OLGA A SYSTEM FOR AUTOMATIC RECORDING AND ANALYSIS OF KINEMATIC AND DYNAMIC MOVEMENT PARAMETERS. APPLICATION IN SPORT

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INTRODUCTION

OLGA is a computer-aided system for automatic analysis of kinematic, dynamic and neuromuscular movement characteristics by implementation of video digitizing and other measuring instruments. It was developed firstly for the application in the training of weightlifters (fig 1).

In the actual configuration it can be used for analysis of movements which have no higher signal frequencies. However the system software allows contemporaneous data collection of analog signals (different then video signal) with a sampling frequency up to 1 KHz. Further technical modifications, especially the increase of time resolution of data collection will enlarge the range of application considerably.

METHODS

The system consists of: IBM - AT3 system unit, real-time-video-storage unit, 4 (512x512x12 BIT), 3x8 BIT DIA- and 8 BIT AID-converter, Nec Multi Sync Monitor, CCir High Resolution Colour Monitor, CCD-CAMCorder (50 B/s) as well data collecting and processing software. For the system configuration, following aspects were taken into account: automatical digitizing of passive markers attached on moving objects. Time minimization for calibration procedure and for data acquisition and processing routines; simultaneous use of other data collecting systems including: force platfonn,
electrogoniometer, accelerometer and EMG; as well minimization of the disturbing influence on the movement execution.

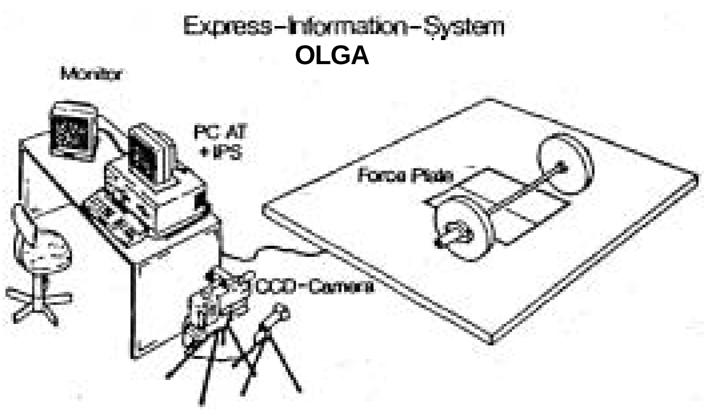

Fig. 1. Schematic set-up of the system during training

RESULTS

Under the possible applications of the system following situations were tested:

- # kinematic structure of the barbell;
- # kinematic structure of linked segments,i.e. of the lower body extremities (e.g. stick figure; time-curves of linear and angular velocity).
- # one point kinematics and external dynamics of the C.G. of the system athlete & barbell;
- # kinematics as well as external and internal dynamics (including net joint moments) in knee joint;
- # calculation of mean curves and their statistical tolerances.
- # use of the Biofeedback-technique hy manipulation of acustic signals in connection with the obtained movement parameters.

The accuracy of the measuring system was controlled by simultaneous measuring of !he barbell movement by means of the videosystem and of an accelerometer assembled on the barbell staff. For the estimation of velocity and acceleration an error of less than **3%** was obtained.

The following comparison was taken:

1. the directly measured acceleration with that obtained by double lime differentiation of vertical and horizontal barbell coordinates.

2. the velocity obtained by time integration of acceleration values, with !he velocity calculated by single lime differentiation of the barbell coordinates.

The trajectory of the barbell in the vertical plane as well as the barbell velocity are of interest lor coaches and athletes. **A** fast information alter he movement execution permits coaching relevant judgement about the influences of external parameters on the barbell movement (including weight, execution movement, pull with and without grip straps, fatigue). 10-15s alter execution of the exercise. the system display shows: !he trajectory and the vertical and horizontal velocity time curves of the barbell as well the GRF lime curves including critical numerical values. These screen diagrams can also be printed out via videoprinter.

The ground reaction lorce represents an important diagnostic parameter. It can be measured with a lorce platform. During exercises with the barbell the ground reaction forces refer to the C.G. system weightlifter + barbell. **A** differentiation of the forces acting on the single C.G. ol the weightlifter (F_B) and of the barbell (F_H) can he obtained as follows (fig. 2).

The acceleration of the barbell a_H can he calculated by double lime differentiation of the barbell coordinates. The force at the barbell F_H is given then according to formula:

$$F_H = m_H * a_H$$

where m_H = mass oi the barbell.

Because GRF = $F_H + F_B$ the lorce acting on the C.G. of the hody can be simply determined.

The movement of the lower extremities can he analysed in the simplest model (under certain assumptions), i.e. through the movement patterns of 4 markers, by means of which the longitudinal axes of the body segments are definable.

With a delay of about 30s after termination of he exercise, the system stores the coordinates of the markers. Consequently the stick diagram ol the leg segments can be displayed on the system screen. The same occurs for other parameters which can be calculated from the joint coordinates. The representation forms include time-history curves of single parameters as well as the relationship of two parameters to each other.

Net moments are internal load quantities, which give informations about the minimal load on anatomical structures as muscles, tendons and ligaments during body postures and movements. They are calculated from the kinematics of the considered joint taken together with the ground reaction force. Under determined conditions and assumptions with respect to anatomical and muscle mechanical data, muscle forces and joint forces can be calculated in good approximation.

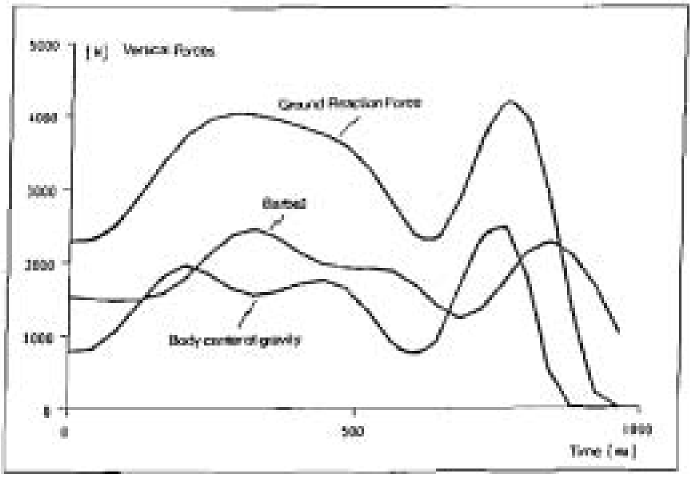

Fig. 2. vertical force components for a selected snatch attempt

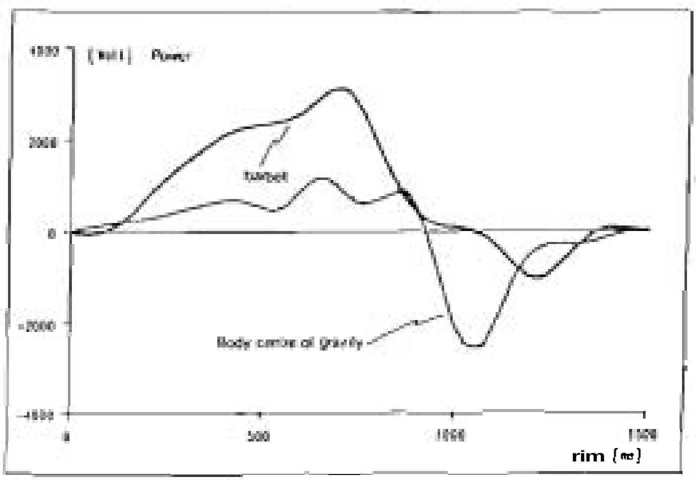

Fig. 3. Vertical GRF and net moment in knee joint during strength exercise

The net moments and the internal forces respectively represent an essential component of the biomechanical structure of a movement. They are an indicator of the load during posture and movements tasks. A fast information about these quantities allows a practice rekvant evaluation of the effect of different training exercises on the considered muscle groups.

The net moments are more complex quantities than kinematic parameters, but they permit a differentiated analysis of the movement (fig. 3). Thus, it can occur that for two movements showing the same kinematic structure the causing net moments and therefore the muscle forces have a quite different patterns.

The mechanical power indicates how fast a force is producing work. In weightlifting, with regard to the competition and training exercise, it is of great relevance to know how total power is distributed within the C.G. of the body and of the barbell respectively.

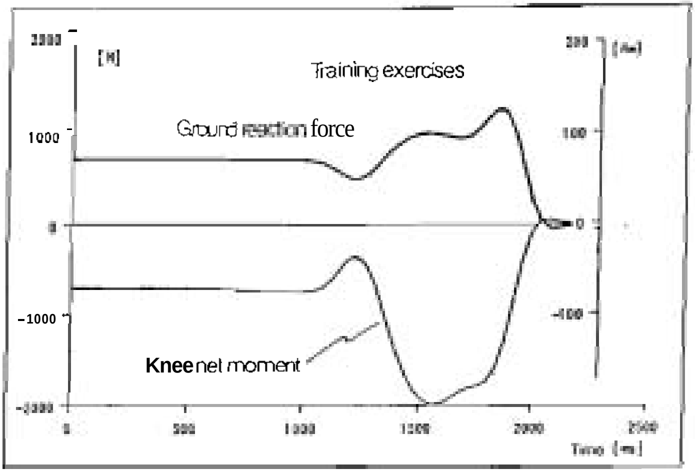

Fig. 4. Vertical power distribution during a snatch attempt

The measure of the ground reaction forces and of the barbell kinematic is sufficient to determine these power distributions. The power on the total system weightlifter & barbell can be calculated from the ground reaction force and by knowing the mass of the total system (fig. 4). The power on the barbell P_H can be calculated from the time history of barbell vertical coordinate and knowing the mass.

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