CONTRAST OF METHODS FOR CALCULATING INTERNAL WORK OF RUNNING FOR TRAINED AND UNTRAINED RUNNERS

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INTRODUCTION

In running events, there is often a very slight margin of victory. The question is—was the victorious athlete better endowed or was he/she more efficient? Historically, there are two routes to calculating mechanical work, they are the energy approach (Wells, 1988) and the power approach (Elftman, 1939). The energy approach uses segmental energies calculated from kinematic data; whereas, the power approach uses force plate data and inverse dynamics to determine work. The energy approach is referred to here as the absolute work approach. A recently developed approach to calculate work is to use absolute power.

Theoretically each runner does the same amount of external work. Therefore, one way to distinguish the efficiency is to measure the amount of internal work done. Winter (1978) defined internal work as the work required to move the body segments through a cyclic movement. The absolute power equation sums the absolute value of the powers produced at each joint and then sums them across the number of samples and subtracts the external work. This approach was validated mathematically by Aleshinsky (1986) and studied by Chapman et al. (1987).

The purpose of this study was to test whether the absolute power method was sensitive enough to distinguish the difference in the internal work done by trained and untrained runners. A secondary purpose was to contrast the absolute work and the absolute power approaches for measuring the internal work of running in trained and untrained runners.

METHODOLOGY

Five trained female varsity level middle distance runners and five female untrained runners were chosen for the study. After informed consent and warmup, each subject was asked to run at a submaximal running speed along a 30 metre platform several times. The subjects were filmed at 100 frames per second and force plate data were collected at 250 hertz. The forces were collected on a microcomputer equipped with A/D converters. Five trials from each subject were analysed. Inverse dynamic equations were use to calculate moments of force and powers at each joint. Internal work was then calculated using both the absolute work and absolute power equations.

Internal Work Equations

1) **Absolute Work Approach** (Winter, 1979)

$$W_{wb} = \left(\sum_{k=1}^{N} |\Delta E_{b_k}| \right) - W_{ext}$$

where W_{wb} is the total internal work done over N sample periods, ΔE_{bk} is the change in total body energy during the k^{th} sample period and W_{ext} is the total external work done over N sample periods.

2) **Absolute Power Approach** (Chapman, 1987)

$$W_i = \left(\sum_{k=1}^{N} \sum_{j=1}^{J} |M_{j_k} \omega_{j_k}| \Delta t \right) - W'_{ext}$$

where W_i is the total internal work done over N sample periods for J joints, M is the joint moment and ω is the angular velocity of the joint and W'_{ext} is the total external work done over N sample periods calculated using trapezoidal integration.

RESULTS AND DISCUSSION

Figure 1 shows typical joint power results for a female trained runner. Positive values indicate concentric work, while negative values indicate eccentric work. It must be noted that in the absolute power approach, the absolute values of the powers are summed, not the positive and negative values. The velocities of the runners averaged 6 m/s. There was no significant difference between velocities of trained runners and untrained runners.

The most interesting result of this study was that the absolute work method averaged values three times more than the absolute power method for both groups. For example, the subject portrayed in figure 1 had average internal work results of 3.97 J/(kg·m/s) and 1.37 J/(kg·m/s), for the absolute work and absolute power methods, respectively, over 5 trials. This is opposite to what Chapman et al. (1986) found in his study. It must be noted, however, that Chapman et al.'s (1986) study only had one subject and the velocity of running was not known and thus may not be comparable.

Another interesting result was the large variability seen in the absolute work values for both trained and untrained runners. The absolute power values did not show this variability. This indicates that the absolute power method is a more reliable method than the absolute work method. It would have been plausible to hypothesis that more variability existed in the untrained runners compared to the trained runners, however, this situation did not exist in the present set of subjects.

The results did not indicate a significant difference, for the absolute power method, between the two groups of runners. This means that unfatigued trained running and unfatigued untrained running styles are not that different in terms of internal work done.

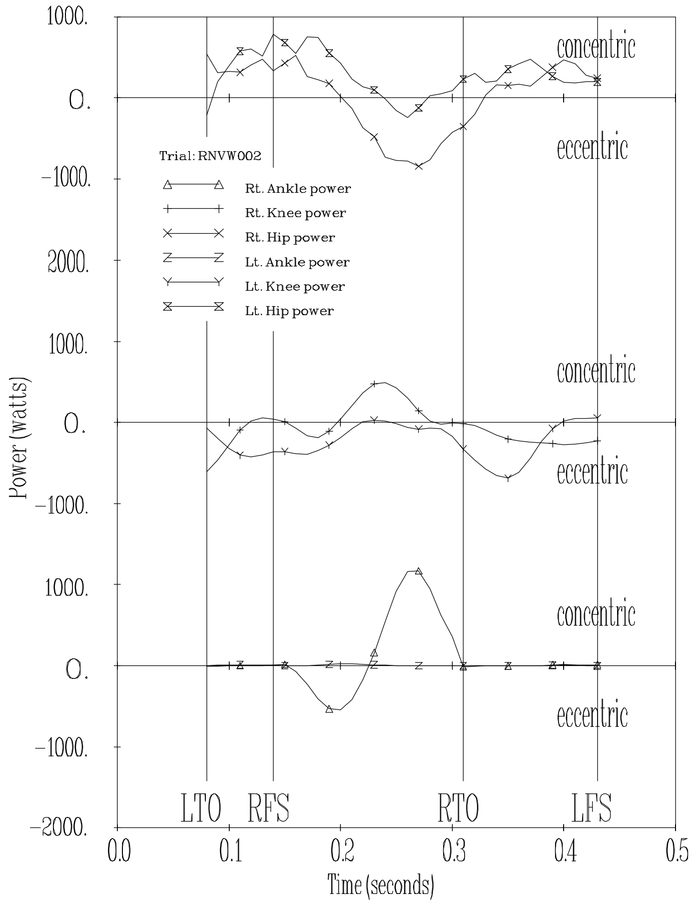

Figure 1: Powers of the hip, knee and ankle moments of force.

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