the ground, minimize impedance during late stance, and achieve a spring-damper during a swing phase. Recent theoretical and experimental investigations have found that a positive force feedback FES control results in robust, spring-like muscle operations. Hence, for the stance phases of walking where a spring-like response is desired, a positive force feedback strategy can be employed. Here muscle or tendon force is the feedback sensory signal. The greater the force borne by the muscle-tendon unit, the greater is the muscle activation. This approach is not only robust to variations in muscle force-length and force-velocity curves, but is a control that rejects system energy disturbances as an emergent response.

[0061] While this invention has been particularly shown and described with references to various embodiments thereof including treatment of drop foot gait, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the scope of the invention encompassed by the appended claims. For example, the devices and methods can be used to treat a variety of ankle foot gait pathologies, including patients suffering from anterior and/or posterior muscle weakness(es).

What is claimed is:

1. A variable-impedance active ankle foot orthosis comprising an actuator for modulating an impedance of an orthotic joint throughout a walking cycle for treating an ankle foot gait pathology.

2. The device of claim 1, wherein the orthosis includes a torsional spring stiffness control.

3. The device of claim 1, wherein the orthosis includes a spring-damper positional control.

4. The device of claim 1, wherein the actuator is coupled to a foot portion of the orthosis.

5. The device of claim 1, wherein the actuator includes a series elastic actuator.

6. The device of claim 1, wherein the orthosis includes an ankle angle sensor.

7. The device of claim 1, wherein the orthosis includes one or more ground reaction force sensors.

8. The device of claim 1, wherein the orthosis includes an actuator, an ankle angle sensor, one or more ground reaction force sensors, and a controller for controlling the orthosis.

9. The device of claim 1, wherein the orthosis includes a foot switch.

10. The device of claim 1, wherein the orthosis is used to treat drop foot gait.

11. The device of claim 1, wherein the orthosis is used to treat a patient having anterior muscle weakness, posterior muscle weakness, or a combination thereof.

12. A device for treating an ankle foot gait pathology comprising:

an orthosis including a leg portion attachable to a leg of a person and a foot portion attachable to a foot of the person; and

an actuator attachable to the leg portion for acting on a spring disposed between the actuator and the foot portion.

13. The device of claim 12, wherein the actuator adjusts stiffness of the orthosis during controlled plantar flexion to minimize forefoot collisions with the ground.

14. The device of claim 12, wherein the actuator minimizes the impedance during late stance.

15. The device of claim 12, wherein the actuator applies a spring-damper positional control during a swing phase.

16. The device of claim 12, further comprising an ankle angle sensor.

17. The device of claim 12, further comprising one or more ground reaction force sensors.

18. The device of claim 12, further comprising a controller for controlling the orthosis.

19. A method comprising modulating an impedance of an orthotic joint of an orthosis throughout a walking cycle.

20. The method of claim 19, further including adjusting the stiffness of the orthotic joint during controlled plantar flexion to minimize forefoot collisions with the ground.

21. The method of claim 20, wherein the stiffness of the orthotic joint is adjusted by applying a biomimetic torsional spring control.

22. The method of claim 19, further comprising minimizing the impedance during late stance.

23. The method of claim 19, further comprising applying a torsional spring-damper positional control during a swing phase.

24. A method of treating an ankle foot gait pathology using functional electrical stimulation, comprising applying electrical pulses to elicit muscle contractions to actively modulate ankle impedance to achieve a torsional spring control during controlled plantar flexion so as to minimize forefoot collisions with the ground, minimizing impedance during late stance, and achieving a spring-damper positional control during a swing phase.

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