sleeve.

7. The knitted compression sleeve of claim 6, wherein a compressible insert is provided in each pocket.

8. The knitted compression sleeve of any preceding claim, wherein the at least two electrodes comprises a pair of electrodes.
9. The knitted compression sleeve of any preceding claim, wherein each electrode measures 5mm or more across.

10. The knitted compression sleeve of any preceding claim, wherein the knitted compression sleeve is formed with a substantially tubular shape.

11. The knitted compression sleeve of any of claims 1 to 9, wherein the knitted compression sleeve is formable into a substantially tubular shape.

12. The knitted compression sleeve of any preceding claim, wherein the knitted compression sleeve is formed to, or formable to, conform to a shape of the body part.

13. The knitted compression sleeve of any preceding claim, wherein a pressure of compression provable by the knitted compression sleeve may be controlled by controlling one or dimensions of the sleeve during manufacture, or by controlling one or dimensions of the sleeve when in-situ around the body part.

14. The knitted compression sleeve of any preceding claim, wherein the electrodes are, in use, configured to stimulate a muscle constituting the body part of the user, or configured to detect electrical activity within a muscle constituting the body part of the user.

15. The knitted compression sleeve of any preceding claim, wherein the electrodes are configured to present a substantially convex outer surface.
INTERNATIONAL SEARCH REPORT

PCT/GB2010/001699

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61F13/08 A61B5/0488 A61B5/0492 A61N1/04

ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61F A61B A61N D04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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