APPLICATION OF FUNCTIONAL DYNAMIC TESTS IN THE LATE POSTOPERATIVE PHASE AFTER ACL-SURGERY FOR THE EVALUATION OF KINEMATIC AND NEUROMUSCULAR PARAMETERS

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INTRODUCTION

The complete restoration of loading capacity and performance of joint systems is the main objective in rehabilitation after joint injury or joint surgery. The optimal cooperation of peripheral and central mechanisms is besides the reconstruction and regeneration of passive structures in the centre of interest of rehabilitative efforts to prepare the patient for everyday and sportspecific stress situations.

For the control of rehabilitative processes usually informations from clinical examinations or manual tests, often in combination with scores (e.g. KRÄMER 1993, LYSHOLM 1982) areused. Results of these tests shall give informations about the loading capacity and the muscular situation of the injured limb. Furthermore data out of isometric ort isokinetic strength measurements in the open kinetic chain and sometimes also in closed kinetic chain are used. But, all these examination techniques can give only reduced informations about the capacity of the neuromuscular system in functional stress situations like everyday or sportspecific situations. Thus a diagnostic deficit can be detected: Dynamic, functional test situations are not yet used in the control of rehabilitation processes.

The goal of this study is the development of functional dynamic tests for the assessment of function and capacity of joint systems in dynamic stress situations.

METHODS

As dynamic tests 1) a one-legged drop jump from a height of 17cm, 2) descending a stair from 40cm step height and 3) as a dynamic repetitive movement the one-legged-hopping were chosen.

The drop jump and the stair descending test were performed by a group of 8 patients (4 male, 4 female,16-57 years) and a control group (6male, 2female, 23-54 years). The patients were on the average 11,6 months after ACL-surgery with a trevira alloplasty. The control group did not have any known lower limb injuries. Both tests were performed 12 times with each limb.

In terms of a case study the one-legged-hopping and the stair descending tests were performed by a male patient (A,22 years) six months after surgery and a female patient (B,26 years) 24 months after surgery.

The experiments were performed under standardized conditions with both lower limbs. The sequence of tests and limb side was randomized. The knee joint angle was measured with calibrated electrogoniometers. The instant and duration of ground contact was measured with a contact mat or adequate sensors underneath the sole. The activity of knee joint muscles was recorded by electromyography considering the ISEK-standard (RAU et al. 1980). The data was sampled with a portable 16-channel amplifier (BIOVISION), digitized with 1000Hz, on-line controlled and stored on harddisk of a personal computer for further analysis. An ensemble averaging for the 12 movement cycles of each test was used for which the instant of ground contact was taken as a trigger. The kinematic parameters were used for the partition of the movement cycles in different phases (preinnervation, reflex induced activity, eccentric phase, concentric phase) (Fig.1) (GOLLHOFER et al. 1990). The duration of ground contact, flight time, duration of eccentric and concentric phase, knee angle maximum, range of motion and knee angle speed were determined as kinematic parameters. The EMG-data was integrated in relation to the determined movement phases and normalized to the total activity of the knee extensor muscles (sum of IEA of quadriceps parts = 100%).

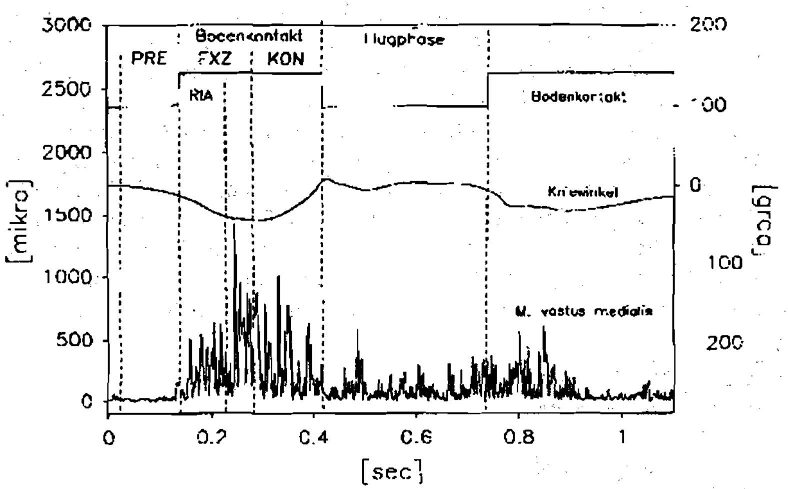

Fig. 1: phases of movement cycle

For the patient group and the control group the sampled data was compared within and between groups (t-test for dependent resp. independent measures) after proof of normal distribution. Additionally a nonparametric method was used. The data of the case studies was analysed descriptively.

RESULTS

The comparance of the kinematic data of the drop jump movements shows clear differences between the injured and non-injured side which indicate a reduced capacity of motor abilities (Fig.2).

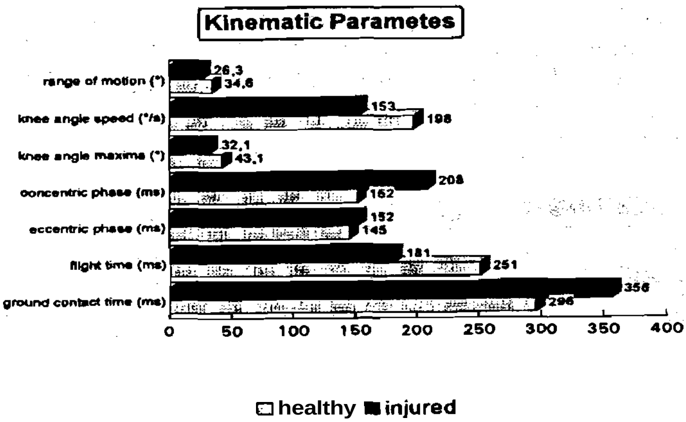

Fig. 2

The injured leg shows a smaller range of motion (ROM) (-8,3°, p<.01), lower angle velocitys (- 45°/s, p<.01), smaller knee angle maximum (-11°, p<.05), longer eccentric phase (+ 7ms, n.s), longer concentric phase (+56ms, p<.01), longer ground contact (+ 60ms, p<.01) and' shorter flight times (-70ms, p<.01).

The absolute and normalized integrated EMG-data show significant differences between the activity of the different quadriceps parts within and between groups. In comparance to the healthy side the v. medialis of the injured leg shows a reduced actvity of about 10% in the preinnervation phase (p< .05), the eccentric phase (p<.01) and the concentric phase (p<.01). In the loaded phases the v.lateralis activity was increased (eccentric +11,2%, concentric +8,5%) which was significant for the eccentric phase (p<.05). In comparance to the control group the differences were also significant on the 5%-level. Within the control group no significant differences could be found.

Important is also the change of the neuromuscular activation of the healthy limb of the patients in the load phases. Here an increase of the vastus medialis activity of about 10% and the vastus lateralis of about 8% is obvious in comparance to the controls. Fig.3 shows the described neuromuscular changes exemplarily for the eccentric phase of the movement,

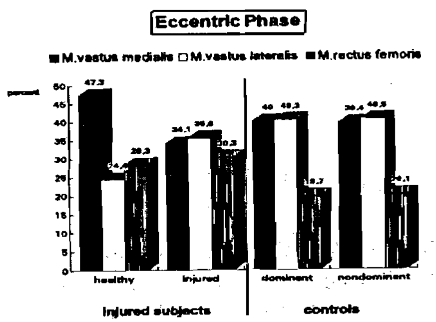

Fig.3

For descending a stair no significant differences could be found in the within or between group comparance one year after surgery.

Different results can be seen in the case studies. Patient A (6 months postsurgical) showed the same changes in the drop jump movement like the patient group. Climbing downstairs also revealed clear differences between injured and non-injured leg. Comparing the absolute and normalized integrated EMG-data lower values could be found for the v.medialis (- 2,5%) and higher values were seen for the v.lateralis (+ 3%). Regarding the kinematic parameters smaller range of motion (- 6°), smaller knee angle at contact (-2 °) and a slower knee angle velocity (48°/s) (Fig.4) was found.

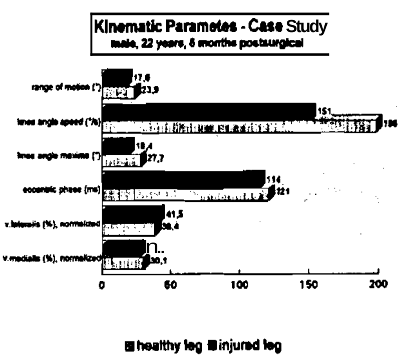

Fig. 4

The dynamic repetitive movements in Patient B also show clear differences between operated and non operated leg. Here, shorter contact times **(-32ms),** smaller knee angle maxima **(-16,9°),** smaller ROM **(-11,3°)** and a longer eccentric and concentric phase (+5 resp. **+40ms)** could be found. The integrated electrical activity was generally reduced on the operated side, esp. in the eccentric phase.

DISCUSSION

The results show that deficient and compensatory changes in the locomotor stereotype can be ascertained in the late rehabilitation phase by dynamic tests. In stress situation like a drop jump stable changes in neuromuscular activation can be shown. The missing difference in the reflex induced phase point to a central manifestation of the changes which may be attributed to reflectory inhibitions during immobilisation (STOKES 1984). The differences in comparing the the kinematic parameters mirror the neuromuscular changes and prove dependent modifications of the movement performance. The kinematic data confirm results of other authors (GAUFFIN et al. 1992, TEGNER et al. 1986) who though used only motor tests without monitoring muscular activities.

One important implication of the documented study is the necessity of phase dependent hierarchical tests like it is shown by the missing changes in the stair descending movement one year postsurgical and the clear differences 6 months postsurgical in the case study. During climbing downstairs one year postsurgical the load of the movement does not seem to be high enough for provocation of deficits. In higher loaded movements like the drop jump the deficits become visible.

For the control of rehabilitative training some implications arise out of the data. For the compensation of the shown deficits it is necessary to use methods for the reintegration of the vastus medialis in the locomotor stereotype, at least to avoid risc factors for the development of secondary damages (e.g. lateralisation of patella). The early use of closed kinetic chain excercises and the use of low impact plyometrics, both in connection with biofeedback methods may be adequate means.

In future studies the described tests and further tests shall be developed and validated to provide possibilities for a phase related control of rehabilitation processes and for the evaluation of the therapeutic effectiveness.

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