JOINT POWER AND ITS RELATIONSHIP TO THE FATIGUE OF HUMAN BODY DURING VERTICAL JUMPS

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In this study, the joint power and its relationship to levels of fatigue in the human body during vertical jumps was examined. The jumping movements, which were performed before and after a 30-second period of pedaling on a Monark bicycle ergometer, were video recorded. The video materials were then analyzed on a motion analysis system. The ground reaction force during jump was measured by a force platform. The joint power was calculated using the data from the above systems. The two groups of data were compared. The variation of joint power at each joint was computed and a quantitative description of the resulting fatigue was obtained.

KEY WORDS: joint power, fatigue, vertical jump

INTRODUCTION: Joint power can be used to describe the physical work capacity of different parts in a human body (Ito & Togashi, 1997; Kaneko, 1994). This quantity must be in close relationship with levels of fatigue in the human body. This relationship requires a quantitative description. To this end, two groups of athletes performing vertical jumps, were examined before and after a 30-second period of pedaling on a Monark bicycle ergometer (Shibukawa, 1969; Banister, Mekjavic, Asmundson, & Ward, 1990). After pedaling with maximal efforts, the subjects were evidently suffering from fatigue. Subsequently, by computing the variation of the joint power at each joint, a quantitative description of the levels of fatigue was obtained.

METHODS: Six subjects (three males and three females) participated in this study. Each subject performed vertical jumps, before and after pedaling on a bicycle ergometer (Monark-834E) for 30 seconds with maximal efforts. The load used was adjusted to 0.075kg per one kg of the body weight. The jumping movements were videotaped with a video camera positioned laterally on the left side of the subject with the lens axis perpendicular to subject's motion plane. The distance of the camera to the motion plane was 6 meters. The calibrated sampling rate of pictures recorded was 60 frames/s. The video material of the takeoff movement was analyzed on a motion analysis system to provide quantitative kinematic data. The ground reaction force was recorded by a force platform with the same sampling frequency as that of the picture sampling.
With the data obtained in this manner, the dynamical analysis could be carried out and the

joint power at each joint was computed for a simplified segmental model (Winter, 1979). The x and y coordinates of the segmental markers on the body were obtained. According to the symmetry in the movements, only the segmental markers on the left side were digitized. The ankle, knee and hip angles were defined as in Figure 1. Zatsiorsky segment parameters were used in the dynamical calculations (Zatsiorsky, Aruin, Seluyanov, 1981).
The segmental pictures with forces and moments on each joint were shown in Figure 2. The dynamical equations of motion could be calculated following the standard format. The joint power was defined as the product of the moment at the joint and the corresponding angular velocity.
The data obtained from the calculation were treated by a digital filter with the value of the cut-off frequency of 8.

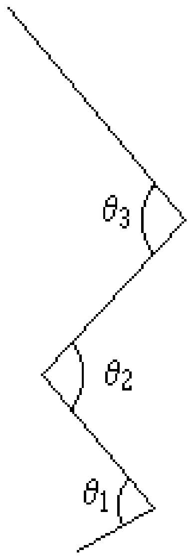

Figure 1 - Segments of the body model and the definition of the joint angles.

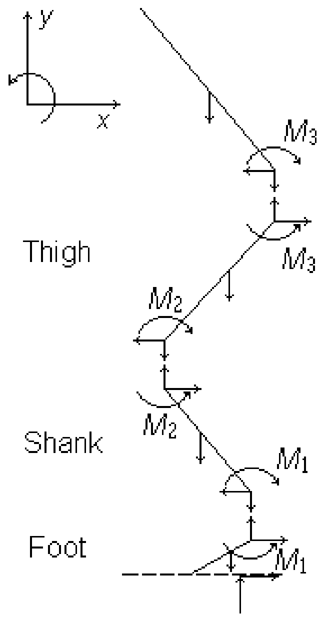

Figure 2 - Free body diagram.

RESULTS: The movement that occurred one second before the feet left the ground was observed. This was divided into two parts with the minimum point of the vertical displacement curve of the C.G. defined as the turning point. The joint power curves for one of the female subjects in the two jumps before and after pedaling on a bicycle ergometer are shown in Figure 3 and Figure 4 respectively. In the first section, the joint power was mainly negative. In the second section, all the joint power was positive. The maximum value of all joint power curves appeared near the end of the second section. No significant differences in the maximum values were observed for the joint power at the ankle and hip in the two jumps. However, a large decrease in the knee joint power was noted from the comparison of the curves in the two figures. After pedaling on the bicycle, the decrement in the maximum knee joint power was more than 50%. The joint power curves for the male subjects in the two jumps were quite similar to the ones in Figure 3 and Figure 4 except for some numerical differences.

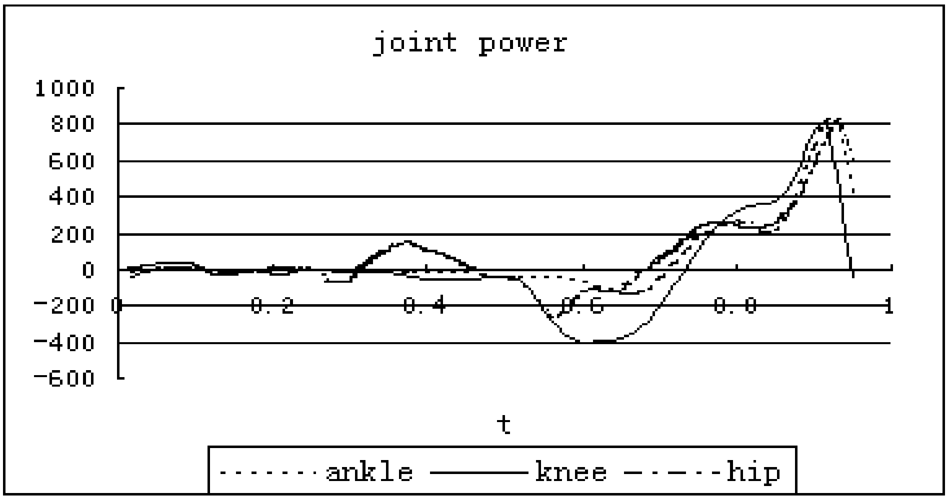

Figure 3 - The joint power before fatigue.

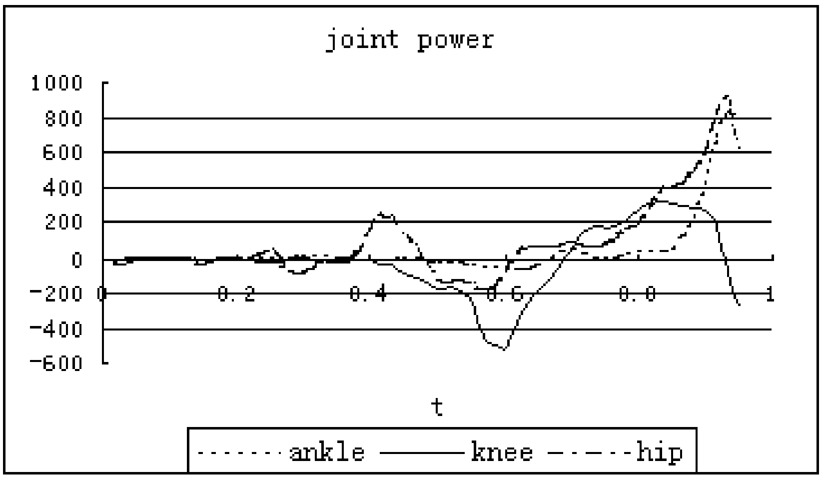

Figure 4 - The joint power after fatigue.

DISCUSSION: Joint power represents the ability for exertion on different parts in a human body. The decrease of this ability could be reflected in the levels of fatigue in the human body. From the above results, it was determined that the joint power at different joints had quite a different relationship to the levels of fatigue in the human body. In the vertical jumps that were considered in this work, the fatigue was predominantly represented by the decrease of the knee joint power in the second section of the jump. However, the changes in the ankle joint power should also be noted. Although the maximum amount remained unchanged for the two jumps, the area under the ankle joint power curve in the second section in Figure 4, significantly decreased. This indicated that the exertion output at this joint decreased by a significant amount. Conversely, this was not a common occurrence among the subjects. The changes of the joint power at the hip joints were much smaller when compared with that of the knee joint power.

CONCLUSION: This study provided a quantitative description of the joint power in vertical jumps. The data showed that the level of fatigue was illustrated by the decrease in the knee joint power whereas the changes in the joint power at the other two joints were much smaller.

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