THE MOVEMENT COORDINATION OF RUNNING AFTER BIKE-RUN-TRANSITIO IN TRIATHLON

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The purpose of this study is to assess single kinematical parameters as well as the coordination of the running movement after prior cycling exercise. Ten male subjects (five triathletes and five sports students) completed a combined cycling-running-exercise. A two-dimensional-analysis was carried out for the running movement on a treadmill. Single kinematical parameters showed no interindividual consistent changes. The results of the order parameter analysis revealed a decrease in the variability of the movement coordination immediately after the cycling exercise. The triathletes are more capable of maintaining this movement variability during the running exercise than the sports students and moreover show a more individual running style.

KEY WORDS: triathlon, kinematics, running, synergetics.

INTRODUCTION: Triathlon is a "recent" sport that involves a succession of the three most popular endurance sports swimming, cycling and running. The total performance in triathlon not only results from the summation of the three individual performances but also from the accomplishment of the transitions and the compensation of the previous exercise. The bike-run-transition seems to be the most uncomfortable part of a triathlon. Competitors report difficulties in finding the "normal rhythm of running" shortly after cycling. Witt (1994) found that on the one hand, the same muscle groups are active for the cycling and running movement but on the other hand, the working conditions are different. Considering the kinematical parameters, Gohlitz et al. (1994) showed a decrease in step frequencies immediately after prior cycling exercise. Contrary results were shown in the study of Hausswirth et al. (1997). No changes in step frequency and step length were reported by Hue et al. (1998). Probably cycling with high cadences may cause changes in step length and step frequency (Gottschall & Palmer, 2002).
The purpose of the study is to assess not only single kinematical parameters of the running movement after prior cycling exercise but also the coordination of the running movement as a whole.

METHODS: The ten male subjects were divided into two groups. The first group consisted of five experienced triathletes, whereas five sports students without prior triathlon experience volunteered for the second group. The tests were realized on a treadmill, immediately after the participants had completed the 20km (sports students) and 40km (triathletes) bike protocol on their own race bikes, mounted on a stationary ergometer. A two-dimensional motion analysis was conducted, in which the joint markers of both lower extremities, the upper body, the left arm and the head were digitised. Twenty consecutive movement cycles were considered 30s, 2min, 4min and 7min after the bike-run-transition. For determination of the movement coordination the following methods were used:

* Time series analysis of horizontal hip velocity,
* Karhunen-Loève (KL)-decomposition for determination of the number of order parameters (Witte, 2002),
* Drawing of the phase plots to characterise the dynamics of the order parameter by using a synergetic approach (Witte, 2002).

RESULTS AND DISCUSSION: The following single kinematical parameters were considered: upper body incline, maximum knee angle, minimum knee angle and maximum hip height. Significant differences between running without prior exercise and running immediately after cycling exercise could be found in some cases only. Furthermore, the changes were not interindividual consistent. Hence, further researches refer to movement coordination.

To determine the variability of the running movement the time series of the horizontal hip velocity were evaluated with the aid of descriptive statistics. For the coefficient of variability (Figure 1) it is obvious that the movement coordination of running without prior exercise (PreRun) is more stable than running immediately after cycling exercise (Run1) for most subjects. The difference of the coefficient of variability between PreRun and Run1 is higher for the sports students (Figure 1, right) than for the triathletes (Figure 1, left).

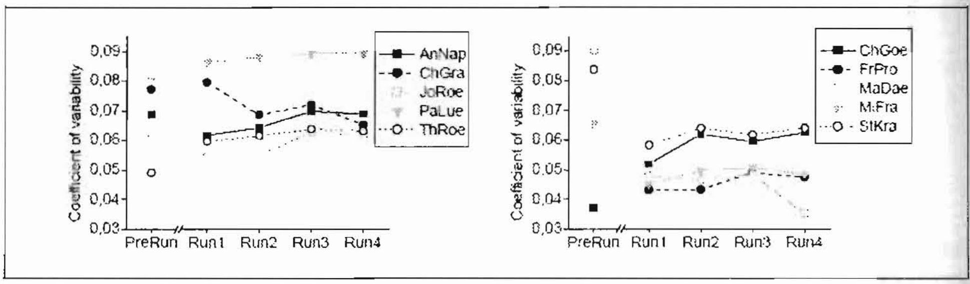

Figure 1: Coefficient of variability of the horizontal hip velocity for the triathletes group (left) and the sports students group (right).

Taking a synergetic approach into account (Haken, 1996), assuming that movement coordination is the result of self-organization-processes, the determination of the order parameters is the main problem. One method is the Karhunen-Loève (KL)-decomposition. Well-learned and automated movements show a predominance of the first KL-mode (Haas, 1995, Witte, 2002). One can further assume that these movements may be characterised by a single order parameter.
The results for the running movement with and without prior exercise support the above mentioned declarations. The consideration of the first three KL-modes is sufficient to describe the running movement (Figure 2). The dominance of the first KL-mode is evident. A slight decrease in the eigenvalue of the first KL-mode with increasing running distance is obvious for the majority of the subjects. Thus, a slight change in movement coordination can be assumed due to the progressive running exercise.

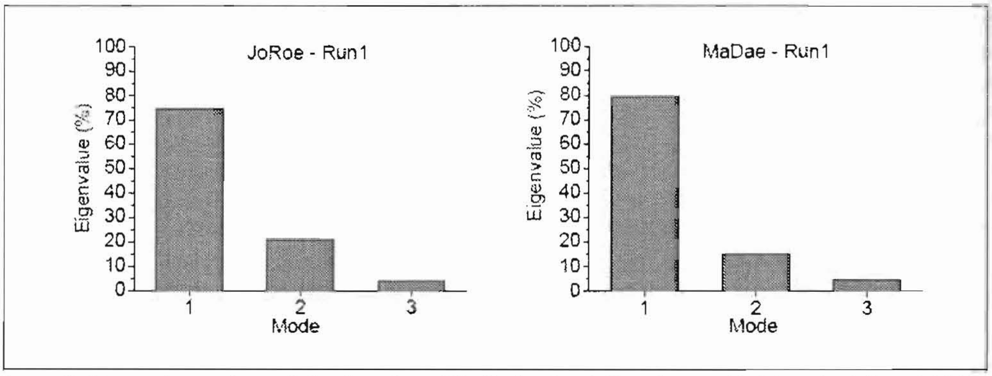

Figure 2: Mean eigenvalues of the first three KL-Modes for JoRoe (group triathletes) - left and MaDae (group sports students) - right.

In relation to the first KL-mode the eigenvalues of the second KL-mode are higher for the triathletes than for the sports students (Figure 3). It can be assumed that the second KL-mode characterises the individual style of the running movement and is therefore more distinct for the experienced triathletes than for the sports students.

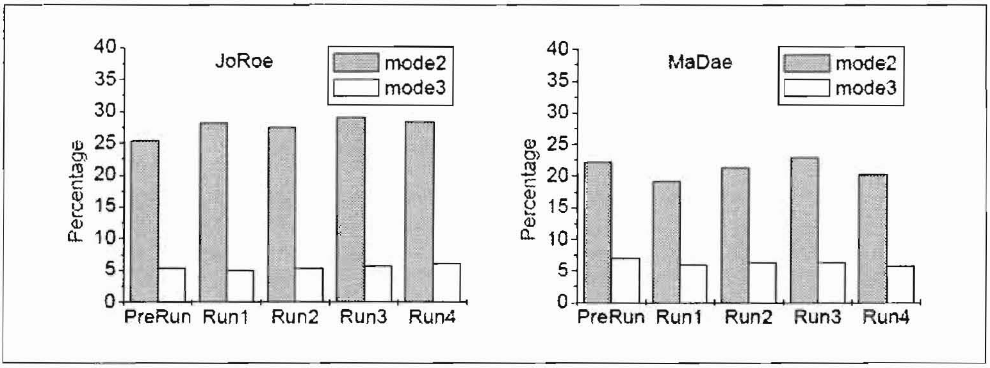

Figure 3: Percentage of second and third KL-mode in relation to first KL-mode for JoRoe (group triathletes) - left and MaDae (group sports students) - right.

The order parameter can be determined by means of the KL-decomposition. By calculating the temporal derivation phase plots can be constructed (Figure 4).

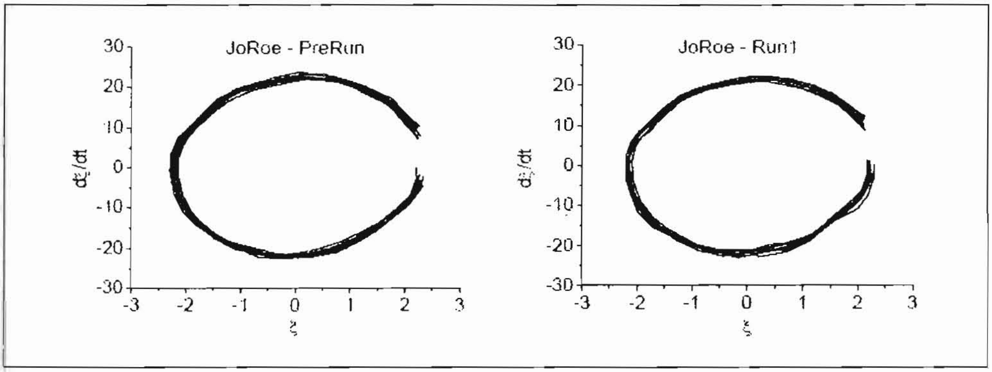

Figure 4: Phase plots of JoRoe (PreRun) and (Run1).

As expected the phase plots show appearances known from running (Witte, 2002). No distinct differences are noticeable during the running exercise. In order to assess the variability of the movement coordination the mean ranges of the order parameter were calculated (Figure 5). It is obvious that the variability of the movement coordination decreases immediately after the cycling exercise and in the further duration of the running leg. The results correspond to those obtained for the variability of the horizontal hip velocity.

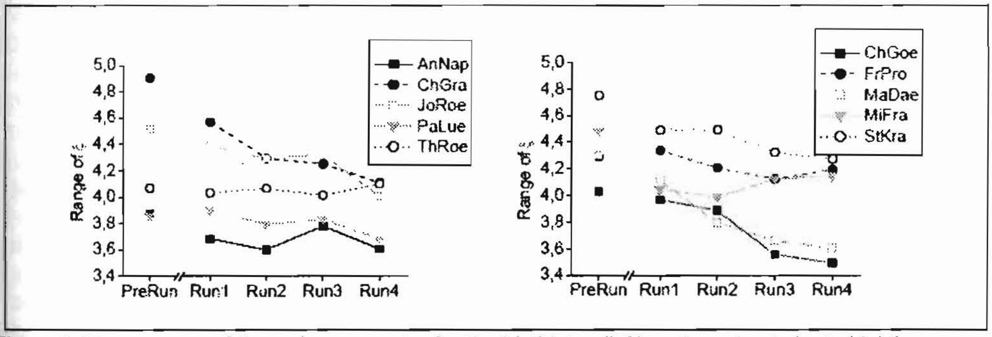

Figure 5: Mean ranges of the order parameter for the triathletes (left) and sports students (right).

CONCLUSION: Changes in single kinematical parameters of running immediately after a cycling exercise show individual characteristics. Distinct trends are not noticeable. However, changes in the movement coordination result in a decrease of variability due to the exercise. Triathletes are more capable of maintaining this movement variability during the running exercise than the sports students. Furthermore, they show a more individual running style.

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