MONITORING VITAL PARAMETERS OF A COMPRESSION GARMENT WEARER

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority from U.S. Provisional Patent Application Serial No. 62/527,155, filed June 30, 2017, the disclosure of which is incorporated in its entirety by reference, including the contents and teachings of any references contained therein.

BACKGROUND

[0002] Intermittent pneumatic compression (IPC) systems include devices used to apply pressurized fluid, such as air, to a limb of a patient or wearer. In some instances, pressurized air is applied to the lower limb of a patient at risk for the formation of a blood clot (thrombus) associated with deep vein thrombosis (DVT). An IPC system typically includes a pumping unit to manage pressurization of the fluid, a tubing set to extend the delivery of fluid beyond the pumping unit, and a compression garment which is wrapped around the patient's limb and contains the pressurized fluid. The IPC system intermittently pressurizes the garment to apply therapeutic compression to the patient's limb, moving blood from that area of the limb. Many IPC systems utilize a pressure sensor as the sole means of feedback. The pressure sensor output is used to adjust fluid delivery to the compression garment and maintain prescribed pressures, but the measurable pressure is confined to the pressure within the compression garment and tubing.

SUMMARY

[0003] The present disclosure is directed to systems and methods of determining a blood pressure and/or a pulse rate of a compression garment wearer.

[0004] In a first aspect, a controller for controlling inflation and deflation of at least one bladder of a garment to provide compression therapy treatment to a wearer of the garment includes a memory, one or more processors, and a non-transitory, computer-readable storage medium. The non-transitory, computer-readable storage medium includes computer-executable instructions for causing the one or more processors to receive, from a pressure sensor, a signal indicative of fluid pressure in the at least one bladder of the garment during a pressure hold period of a compression therapy treatment cycle and determine~~, based on pressure received from the pressure sensor only during a static pressure period,~~ whether the received signal includes oscillating amplitude as a function of time. The non-transitory,

computer-readable storage medium also includes computer-executable instructions for causing the one or more processors to based at least in part on the determination of whether the received signal includes oscillating amplitude as a function of time, estimate a blood pressure of the wearer of the garment ~~based on the pressure received by the pressure sensor only during the static pressure period~~.

[0005] In a second aspect, a system comprising: a compression garment including at least one inflatable and deflatable bladder and the compression garment is securable about a limb of a wearer and configured to provide compression therapy treatment to the wearer; a controller , the controller comprising a memory and one or more processors, the memory including computer-executable instructions for causing the one or more processors to: receive, from a pressure sensor, a signal indicative of fluid pressure in the at least one inflatable and deflatable bladder during a pressure hold period of a compression therapy treatment cycle; determine~~, based on pressure received from the pressure sensor only during a static pressure period,~~ whether the received signal includes oscillating amplitude as a function of time; and based at least in part on the determination of whether the received signal includes oscillating amplitude as a function of time, estimate the blood pressure of the wearer ~~based on the pressure received by the pressure sensor only during the static pressure period~~.

[0006] In a third aspect, a controller for controlling inflation and deflation of at least one bladder of a garment to provide compression therapy treatment to a wearer of the garment, the controller comprising a memory, one or more processors, and a non-transitory, computer-readable storage medium including computer-executable instructions for causing the one or more processors to: receive, from a pressure sensor, a signal indicative of fluid pressure in the at least one bladder of the garment during a pressure hold period of a compression therapy treatment cycle; determine~~, based on pressure received from the pressure sensor only during a static pressure period,~~ whether the received signal includes a representation of a pulse of the wearer; and based at least in part on the determination of whether the received

signal includes a signal indicative of the pulse of the wearer, determine a blood pressure of the wearer of the garment ~~based on the pressure received by the pressure sensor only during the static pressure period~~.

[0007] In a fourth aspect, a system includes a compression garment including at least one inflatable and deflatable bladder and the compression garment is securable about a limb of a wearer. The system further includes a controller

WHAT IS CLAIMED IS:

1. A controller for controlling inflation and deflation of at least one bladder of a garment to provide compression therapy treatment to a wearer of the garment, the controller comprising one or more processors and a non-transitory, computer-readable storage medium including computer-executable instructions for causing the one or more processors to:

receive, from a pressure sensor, a signal indicative of fluid pressure in the at least one bladder of the garment during a pressure hold period of a compression therapy treatment cycle;

determine~~, based on pressure received from the pressure sensor only during a static pressure period,~~ whether the received signal includes oscillating amplitude as a function of time; and

based at least in part on the determination of whether the received signal includes oscillating amplitude as a function of time, estimate a blood pressure of the wearer of the garment ~~based on the pressure received by the pressure sensor only during the static pressure period~~.

2. The controller of claim 1, wherein the instructions to receive the signal indicative of fluid pressure include instructions to receive the signal indicative of fluid pressure while the at least one bladder is inflated.

3. The controller of claim 1, wherein the at least one bladder is inflated at a substantially constant pressure during the ~~static~~ pressure hold period.

4. The controller of claim 3, wherein the substantially constant pressure changes by less than ten percent over the period of the determination.

5. The controller of claim 2, wherein the instructions to receive the signal indicative of fluid pressure include instructions to receive the signal indicative of fluid pressure over a period of greater than 5 seconds and less than 60 seconds.

6. The controller of claim 1, wherein the instructions to receive the signal indicative of fluid pressure include instructions to receive the signal indicative of fluid pressure at a predetermined interval.

7. The controller of claim 1, wherein the instructions to receive the signal indicative of fluid pressure include instructions to receive the signal between therapeutic compression cycles of the at least one bladder.

8. The controller of claim 1, wherein the instructions to receive the signal indicative of fluid pressure include instructions to receive the signal based at least in part on a user input.

9. The controller of claim 1, wherein the non-transitory, computer-readable storage medium further includes computer-executable instructions for causing the one or more processors to detect whether the at least one bladder of the garment is in communication with the pressure sensor, wherein the instructions to receive the signal indicative of fluid pressure include instructions to receive the signal based at least in part on detection of the communication between the at least one bladder and the pressure sensor.

10. The controller of claim 9, wherein the detected communication between the compression garment and the pressure sensor is fluid communication.

11. The controller of claim 1, wherein the instructions to receive the signal indicative of fluid pressure include instructions to receive the signal indicative of fluid pressure while the at least one bladder is inflated to a non-therapeutic pressure.

12. The controller of claim 11, wherein the non-therapeutic pressure is 160 mmHg or greater.

13. The controller of claim 1, wherein the instructions to receive the signal indicative of fluid pressure include instructions to receive a first signal indicative of fluid pressure in a first bladder and to receive a second signal indicative of fluid pressure in a second bladder, and the instructions to determine whether the received signal includes oscillating amplitude includes

instructions determine whether the first signal and the second signal each include oscillating amplitude.

14. The controller of claim 1, wherein the instructions to determine whether the received signal includes oscillating amplitude include instructions to band-pass filter the received signal to extract frequencies of 0.5 Hz to 25 Hz.

15. The controller of claim 14, wherein the instructions to determine whether the received signal includes oscillating amplitude further include instructions to smooth the band-pass filtered signal.

16. The controller of claim 14, wherein the instructions to determine whether the received signal includes oscillating amplitude further include instructions to low-pass filter the band-pass filtered signal at a frequency of 5 Hz or under.

17. The controller of claim 1, wherein the instructions to determine whether the received signal includes oscillating amplitude include instructions to detect peaks in the signal.

18. The controller of claim 17, wherein the instructions to detect peaks in the signal include instructions to detect peaks in a frequency range of 0.5 Hz to 4 Hz.

19. The controller of claim 18, wherein the instructions to detect peaks in the signal include instructions to detect peaks corresponding to a variation in the fluid pressure of greater than 0.05 mmHg.

20. The controller of claim 1, wherein the instructions to determine whether the received signal includes oscillating amplitude include instructions to detect a repeating signal within a frequency range of 0.5 Hz to 4 Hz.

21. The controller of claim 1, wherein the oscillating amplitude as a function of time of the received signal is representative of a pulse of the wearer of the garment.

22. The controller of claim 1, wherein the non-transitory, computer-readable storage medium further includes computer-executable instructions for correlating the estimated blood pressure with an arterial blood pressure of the wearer.

23. A system comprising:

a compression garment including at least one inflatable and deflatable bladder, the compression garment securable about one or more limbs of a wearer and configured to provide compression therapy treatment to the wearer; and

a controller, the controller comprising a memory and one or more processors, the memory including computer-executable instructions for causing the one or more processors to:

receive, from a pressure sensor, a signal indicative of fluid pressure in the at least one inflatable and deflatable bladder during a pressure hold period of a compression therapy treatment cycle;

determine~~, based on pressure received from the pressure sensor only during a static pressure period,~~ whether the received signal includes oscillating amplitude as a function of time; and

based at least in part on the determination of whether the received signal includes oscillating amplitude as a function of time, estimate a blood pressure of the wearer~~ based on the pressure received by the pressure sensor only during the static pressure period~~.

24. The system of claim 23, further comprising a pump and at least one valve, wherein the at least one valve is in fluid communication with the pump and the at least one inflatable and deflatable bladder, the at least one valve is in electrical communication with the controller, and the memory of the controller further includes computer-executable instructions for causing the one or more processors to actuate the at least one valve to control fluid communication between the pump and the at least one inflatable and deflatable bladder.

25. The system of claim 23, further comprising a pump in fluid communication with the at least one inflatable and deflatable bladder, wherein the pump is in electrical communication with the

controller, and the memory of the controller further includes computer-executable instructions for causing the one or more processors to adjust a speed of the pump.

26. The system of claim 23, wherein the at least one inflatable bladder extends at least partially around a portion of the limb of the wearer when secured about the limb of the wearer.

27. A controller for controlling inflation and deflation of at least one bladder of a garment to provide compression therapy treatment to a wearer of the garment, the controller comprising a memory, one or more processors, and a non-transitory, computer-readable storage medium including computer-executable instructions for causing the one or more processors to:

receive, from a pressure sensor, a signal indicative of fluid pressure in the at least one bladder of the garment during a pressure hold period of a compression therapy treatment cycle;

determine~~, based on pressure received from the pressure sensor only during a static pressure period,~~ whether the received signal includes a representation of a pulse of the wearer; and

based at least in part on the determination of whether the received signal includes a signal indicative of the pulse of the wearer, determine a blood pressure of the wearer of the garment ~~based on the pressure received by the pressure sensor only during the static pressure period~~.

28. The controller of claim 27, wherein the instructions to receive the signal indicative of fluid pressure include instructions to receive the signal indicative of fluid pressure while the at least one bladder is inflated.

29. The controller of claim 27, wherein the at least one bladder is inflated at a substantially constant pressure during the ~~static~~ pressure hold period.

30. The controller of claim 27, wherein the instructions to determine whether the received signal includes a representation of a pulse of the wearer include instructions to detect a repeating signal within a frequency range of 0.5 Hz to 4 Hz.

31. The controller of claim 27, wherein the computer-executable instructions include instructions for correlating the determined blood pressure with an arterial blood pressure of the wearer.

32. A system comprising:

a compression garment including at least one inflatable and deflatable bladder, the compression garment securable about a limb of a wearer; and

the controller of any of claims 27-30.

33. The system of claim 32, further comprising a pump and at least one valve, wherein the at least one valve is in fluid communication with the pump and the at least one inflatable and deflatable bladder, the at least one valve is in electrical communication with the controller, and the non-transitory, computer-readable storage medium of the controller further includes computer-executable instructions for causing the one or more processors to actuate the at least one valve to control fluid communication between the pump and the at least one inflatable and deflatable bladder.

34. The system of claim 32, further comprising a pump in fluid communication with the at least one inflatable and deflatable bladder, wherein the pump is in electrical communication with the controller, and the non-transitory, computer-readable storage medium of the controller further includes computer-executable instructions for causing the one or more processors to adjust a speed of the pump.