INVESTIGATING THE BIOMECHANICS OF SWING MOTION

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Introduction

Swing motion has a potential for exercise, and particularly rehabilitation, due to the involvement of neuromuscular function during the movement without the need of supporting the subject's weight through the limbs. An in-depth understanding of the biomechanics of swing motion is needed to objectively assess the effects of this therapy. The physics of swing motion using simple mathematical models has previously been studied by other authors [1]. The aim of the current work is to develop a multi-segment biomechanical model for the computational analysis of the swing motion dynamics. A prototype mechanical swing has been developed and, as a first step, the physiological response to exercise using the swing in a sample of healthy subjects has been measured. This paper presents preliminary findings.

Methods

The prototype swing (Figure 1) has been designed for use in a movement analysis laboratory. It is self-supporting and stable without ground fixings. The swing may be used by both children and adults. A unique feature of the swing is that a variable resistor is linked to the main pivot shaft, such that a constant angle of swing can be maintained during active swinging. A US patent has been granted and the European patent is pending [2]. This feature increases the intensity of the aerobic exercise. It also enables steady state kinematic measurement of active swinging to be undertaken. The prototype employs a fluid resistor. The damping characteristic of the resistor was evaluated from drop tests using standard weights. The physiological response to exercise on the swing was measured using a cohort of twelve healthy male volunteers (age 23.4 ± 4.1 years, height 179 ± 5 cm). Physiological measures included heart rate, VO2, Rate of Perceived Exertion (RPE), and blood lactate levels. Sample video recordings were made for each of the participants for qualitative analysis.

Results

Rapid damping is achieved when the fluid resistor is employed. The damping characteristic is exponential such that the drop in swing angle per cycle is greater at higher swing angles. Without resistance, the swing amplitude reduces much more slowly due to air resistance and a small amount of mechanical friction. Figure 2 shows the result when using a 30 kg mass at the swing seat. Correspondingly, a significant increase in all four of the physiological measures was noted when maintaining a seventy degree swing amplitude against resistance as compared with maintaining the same angle without resistance. This observation was consistent across all participants. However, it was noted from the qualitative assessment that there was significant inter-subject variability in respect of body movement and swinging technique. Timing of body movement was observed to be an important determinant of swing efficiency.

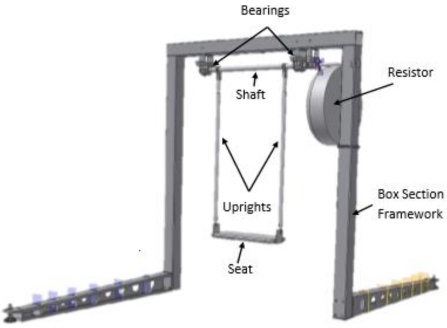

Figure 1: General assembly of the prototype swing (Front left and rear right feet omitted for clarity).

Discussion

The study has demonstrated the potential of the device to provide a means of body mass supported exercise and maintenance of aerobic fitness for adults. The damping characteristics of a fluid resistor are well suited to the application. It is anticipated that the multi-segment biomechanical model will provide quantitative data on the main joint movements, and enable the determinants of swing efficiency and the inter-subject variability to be assessed and quantified in detail. This will inform further development of the swing and will enable specific rehabilitation applications to be identified.

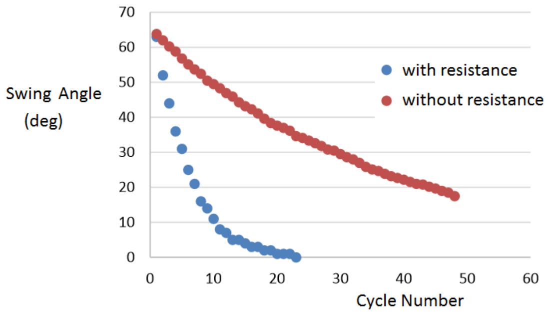

Figure 2: Typical drop test result .

References

1. S.O. Linge, Computer Methods in Biomechanics and Biomedical Engineering, 15:1103-1109, 2012
2. W. Thomson, U.S. Patent No 9,486,661 B2, European Patent Application No. 11726474.7