CLAIMS

1. A device for supporting a user, comprising:

a support interface;

one or more sensors disposed to sense forces exerted on the support interface; and

a linkage structure having a plurality of lower-pair joints and a plurality of linkages, the support interface being coupled to one of the plurality of linkages, each of the plurality of lower-pair joints coupling two of the plurality of linkages such that the linkage structure defines a closed kinematic chain, wherein a selected plurality of the lower-pair joints is a plurality of lockable lower-pair joints, each of the plurality of lockable lower-pair joints having a locally actuatable braking mechanism that is actuatable independently of any other of the plurality of lower-pair joints.

2. The device as recited in claim 1, wherein each of the plurality of lockable lower-pair joint is actuatable to lock respective pairs of the plurality of linkages relative to one other.

3. The device as recited in claim 1 or claim 2, wherein the linkage structure changes from being a compliant structure in one instant to being a rigid body in a next instant in response to the selected plurality of the lower-pair joints being actuated from an unlocked state to a locked state.

4. The device as recited in any one of claims 1 to 3, wherein two of the one or more force sensors are disposed spaced apart from each other along a lateral axis of the support interface, the lateral direction being transverse to a supporting direction defined as extending from the support interface toward the linkage structure.

5. The device as recited in any one of claims 1 to 4, wherein the locally actuatable braking mechanism comprises a pair of magnetically actuated friction members.

6. The device as recited in claim 5, wherein the lockable lower-pair joint comprises a gear box in engagement with the respective pair of magnetically actuated friction members, and wherein the gear box is configured to increase a braking torque between the respective pair of magnetically actuated friction members.

7. The device as recited in claim 6, wherein the braking torque is configurable by varying a gear ratio of the gear box.

8. The device as recited in any one of claims 1 to 7, wherein the support interface is coupled to the linkage structure such that the support interface is displaceable relative to the linkage structure in three Degrees-of-Freedom (DOF).

9. The device as recited in any one of claims 1 to 8, wherein the linkage structure comprises six lower-pair joints and six linkages, and wherein each of four of the six lower-pair joints are lockable lower-pair joint is lockable independently of any other of the six lower-pair joints.

10. The device as recited in any one of claims 1 to 9, wherein at least two of the plurality of lower-pair joints are prismatic joints.

11. The device as recited in any one of claims 1 to 10, wherein the support interface is configured to support a part of the hips of the user.

12. The device as recited in any one of claims 1 to 10, further comprising a harness coupled to the support interface, wherein the harness is wearable about at least a part of a torso of the user.

13. The device as recited in any one of the claims 1 to 12, further comprising a controller, the controller being configured to:

    determine if the forces sensed by the one or more sensors are indicative of an abnormality; and

    responsive to the abnormality being determined, locking the selected plurality of lockable lower-pair joints to provide a supporting force at the support interface.

14. The device as recited in claim 13, wherein the abnormality comprises any one or more of the following: (i) an average of the forces exceeds a first threshold; (ii) a difference between the forces sensed by two of the one or more sensors exceeds a second threshold; (iii) a change in the forces over a few time instants; and (iv) the magnitude of one or more of the forces exceeds a third threshold.

15. A balance-assistive system for use with a user, the balance-assistive system comprising:

    a support interface having a harness, the harness being wearable by the user;

    one or more sensors disposed to sense forces exerted on the support interface by the user;

a linkage structure having a plurality of lower-pair joints and a plurality of linkages, the support interface being coupled to one of the plurality of linkages, each of the plurality of lower-pair joints coupling two of the plurality of linkages such that the linkage structure defines a closed kinematic chain, wherein a selected plurality of the lower-pair joints is a plurality of lockable lower-pair joints, each of the plurality of lockable lower-pair joints having a locally actuatable braking mechanism that is actuatable independently of any other of the plurality of lower-pair joints;

a base, the linkage structure being coupled to the base; and

a controller, the controller being configured to lock the selected plurality of the lower-pair joints in response to determining an abnormality in the forces sensed, such that respective pairs of the plurality of linkages are locked relative to one another.

16. The balance-assistive system as recited in claim 15, wherein the controller is configured to stop any movement of the base in response to the abnormality being determined.

17. The balance-assistive system as recited in claim 15 or claim 16, wherein the abnormality comprises any one or more of the following: (i) an average of the forces exceeds a first threshold; (ii) a difference between the forces sensed by two of the one or more sensors exceeds a second threshold; (iii) a change in the forces over a few time instants; and (iv) the magnitude of one or more of the forces exceeds a third threshold.

18. The balance-assistive system as recited in any one of claims 15 to 17, wherein the controller is configured to monitor the forces sensed over a period of time with the linkage structure in a compliant state.

19. The balance-assistive system as recited in claim 18, wherein responsive to the selected plurality of the lower-pair joints being locked, the linkage structure is changed from the compliant state to a rigid body state in which a supporting force is provided to the user.

20. The balance-assistive system as recited in any one of claims 15 to 19, wherein the linkage structure comprises six lower-pair joints and six linkages, and wherein each of four of the six lower-pair joints is lockable lower-pair joint is lockable independently of any other of the six lower-pair joints.