A Step Machine for Elderly Osteoarthritis Patients

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Abstract— **This step machine was specifically designed for the elderly who suffered from symptoms of advanced knee osteoarthritis with joint movement difficulties and leg muscle weakness. We built a special step machine which strengthens leg muscles via climbing exercise while requiring minimal range of knee motion hence improving the recovery of knee joint[1] movement with comfort. The patient can obtain the condition of the movement information and the physical ability from a LCD (Liquid Crystal Display) touch panel, so that he or she can manage for the optimal advantages from the exercise. The structure of this step machine uses the footboard which forces on the gear to the unidirectional bearing and the connecting rod, and finally leads to the wheel revolution. The movement data are monitored by torsion and revolution sensory devices, and such data will then be processed by the microprocessor system, and then output on the LCD. Lastly, the touch-control LCD panel allows the users to programme not only the pedalling–resistance but also the movement of single or both feet on demand, easily and interactively. To sum, this machine endows the osteoarthritis patient with full control of his or her recovery course via interactive interface, whereas the machine's mechanism would ensure user's maximum comfort and recuperating result.**

Key words: osteoarthritis, stepper, step machine, health care

I. INTRODUCTION

Osteoarthritis is the most prevalent form of arthritis among elderly over the age of 65, it is estimated that 10% of men and 21% of women have osteoarthritis in the knee joint, in the hip joint or in both joints[1-2]. Symptoms usually can be reduced by some rehabilitating movements to improve mobility and ease pain. Using a stationary bike, step exerciser or peddler that promotes leg stretching movement are some of the best ways to improve the mobility. [3-5]

Since most stepper fitness equipments in the market are provided to the young and athletic users [6], these equipments are not suitable for elderly with feeble knees that are less tolerate to big knee impacts [7]. Therefore a slowly up and down vertical trajectory step exerciser will provide fitness effects to the silver-haired with comfortable and relaxing movement. Our step machine consists of footboard, gear, unidirectional bearing as well as the connecting rod which leads to the electronic resistance control. Which adapts different user's strength demand on foot pedal resistance simultaneously via torsion and revolution sensory devices; the detected data are then passed to the microprocessor system, and then output the exercise information and the calorie consumption to the liquid-crystal display (LCD) that allows the user to monitor

the fitness performance. Moreover, the use of superb computerization means that multi-users can specify and store personalized preference and individual profile simultaneously via the touch panel screen to track record their own individual progressive fitness condition. [8]

II. METHODS

A. Mechanism structure of the step exerciser

The mechanism structure of this step machine relies on the footboard which force on the gear to the unidirectional bearing and the connecting rod, and leading to the wheel revolution. This wheel will determine the degree of torsion via an electronic break system. What makes this step machine different from others is the special function that allows the user to use in sole side or in both sides of the foot pedals. The user may, depend on his or her health condition and physical strength, choose to adopt single foot movement or the both feet movement. Furthermore, no matter the length of peddling stroke may be, it will let the silver-haired users with deferring knee conditions to carry on the fitness exercises. The mechanism structure of the step machine is shown in Figure 1. The single foot movement and the both feet movement is shown in Figure 2.
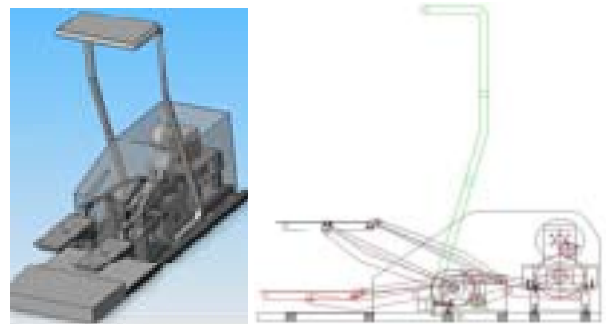

Fig. 1 The mechanism structure of the step machine

Fig.2 The single foot and the both feet movement

B. Functions

The athletic situation which recorded by torsion sensory and revolution sensory devices are processed by the microprocessor system and finally displayed on the LCD. Moreover, utilizing a touch panel, the elderly user could easily adjust the resistance of the foot pedal on his or her demand. The structure of microcomputer is shown in Figure3. With all conditions of the movement and the physical information clearly shown to the users, they are better off to exercise with best possible optimal results. This computer system may simultaneously store up to 12 different users' data, meaning no need to program the machine each time when another patient take turns. The individual user's record and the health improvement condition (i.e. ideal foot pedal resistance for someone's knee joint) will all be stored up in the computer and displayed in friendly graphic interface. The user selects his own personal profile shown in Figure 3. All stored profiles are shown for selection as shown in Figure 4. The exercise condition screen consists of interval, calorie consumption, pedal resistance, overall personal fitness progressive record, as illustrated in Figure 5.
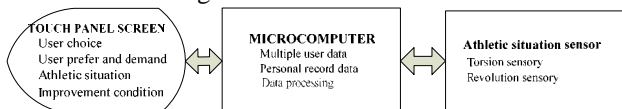

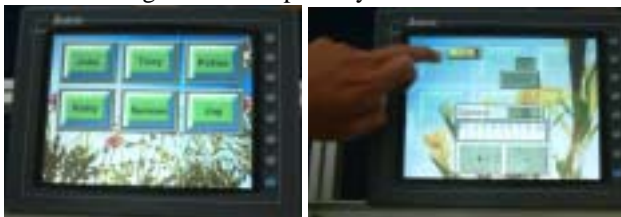Fig. 3 The computer system structure

Fig. 4 Touch panel and personal profile selection

Fig. 5 The exercise condition and health improvement

III. RESULTS AND DISCUSSION

We have applied this step machine for 24 elderly patients (range from age 65 to 85) with some joint symptoms, the group comprised 8 males and 16 females, with average age 73 and 75, respectively. All of them have osteoarthritis symptoms such as knee joint movement difficulties, and leg muscle weakness. It is difficult to identify objective parameters for assessing joint function when the degenerative joint disease generally followed a slowly progressive exercise. Therefore this experiment was carried for a period of 3-month, with the following result. 7 patients (29%) reported significant reduce of osteoarthritis pain. 8 patients

(33%) reports some degree of reduction of the pain, while 6 (25%) asserts no changes after using this machine, and 3 (12.5%) reject the use of this machine after one month. In terms of the adaptation of peddling resistance, 6 patients (25%) used 75% resistance, 7 patients (29%) are using up to 50% of the resistance force; and 8 patients(33%) were using only 30% of the resistance. Lastly, on the fitness of the feet movement, 9 patients (38%) were adopting both feet movement with full stroke, whereas 12 patients(?%) used only single feet movement and some degree of the peddling stoke.

Therefore, we may conclude that although this step machine may not be functioning well for all elderly osteoarthritis patients, but at least half of our experience subjects are reporting some significant help and advantage from using this machine in a way that this machine is providing a gentle and comfortable exercise for reducing Osteoarthritis pain.

IV. CONCLUSION

This step machine facilitates a smooth and comfortable experience, which allows for single or dual feet movement, varied foot stroke length and stroke resistance, suitable for elderly Osteoarthritis patients' exercise and therapy for reducing pain and progressive fitness condition. The user-friendly interface not only records their fitness and exercise data individually, but also as a mean to indicate their achievement that encourages further implementation of their exercise and therapy. With our continual development and improvement, we look forward to commercialize this product to help the aging society.

REFERENCES

[1] Z. Bejek, R. Paróczai, Á. Illyés,L. Kocsis, R. Kiss,"Gait Parameters of Patients with Osteoarthritis the Knee Join", Physical Education and Sport Vol. 4, No 1, 2006, pp.9-16.

[2] Al-Zahrani, K.S., & Bakheit, A.M. (2002). A study of gait characteristic of patients with chronic osteoarthritis of the knee. Disabil Rehabil .,24, 275-280

[3] M. Xiao, J. Higginson,"Simulation Study of Walking Patterns with Knee Osteoarthritis using OpenSim", American Society of biomechanics, 2007 Annual Meeting.

[4] Fregly, B. J., Reinbolt, J. A., Rooney, K. L., Mitchell, K. H., "Design of Patient-Specific Gait Modifications for Knee Osteoarthritis Rehabilitation", Biomedical Engineering, IEEE Transactions on. Vol.54, Iss.10, Oct. 2007 pp:1905 -1905

[5] Thambyah, A., Goh, J., Bose, K.,"Contact stresses in the knee during walking and squatting",Engineering in Medicine and Biology Society, 2000 Proceedings of the 22nd Annual International Conference of the IEEE,Vol.4, July 2000 pp.2897 – 2898.

[6] J. Shyu, Y. Kuo," On the Review and Analysis of StepExercisers".

[7] G. Chen, S.A. Kautza,E. Zajaca, "Simulation analysis of muscle activity changes with altered body-orientations duringpedaling", Journal of Biomechanics 34 (2001) 749–756

[8] Chia-Nan Ko, Tsong-Li Lee, Han-Tai Fan, and Chia-Ju Wu, "Genetic Auto-Tuning and Rule Reduction of Fuzzy PID Controllers", 2006 IEEE International Conference on Systems, Man, and Cybernetics, SMC2006, Taipei, October 2006.G. O.