

CLAIMS

1. A wearable non-invasive apparatus for enhancing lower limb venous return of a subject, the apparatus comprising:
 - a controller unit comprising:
 - a monitoring device comprising a photoplethysmography sensor configured to determine a venous state indicated by a flow of red blood cells in a subject; and
 - a neuromuscular electrical stimulation (NMES) device configured to generate an electrical stimulus in response to the determined venous state and further configured to concurrently stimulate ~~the~~ a triceps surae and ~~the~~ a deep posterior calf muscle of the subject with the generated electrical stimulus to enhance lower limb venous return; and
 - an electrode pad coupled to the controller unit and configured to be placed in contact with a skin surface around an ankle of the subject;
 - wherein the electrode pad comprises a hole so that the photoplethysmography sensor passes through the hole when the electrode pad is coupled to the controller unit.
2. The apparatus of claim 1, ~~further comprising at least one electrode~~ wherein the electrode pad is adapted to be positioned at the triceps surae of the subject, or the deep posterior calf muscle of the subject, or a tibial nerve of the subject to retrograde target the triceps surae and the deep posterior calf muscle of the subject.
3. The apparatus of claim 2, wherein the ~~at least one electrode~~ electrode pad is adapted to be positioned at the triceps surae selected from the group consisting of the gastrocnemius muscle and the soleus muscles.
4. The apparatus of claim 2, wherein the ~~at least one electrode~~ electrode pad is adapted to be positioned at the deep posterior calf muscle selected from the group consisting of a

flexor digitorum longus muscle, flexor hallucis longus, posterior tibialis and popliteus muscles.

5. The apparatus of claim 2, wherein the at least one electrode is adapted to be positioned at the tibial nerve through a posterior tibial nerve.
- ~~6. The apparatus of claim 2, wherein the at least one electrode comprises a disposable pad configured to be placed in contact with a skin surface around an ankle of the subject or at least substantially near to an ankle of the subject.~~
- ~~7. The apparatus of claim 6, wherein the at least one electrode forms an integral part of the disposable pad.~~
- ~~8. The apparatus of claim 1, wherein the venous state comprises at least one of an outflow fraction, a venous filling index, a venous refill time (VRT), an ejection volume, an ejection fraction, a venous volume and a residual volume fraction.~~
- ~~9. The apparatus of claim 1, wherein the venous state is determined via at least one of plethysmography, skin turgor, edema, tissue oxygen perfusion, pain, inflammation and induration.~~
- ~~10. The apparatus of claim 1, wherein the monitoring device comprises a photoplethysmography (PPG) sensor.~~
- ~~11.~~6. The apparatus of claim 1, wherein the NMES device is configured to provide retrograde neurostimulation of a posterior tibial nerve of the subject.
- ~~12.~~7. The apparatus of claim 1, further comprising at least one activity sensor configured to sense at least one of a physiological parameter, a postural parameter, an ambulatory parameter, and a gait parameter of the subject.

- ~~13.8.~~ The apparatus of claim ~~12~~7, wherein the NMES device comprises a controller configured to interface with an electrostimulation software to provide the electrical stimulus dependent on the at least one of the physiological parameter, the postural parameter, the ambulatory parameter, and the gait parameter.
- ~~14.9.~~ The apparatus of claim ~~13~~8, wherein the controller is configured to wirelessly interface with the electrostimulation software.
- ~~15.10.~~ The apparatus of claim 1, further comprising a disposable adhesive electrode strap or a patch to allow for easy placement of the apparatus on a skin surface of the subject upon use.
- ~~16.11.~~ The apparatus of claim 1, further comprising an visual indicator configured to aid proper positioning of the apparatus on a skin surface around an ankle of the subject or at least substantially near to an ankle of the subject.
- ~~17.12.~~ The apparatus of claim 1, further comprising a wearable cuff, or a sock.
- ~~18.13.~~ The apparatus of claim 1, wherein the apparatus comprises a portable, battery-operated apparatus.
- ~~19.~~ A method of enhancing lower limb venous return of a subject, the method comprising:
~~—determining a venous state of a subject; and~~
~~—generating an electrical stimulus in response to the determined venous state; and~~
~~concurrently stimulating the triceps surae and the deep posterior calf muscle of the subject with the generated electrical stimulus.~~
- ~~20.~~ The method of claim 19, further comprising positioning a wearable non-invasive apparatus of claim 1 around an ankle of the subject or at least substantially near to an ankle of the subject.