CLAIMS

What is claimed is:

1. A device for human trunk assistance, comprising:

a trunk link (1), coupled to an upper back of a user through back straps (2);

two thigh links (3), coupled to left and right thighs of the user through leg straps (4) respectively;

two hip joint hinges (5), placed align to left and right hip joints of the user respectively, and configured for rotatably coupling the trunk link (1) and the two thigh links (3); and

a torque generator (6), coupling to the two hip joint hinges (5) through Bowden cables (7), and configured to generate an assist torque to reduce moment burden to the user, wherein the torque generator comprises:

a prime mover, comprising a motor (601) and a ball screw (602) fixed on a base plate (603), the base plate (603) being provided with a slide rail (605); and

a slider (604), connected to the ball screw (602) and movable along the slide rail (605) by the prime mover,

wherein the Bowden cables (7) are connected between the slider (604) and the hip joint hinges (5) to provide a resistance moment between the trunk link (1) and thigh links (3),

wherein the Bowden cables (7) comprise an outgoing Bowden cable (701) and a returning Bowden cable (702), and the torque generator (6) further comprises a first roller (606A) and a second roller (606B) installed on the slider (604); the outgoing Bowden cable (701) being wound on the first roller (606A) and its two ends respectively connect the two hip joint hinges (5), and the returning Bowden cable (702) being wound on the second roller (606 B) and its two ends also connect the two hip joint hinges (5) respectively.

2. The device as claimed in claim 1, wherein the trunk link (1) comprises:

two hip links (101), rotatably coupled with the two hip joint hinges (5), respectively;

two cable connectors (102), respectively fixed on the two hip links (101) and configured to connect the Bowden cables (7);

two upper hip links (104), rotatably coupled with the two hip links (101) respectively by upper hip hinges (103);

two waist links (105), respectively connect to the two upper hip links (104), then are fixed to a waist connector (106); and

a back link, an end of the back link being fixed on the waist connector (106), and the other end of the

back link being rotatably coupled with an upper back plate, and the upper back plate is configured for following a position change of an upper back of the user.

3. The device as claimed in claim 2, wherein each of the hip joint hinges (5) comprises:

a pulley (501), which is fixed with the thigh link (3) and rotatably coupled with the hip link (101);

a hinge support (502), rotatably coupled with the pulley (501) and connects the back straps (2); and

two end caps (503), configured to lock an axial position of the pulley (501).

4. The device as claimed in claim 3, wherein one end of the Bowden cable (7) is stuck in the pulley (501) and the other end connects the torque generator (6).

5. The device as claimed in any one of claims 1-4, wherein the torque generator (6) is attached to a waist position and drives the two hip joint hinges (5) by the Bowden cables (7).

6. The device as claimed in claim 5, wherein the torque generator (6) comprises:

a support plate (601),

two shaft bases (602A) and (602B), respectively fixed on two ends of the support plate (601);

two outer sliding plates (604A) and (604B), movably between the two shaft bases (602A) and (602B);

two inner sliding plates (605A) and (605B), movably between two outer sliding plates (604A) and (604B); and

a compression spring (606), attached between the inner sliding plates (605A) and (605B);

wherein one end of the Bowden cable (608A) is fixed to the outer sliding plate (604B) and the other end connects to one of the hip joint hinge (5), and one end of the Bowden cable (608B) is fixed to the outer sliding plate (604A) and the other end connects the other one of the hip joint hinge (5).

7. The device as claimed in claim 6, wherein the torque generator (6) further comprises:

two shafts (603A) and (603B), placed parallel to each other and are supported by the shaft bases (602A) and (602B); and

the two outer sliding plates (604A) and (604B) and the two inner sliding plates (605A) and (605B) are connected to the shafts (603A) and (603B) and are able to move smoothly along the shafts (603A) and (603B).

8. The device as claimed in claim 6, wherein the torque generator (6) further comprises:

a spring sleeve (607), fixed on a middle of the support plate (601) and is further configured to guide the compression spring (606).

9. The device as claimed in claim 6, wherein torque generator (6) further comprises:

elastic ropes (610), connected between the outer sliding plates (604A) and (604B) and fixed points

of the device, and configured to tension the Bowden cables (608A) and (608B).

10. The device as claimed in claim 6, wherein the outer sliding plates (604A) and (604B) are at preset initial positions when the user stands straight, and a distance between the outer sliding plates (604A) and (604B) is larger than an initial length of the compression spring (606).

11. The device as claimed in claim 6, wherein when the user raises one leg to a predetermined angle A, the compression spring (606) does not compress, where at the predetermined angle A, one of the outer sliding plates is pulled by the Bowden cable to contact with the corresponding inner sliding plate.

12. The device as claimed in claim 11, wherein when the user bends or squats and an angle between the trunk and thighs is reduced by less than or equal to A/2, the compression spring (606) does not compress, and when the user bends or squats and an angle between the trunk and thighs is reduced by more than A/2, the compression spring (606) is compressed and generates an assist torque at the hip joint hinges (5) to reduce moment burden of a waist joint of the user.

13. The device as claimed in any one of claims 1-4, wherein the torque generator (6) is installed on the trunk link (1) and drives both hip joint hinges (5) via the Bowden cables (7), and device further comprises a sensing and control box (8), and the sensing and control box (8) is also installed on the trunk link (1) and provides control signal and energy to the torque generator (6).

14. The device as claimed in any one of claims 1 to 13, wherein the slider (604) is configured to move backward and pull the outgoing Bowden cable (701) by the motor (601).

15. The device as claimed in claim 13, wherein the torque generator (6) comprises:

a base plate (603);

a slide rail (605), fixed on the base plate (603); and

a prime pulley (614), coupled with the motor (601);

wherein the motor (601) drives the prime pulley (614) to pull the Bowden cables (7) to drive the slider (604) moving backward.

16. The device as claimed in claim 15, wherein the prime pulley (614) comprises an inner ring (614-1) and an outer ring (614-2), a plurality of elastic elements are arranged between the inner ring (614-1) and the outer ring (614-2) and configured to measure an angle shift between the inner ring (614-1) and the outer ring (614-2).

17. The device as claimed in any one of claims 1 to 15, wherein the prime mover comprises a hydraulic cylinder, or a pneumatic cylinder.

18. The device as claimed in claim 13, wherein the sensing and control box (8) is configured to

monitor a motion condition of the user and a force on the Bowden cables (7) to send a control signal to the torque generator (6) to tension the Bowden cables (7) in a working condition, and to ensure the force of the Bowden cables (7) are zero in a non-working condition.