POSSIBILITIES OF IMPLICIT MOTOR LEARNING IN LONG JUMP PERFORMANCE INVESTIGATED BIOMECHANICALLY

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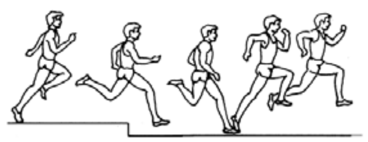
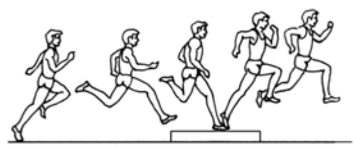
INTRODUCTION: Many investigations, e.g., HAY/NOHARA (1990) deal with the biomechanics and movement techniques of the long jump. Therefore we obtained information about the best performance and advice on how to achieve this goal. Two main strategies of motor learning are known in long jump training: The first is feedback training, where the athlete consciously tries to adapt his performance according to the ideal. The desired ideal is normally a conclusion about technique features averaged over the world's best long jumpers. Individual styles which play an important role in performance as found in earlier investigations dealing with discus throwing (BAUER/SCHÖLLHORN 1997) and running (SCHÖLLHORN, in print) are neglected. The second aims at changes in movement patterns by special exercises and arrangements, e.g., takeoff (TO) at a lower position. In this situation, long jump performance adapts to the situation without the athlete being aware of what he is doing. The lack of a given ideal may lead to individual solutions in order to handle the training situation. Although this strategy is often used in long jump training, especially with novices, even the trainer doesn't really know what the results of this training are. The aim of our study is to investigate changes in long jump techniques of preparation for TO and TO under conditions of 'unconscious' practice.

METHODS: Three groups of students, each in one special training situation (Fig. 1), practiced long jump performance in four training sessions.

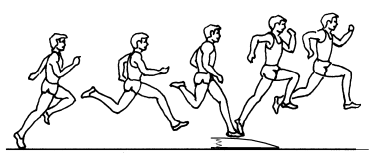
Figure 1



Situation 1:Take-Off at lower position



Situation 2: Take-Off at higher postion



Situation 3: "supported" Take-Off

Two-dimensional kinematic data on the last three strides and TO were filmed at 150 F/s before (pre-test) and after the training phase (post-test). For each subject two trials of the pre-test and the post-test were taken for analysis (Fig. 2)

	A1 TO at lower position	A2 TO at higher position	A3 "supported" TO
Pre-test	TBE1, TBE5, MAE3, MAE4	JFE2, JFE3, IHE2, IHE4	CTE2, CTE4, MKE3, MKE4
Post-test	TBA3, TBA4, MAA4, MAA5	JFA2,JFA3, IHA3,IHA4	CTA2, CTA3, MKA4, MKA5

Figure 2

The subject's movement was described by the time courses of the main joint angles and angular velocities.

The analysis of the time-normalized data followed a combination of several statistical methods according to SCHÖLLHORN (1995) (Fig. 3).

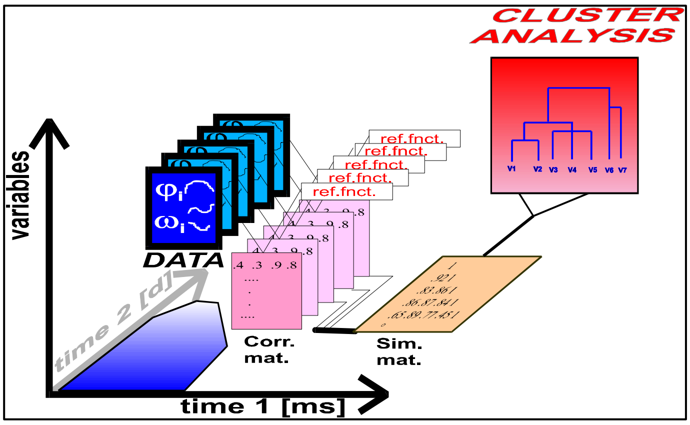


Figure 3 mot. SCHÖLLHORN, 1995

The first step was a reduction of data by means of PCA. Therefore the time courses were correlated by ten Taylor polynomials which according to PCA principles were normed orthogonally. At the second step the similarity between factor matrices was stated by the correlation coefficient s_{kl}, which was defined as follows:

$$s_{kl} = \frac{Tr(C'_k C_{k*})}{\sqrt{Tr(C'_k C_k) * Tr(C'_{k*} C_{k*})}}$$

Cluster analysis was used to classify the results.

RESULTS: Clustering the trials by means of all variables (Fig. 4), the analysis shows a separation by individuals at the most general level which is independent of pre- or post-test. The next step of cluster analysis classifies the long jump trials by pre- and post-test. A subdivision of joint angles and angular velocities or flight and contact phases clusters similar for angular velocities only during the contact phase at TO.

Figures 5 and 6 show the similarity of the time courses of single variables in comparison with trial cta3, which was the best performance of all subjects. The trials are sorted by individuals and training situations. Changes in the similarity between trials of pre- and post-test indicate the influence of the specific training situations and may be reasonable for the identified changes in the complex movement patterns. As example the changes in the velocity of the foot angle of the swinging leg shown in Figure 5 tend to be characteristic for the training situation 2 (σ). For situation 3 (υ) or 3 (9) similar characteristics concerning this variable can't be found. On the other side, the changes of the angle of the head (Fig. 6), as an example, seem to be a result of individual motor learning (tbe1-tba4).

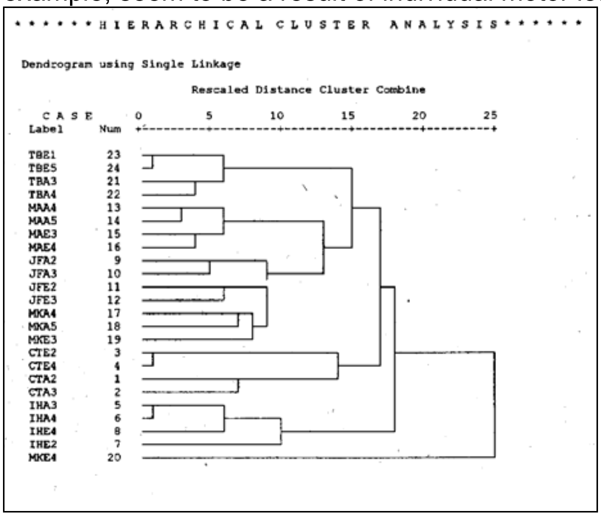


Figure 4 Dendrogram

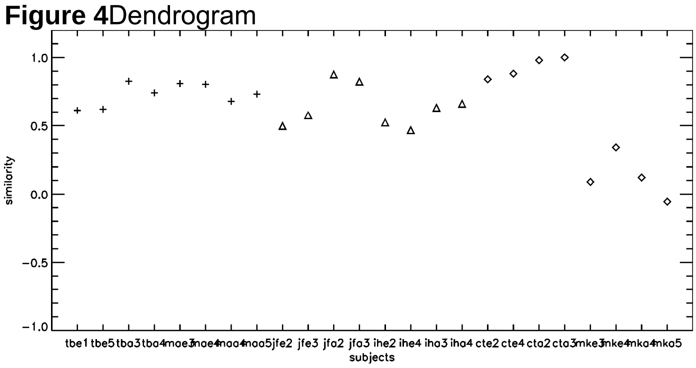


Figure 5 Angular velocity of the torque

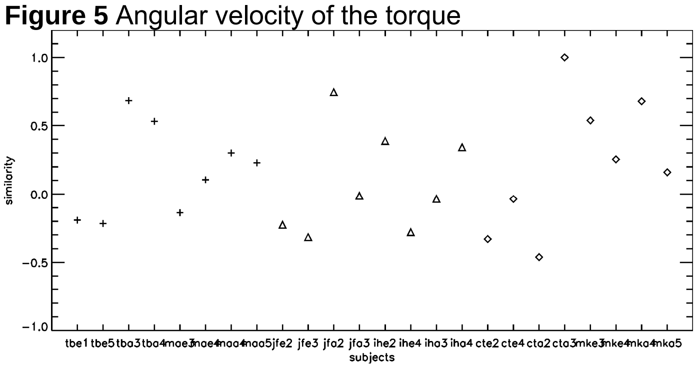


Figure 6 Angle of the head

DISCUSSION: The results of the cluster analysis give information on the individuality of movement patterns in long jump performance and the effect of implicit long jump training under special arrangements. The individuality of the movement patterns can be identified not only for the complex movement during the last three steps, but also for the short contact phase of the jump. Due to the necessary adaptation of the approach to the board, the contact phases of the last steps before TO show greater differences. In addition to the investigations of BAUER/ SCHÖLLHORN 1997 and SCHÖLLHORN (in print), which identified individual patterns in running (contact phases) and discus throwing (delivery phase) over a very short time, the results of our investigation show the individuality of movement patterns over a longer period.
Concerning motor learning, the classification of the long jump performances by pre- and post-test shows the effects of implicit long jump training under specific conditions. The subdivision of variables allows us to identify which parts of long jump performance are trained by the applied training arrangement. These parts can be characteristic for all subjects trained under the same conditions (e.g., the angular velocity of the torque), but they also differ by individuals (e.g., head angle). The results of our investigation indicate that implicit long jump training under specific conditions offers a great variety of strategies to adapt the performance, which allows the athlete to select the right one for himself. Whether this variety is characteristic for implicit training only, where the decision how to deal with the specific training conditions need not be a conscious one, or can also be found in feedback training using conscious variations of performance has to be investigated. Further investigations are also necessary to prove that the identified changes are individual and do not follow a universal 'ideal technique' in the long jump.

REFERENCES:

Schöllhorn, W. I. (1995). Comparison of Biomechanical Movement Patterns by Means of Orthogonal Reference Functions. In *Biomechanics in Sports XII* (pp. 20-24). Budapest.
Hay, J. G., Nohara, H. (1990). Techniques Used By Elite Long Jumpers in Preparation for Takeoff. *J. Biomechanics* **23**, 229-239.
Schöllhorn, W. I. (in print). Identification of Individual Running Patterns by Means of Self-Organizing Neural Nets. In J. Perl, J. Mester, *Computer Science and Sports*. Köln: Strauss.
Bauer, H. U., Schöllhorn, W. I. (1997). Self-Organizing Maps for the Analysis of Complex Movement Patterns. *Neural Processing Letters* **5**, 193-199.