

Paper:

Development of an Active Walker and its Effect

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In Japan alone, more than one million people have walking difficulties. The many kinds of walker being developed thus far for gait training are used by grasping the front and/or back in order to balance the body. This requires tilting the upper half of the body forward or backward, making it difficult to keep the right posture for walking. There are moreover few examples of an active walker that is used if people have no muscular strength for walking. In order to deal with these issues, we have been developing an active walker using the Hart Walker which consists of a double upright knee-ankle-foot orthosis and a 4-wheeled carriage with a stem located in the center of the carriage. Since the waist of the orthosis is attached to the top of the stem, there is no risk of falling, it is possible to keep the right posture, and both hands become completely free. McKibben artificial muscles are attached to the Hart Walker in order to control the gait as an active walker. In walking experiments using a child-size doll with the same kinds of joints and weight that a human child has, we confirmed that a human-like gait is realized by the active walker we developed. Many patients who have different kinds of disease are using it and we have confirmed that all of them can walk by using the active walker. The active walker is now commercially available.

Keywords: active walker, gait disorder, hart walker, McKibben artificial muscle

1. Introduction

In Japan alone, more than one million people have gait disorders. Many kinds of walker being developed thus far for gait training and/or supporting walking motion however, are used by grasping the front (**Fig. 1(a)**) or back of the walker in order to balance the body. This requires tilting the upper half body forward or backward, making it difficult to keep the right posture for walking. To avoid falling and to decrease load, underwater gait training (**Fig. 1(b)**) and/or a hanging treadmill (**Fig. (c)**) are applied, but these are expensive and require a special facility. There are moreover few examples of an active walker

that is used if people have no muscular strength for walking. The Locomat [1] made by ETH and the robotics stepper made by NASA and UCLA [2] are good and only examples of an active walker that consists of a treadmill and a manipulator attached to the body. Although they are very sophisticated, they are very expensive and cannot be used in daily life. Although wheel chairs are normally used for people who have gait disorders, it leads to disuse syndrome (amyotrophica, or progressive muscle waste), arthrogryposis (permanently contracted joints), and impediments of the circulatory system and keeping upright and walking are therefore very crucial indeed.

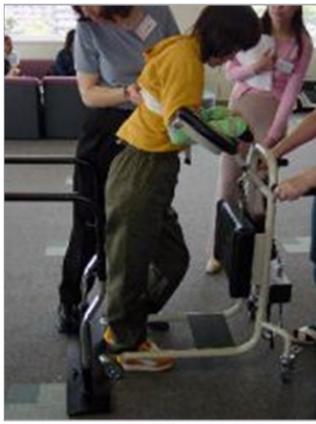
We have been developing an active walker using the Hart Walker (**Fig. 2**) which consists of a double upright knee-ankle-foot orthosis and a 4-wheeled carriage with a stem located in the center of the carriage [3]. Since the waist of the orthosis is attached to the top of the stem, there is no risk of falling, it is possible to keep the right posture and both hands become completely free. When the McKibben artificial muscle is applied to make the Hart Walker an active walker, people can walk like a healthy human gait even if they have no muscular strength at all. The active walker is simple, inexpensive and able to be used in daily life

In this paper, we first introduce the structure and the system of the active walker. To realize a healthy human gait using the active walker, we analyze the human gait and acquire the ideal gait pattern for the active walker. Sequential control is applied to implement a healthy human gait and we have found that our method is feasible and very flexible in weight and height change in experiments using a doll that has the same kinds of joints and weight that a human being has. A clinical test has also been undertaken and we have clarified that all kinds of patients have applied the active walker and have succeeded in walking.

2. Structure of the Active Walker

2.1. Hart Walker

The Hart Walker shown in **Fig. 2** was developed in 1989 in England for mainly applying in infantile paraly-



(a) Walker



(b) Underwater gait training



(c) Hanging type treadmill

Fig. 1. Walker and/or gait training system.

sis. Over 5000 children are using it all over the world and more than 250 ones use it in Japan. It consists of a knee-ankle-foot orthosis and a carriage. The greatest advantage of the Hart Walker is that the user's hands become free and the user can keep the right posture without any risk of falling. The load on the leg is controllable by modifying the height of connection point between the stem and knee-ankle-foot orthosis. It is very easy moreover to adjust the length of frames to the body.

In order to measure angles for hip and knee joints, we utilize the potentiometers described in Fig. 3.

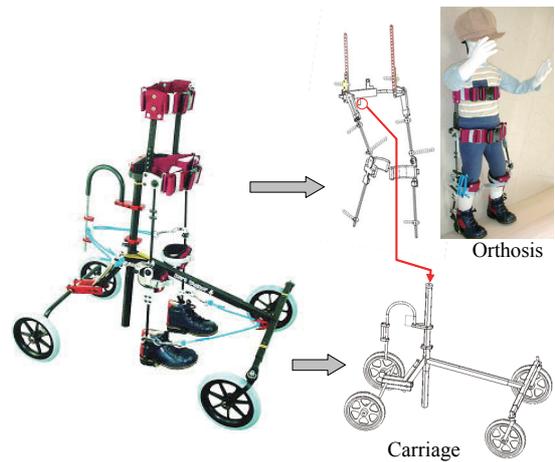


Fig. 2. Hart walker.

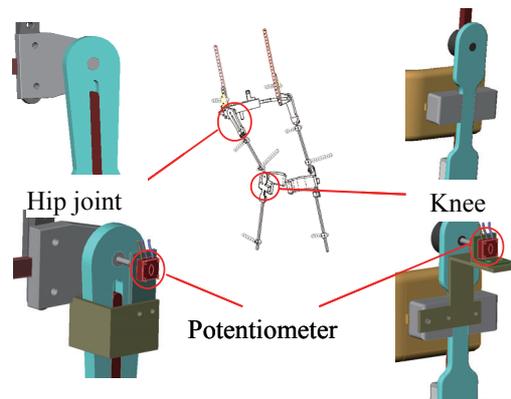


Fig. 3. Position of potentiometer.

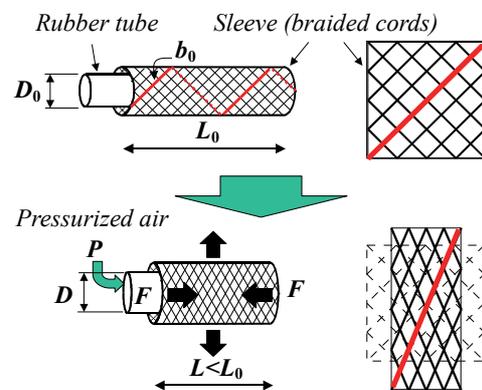


Fig. 4. Structure of McKibben artificial muscle.

2.2. McKibben Artificial Muscle

The McKibben artificial muscle consists of an internal bladder surrounded by a braided mesh shell with flexible yet nonextensible threads that is attached at either end to fittings. As shown in Fig. 4, when the internal bladder is pressurized, the highly pressurized air pushes against its inner surface and against the external shell, increasing its volume. Due to the nonextensibility of the threads in the braided mesh shell, the actuator is shortened according to its volume increase and/or produces a load if it is coupled to a mechanical load. Contractive force depends basically