Medically controlled conditioning of the spine-stabilising musculature for the prevention and therapy of back problems using biofeedback-led strength training with real and virtual strength training devices

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Problem

The reduction of the resilience and functionality of the musculoskeletal system of people in the so-called developed industrial countries leads inevitably to large societal problems. Lack of exercise, one-sided, long-lasting physical or psychological strain can lead to “creeping” negative changes of the neuromuscular status of the spine stabilizing musculature and thus impair the performance of movement and the resilience of the back considerably.

To avoid overloading of the spine and the thus resulting back problems a balanced function of the spine-stabilising musculature and its sensomotor systems is of utmost importance.

Back problems are in most cases a result of functional dysbalances and performance deficits of the torso’s musculature. Functional dysbalances and deficits are in 80-85% of cases the sole reason for the development of back problems.

This can be met both with prevention and therapy through targeted conditioning of the torso’s sensomotor in the framework of a “functional strength training”.

“Functional strength training” is biofeedback-led medically controlled training for the removal of neuromuscular dysbalances and deficits. It is a target-oriented conditioning training.

Requirements for a medically controlled “functional strength training of the spine-stabilising musculature[1]

General requirements

A medically controlled “functional strength training” can only be conducted, if there is a tool which allows on the one hand to diagnose muscular dysbalances and performance deficits and on the other to expose the global drive musculature and the local (autochthonic) musculature with a well dosed strain.[2] The strain in this context

[1] Musculature here means the totality of the hierarchically organized sensomotor functional chains, that means biological closed loops, in which the muscles act as energy convertors/bio motors. The hierarchy of such sensomotor systems goes from the highest level of the central nervous system to the muscle itself as bio motor.

[2] The autochthonic musculature is the system of small muscles that are located spatially around the vertebrae and connect the individual vertebrae directly or across one another. They regulate the position of the vertebae actively according to the applied strain. The correct function of the autochthonic musculature of the spine is crucial for the resilience of the spine as the central organ of the musculoskeletal system.
It is known, however, that the autochthonic musculature cannot a priori be activated willingly. Thus it can only if at all be trained indirectly with conventional means. A strength training, as carried out in the fitness sector, can even cause considerable damage if there are hidden performance deficits in the autochthonic musculature. In such a case strains, caused by the drive musculature overcoming outer movement resistances, are transmitted without control onto the spinal skeleton. This leads to enormous overstraining of the spinal discs and vertebrae.

fulfills the function of a therapeutic. The therapeutic effect is dependent to the highest degree on the control over the dosing of said strain. If the dosage cannot be controlled, strength training could lead to unforeseeable consequences.

A strength training, which is not designed on the basis of the identification of the neuromuscular status (objectification of performance deficits and dysbalances) and which cannot guarantee the control over the change in the neuromuscular status due to the applied strains, can lead to different results in different people. In such a strength training, changes in the neuromuscular status can occur that were not intended whilst those aimed for do not occur. The result is not satisfactory as the what needs to be trained is not. Thus the contradictory results of a number of studies and the contrary discussions in the scientific literature concerning the benefit of a strength training to eradicate back problems can be explained. This is regardless of the fact that there are some startling inconsistencies in these studies themselves.

With this in mind, the often quoted line “A strong back knows no pain” needs to be relativised, as in this context it is not only strength that matters but also the balance and control in the exertion of strength.

Specific requirements

The “functional training” of the spine-stabilising musculature requires a targeted training of the global and local (autochthonic) musculature and the cooperation of the ideomotor and sensomotor functional systems of the central nervous system (CNS) in the realisation of such complex motoric tasks as for example the movement und posture regulation. One most not forget that

1. in the realisation of any motoric action and especially movement a number of sensory systems (e.g. the proprioceptor system, the nociceptor system, the staticodynamic system [balance analyser]) as well as audio and video analyser systems are involved and influence and enable them. As the “functional strength training” is a motoric learning training, the necessary feedback information, which is needed to fulfill the movement tasks correctly or allows for necessary adjustments in case of deviations, has to be provided simultaneously to the probed.
2. a priori the autochthonic musculature cannot be activated deliberately; new unconventional means to train it need to be found.

Requirements for a tool for the execution of a medically controlled “functional strength training”

The aim of a medically controlled “functional strength training is the reconstitution and maintenance of the functionality of the musculoskeletal system and the safeguarding of the resilience of the different joint drives through the reduction of existing muscular dysbalances and deficits.

BfMC GmbH Leipzig developed device concepts in the framework of the medical training therapy for the treatment of problems of the musculoskeletal system. These device systems are based on the application of Computer-supported Test and Training systems (CTT) and biofeedback methods (figure 1).

The possibilities of diagnosing strength (identification of neuromuscular dysbalances and deficits) and conducting a biofeedback-led strength training are significant performance characteristics of such complex device systems. Biofeedback

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This can result in irreparable spinal damage. Even in a best case scenario such a conventional strength training will not lead to the desired effect.

methods allow a well differentiated dosing of strain, a basic prerequisite for the use in therapy. The training navigation software TN-BioMC as immanent part of these CTT device systems supports the conduct of a highly efficient, time optimized strength diagnosis and a biofeedback-led strength training. Thus the fundamental requirements of a "functional strength training" are fulfilled. An application of such complex and relatively expensive device systems is mainly envisaged for clinical institutions (e.g. rehabilitation and health centers, orthopedic practices).

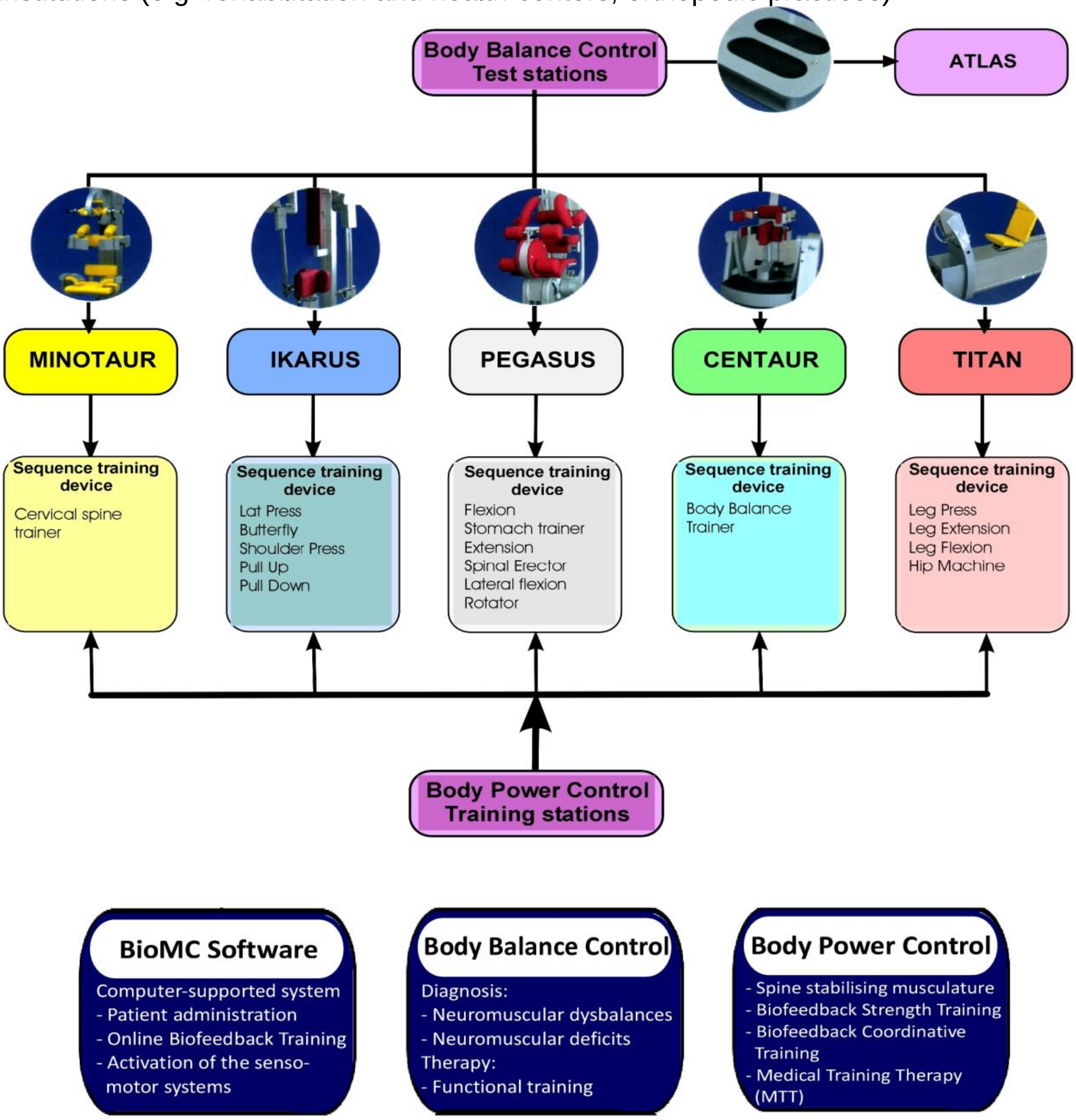


Figure 1: BFMC Device Concepts BBC and BPC

Next to the planning, conduct and documentation of the results of the strength training, the TN-BioMC Software also supports the design of specific demand-structures and profiles through the combination of qualitative, quantitative and dynamic components of the movement task. Only thus a target-oriented application of a physical strain/demand as broad spectrum therapeutic becomes possible.

For the conduct of a highly efficient "functional strength training" of the musculature of the musculoskeletal system a number of Computer-supported Test and Training device systems have been developed for the application in clinical institutions (figure 1). The device systems 3D Pegasus and 3D Centaur are especially suited for the objectification of muscular dysbalances and deficits and for the conditioning of the spine-stabilising musculature. The TN-BioMC Software supports the conduct of biofeedback-led strength training and the functionality of all special strength training devices of the BBC-device concept. Furthermore it also supports sequence training devices (devices with weights) of the BPC-device concept that have been upgraded with the BMC-Unit (distance and strength sensors), that means it supports the use of real strength training devices in clinical institutions.

For the conduct of a target-oriented medically controlled "functional strength training" outside of clinical institutions (e.g. training close to the workplace or at home), the method of strength training using virtual "strength training devices" was developed. For this reason the TN-BioMC Software has been modified and supplemented with further graphic performance characteristics to support the handling.

Training at virtual "strength training devices" is biofeedback.-led strength training without devices (training at envisaged devices). It is a training to maintain the existing condition of the neuromuscular systems. The strength resistance is created by the antagonists (muscles) and the joint-stabilising musculature through isometric tension and then overcome through the drive musculature (agonists).

"Functional strength training" for the treatment of back problems in clinical institutions

General notes

The aim of a "functional strength training" in clinics is to objectify existing dysbalances and deficits and eradicate these through targeted, controlled application of well dosed strains. Through this, adaptive reactions are initiated, that means a functional reorganisation is initiated and a morphological adaption of the neuromuscular sensomotor systems of the skeleton's motoricity takes place, which leads to the eradication of dysbalances and deficits (figure 2).

The computer-supported test and training devices CTT 3D Pegasus and CTT 3D Centaur have been developed especially for the objectification of existing neuromuscular dysbalances and deficits of the spine-stabilising musculature and to safeguard an effective "functional strength training" in clinics.

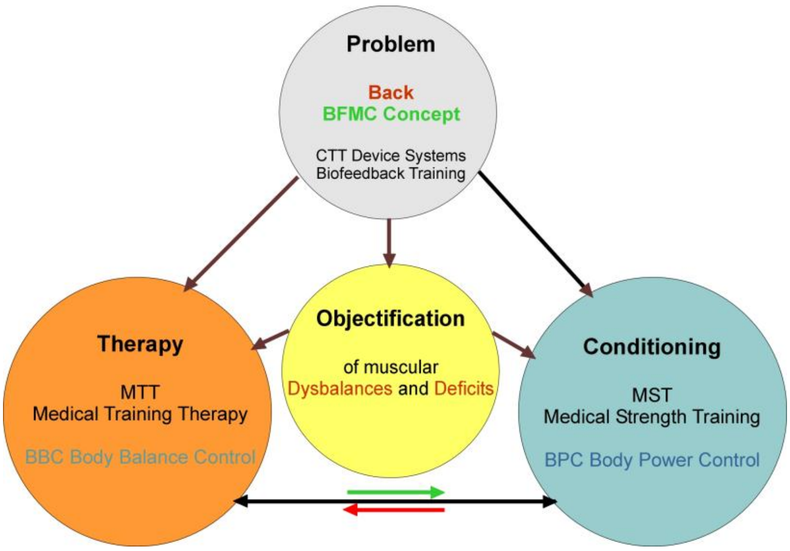


Figure 2: Task structure of the CTT device systems for Therapy, Rehabilitation and Prevention in clinics

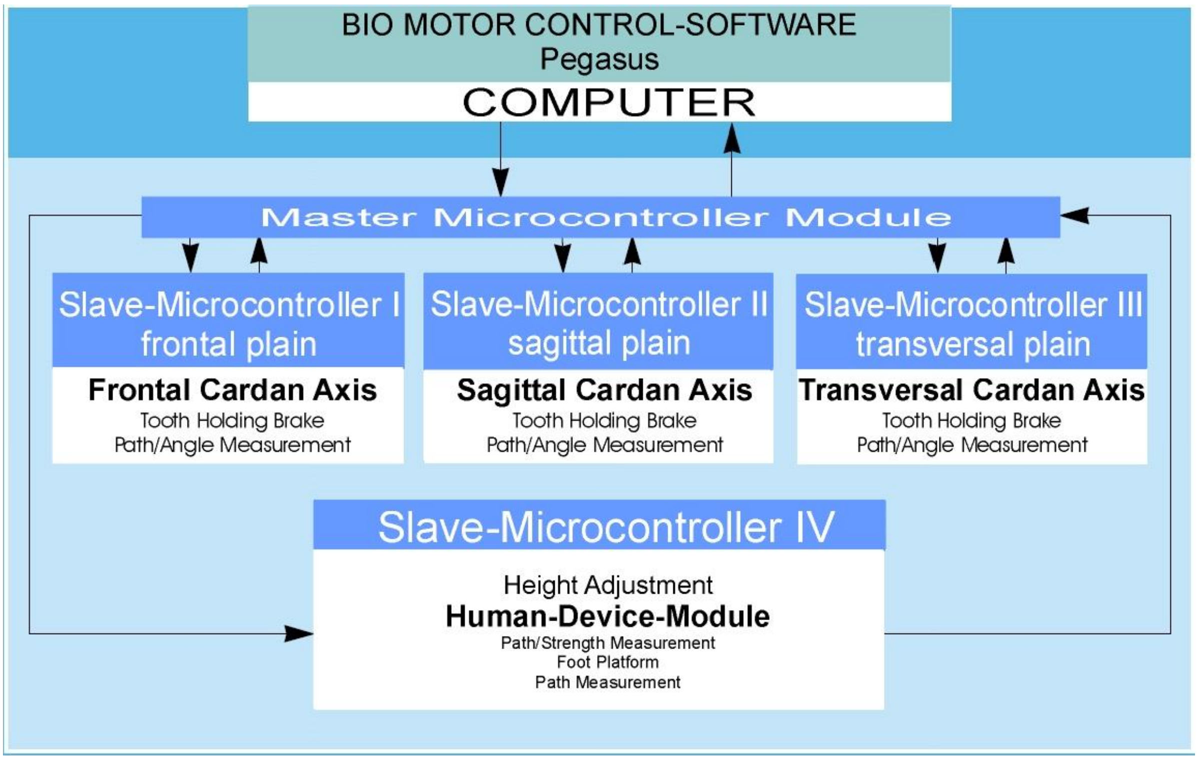


Figure 3: Functional structure of CTT 3D PEGASUS

Figure 4: Morphological structure of CTT 3D PEGASUS

CTT 3D Pegasus – General Characteristics

In its functional structure, Pegasus is a three-dimensional computer-supported test and training device system, a robot system (figure 3 and 4).

Function and application of CTT 3D Pegasus

Pegasus was mainly developed to objectify strength and movement dysbalances and performance deficits of the spine musculature. The BioMC Software for Pegasus supports also a number of biofeedback-led training and treatment programmes. In the development of Pegasus an emphasis was placed on rational handling and time-saving. The positioning of the proband and the choice of the respective measurement plain are supported by the BioMC software for Pegasus. All test and training programmes are completed by the proband in a seated position with the hip and thighs fixed (figure 5).

As one can see in figure 5, the human-machine-link (upper body/ machine) is made by a Cardan shaft frame system. The Cardan system has three movement axes with controllable brakes. The movement axes can be blocked and release simultaneously or individually, according to the task at hand. The freedom of movement of the upper body is not hindered by the machine when all axes are released. The BioMC Software for Pegasus supports especially the solution of diagnostic problems such as the identification of muscular dysbalances and deficits. It also supports the conduct of a highly efficient “functional strength training” of the spine-stabilising musculature in the lumbar/ thoracic spine area. Rational handling and time saving are also features. A complex test for the identification of functional dysbalances and deficits can be undertaken in just 15min. A training session of the entire back musculature (the muscles around the spine) takes approx. 10min.

Figure 5: Test and Training execution with CTT 3D PEGASUS

The recording of strength profiles takes place under isometric strain conditions. The identification of the strength profiles can take place in any point of the upper body’s range of motion by blocking the respective Cardan axes. The reproducibility of the machine settings (coordinates of the Cardan axes) for repeated measurements has an accuracy of 1.8 degrees. With the respective positioning (choice of freedom of movement in the individual Cardan axes) movement and strength profiles can be identified in the anatomical main plains (sagittal plain [flexion/extension], frontal plain [lateral flexion left/right] and transversal plain [rotation left/right]). The measurements are taken with the proband in an upright seated position. On the basis of thus recorded strength profiles existing strength dysbalances and strength deficits can be established with the use of reference values.

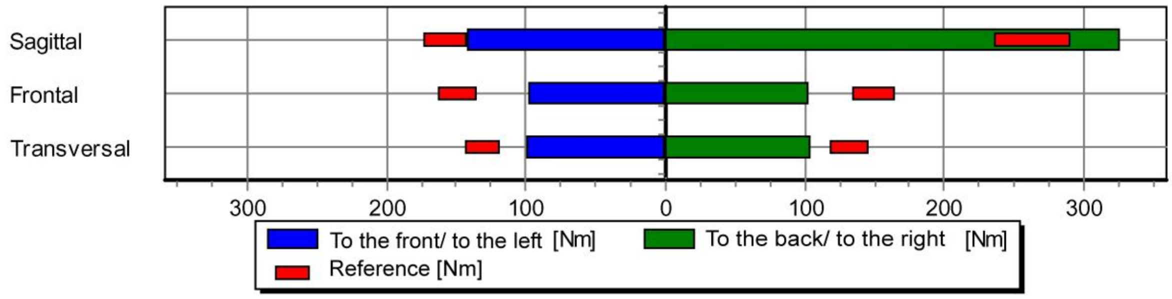
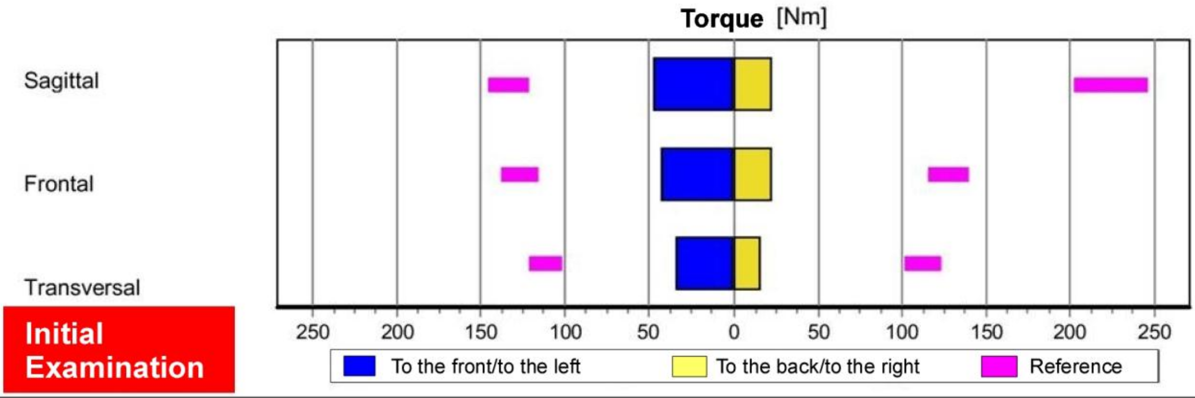


Figure 6: Recorded strength profiles in the anatomical main plains with CTT 3D PEGASUS

Plain	Direction 1	Reference	Actual	% Reference	Direction 2	Reference	Actual	% Reference	Dysbalance
Sagittal	To the front	121-148	49	41	To the back	202-246	22	11	115
Frontal	To the left	115-140	44	38	To the right	115-140	20	20	62
Transversal	Left turn	101-123	35	35	Right turn	101-123	16	16	72

Measurement Units: Reference/Actual-Torque [Nm], Dysbalance - [%]



Plain	Direction 1	Reference	Actual	% Reference	Direction 2	Reference	Actual	% Reference	Dysbalance
Sagittal	To the front	121-148	130	100	To the back	202-246	332	135	-42
Frontal	To the left	115-140	169	120	To the right	115-140	176	125	-4
Transversal	Left turn	101-123	166	135	Right turn	101-123	140	114	17

Measurement Units: Reference/Actual-Torque [Nm], Dysbalance - [%]

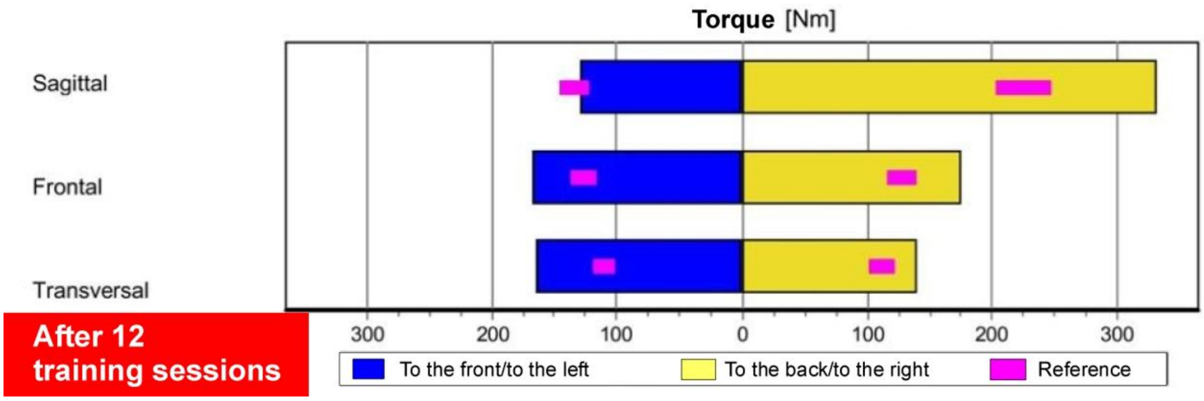
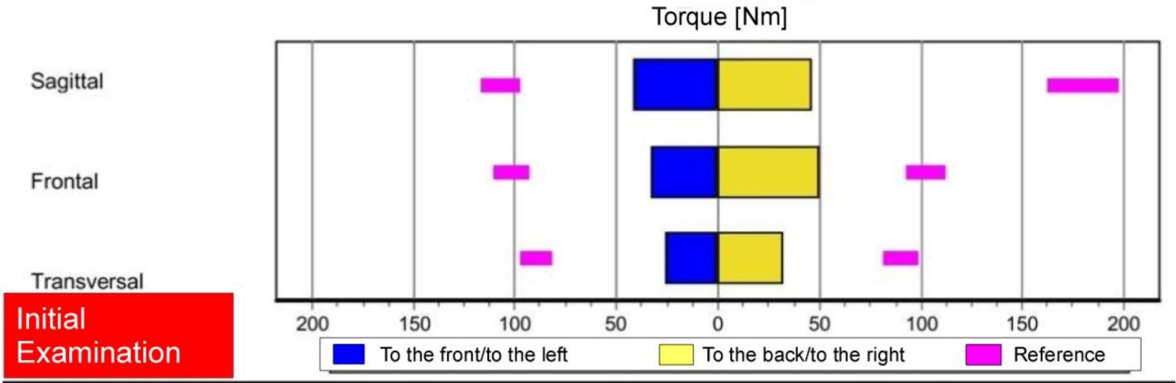


Figure 6a: Initial examination and test after 12 training sessions (example patient 1, clinical settings)

Plain	Direction 1	Reference	Actual	% Reference	Direction 2	Reference	Actual	% Reference	Dysbalance
Sagittal	To the front	97-119	42	44	To the back	162-198	47	29	41
Frontal	To the left	92-113	34	37	To the right	92-113	49	54	-37
Transversal	Left turn	81-99	26	32	Right turn	81-99	32	40	-20

Measurement Units: Reference/Actual-Torque [Nm], Dysbalance - [%]



Plain	Direction 1	Reference	Actual	% Reference	Direction 2	Reference	Actual	% Reference	Dysbalance
Sagittal	To the front	97-119	66	68	To the back	162-198	184	100	-50
Frontal	To the left	92-113	118	105	To the right	92-113	112	100	6
Transversal	Left turn	81-99	66	82	Right turn	81-99	66	82	0

Measurement Units: Reference/Actual-Torque [Nm], Dysbalance - [%]

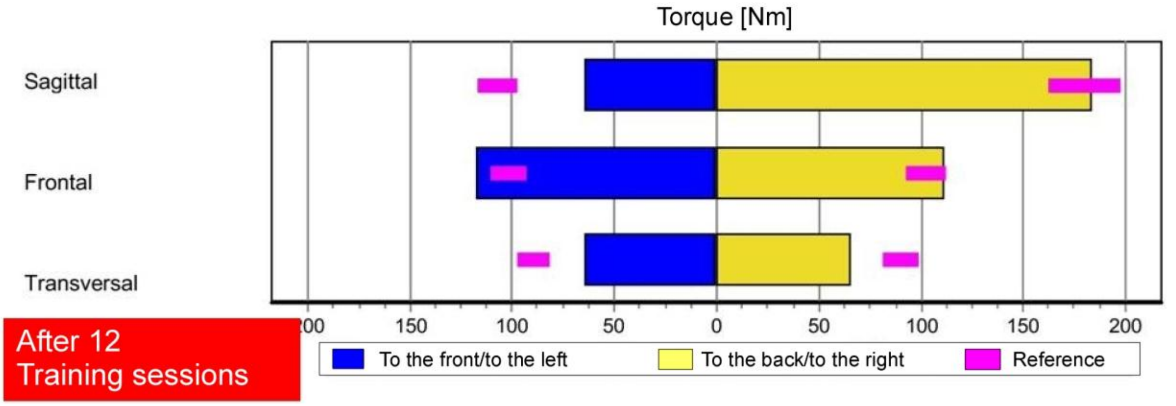


Figure 6b: Initial examination and test after 12 training sessions (example patient 2, clinical settings)

Using biofeedback methods, a specific, highly efficient training (maximum strength, strength endurance, strength coordination and mobility training) of the sensomotor systems of the lumbar spine joint motoricity can be conducted. This is aimed at reducing existing strength dysbalances and performance deficits and maintaining/restoring the natural mobility and resilience of the spine in this area.

Figure 6a and 6b show the results of an initial test and the results after 12 training sessions for 2 male probands. The achieved progress in the conditioning of the spine-stabilising musculature after just 12 training sessions can be seen clearly in the changes of the strength profiles.

The performance profile of 3D Pegasus

3D Pegasus allows

- the identification of existing mobility and strength dysbalances and deficits of the spine-stabilising musculature

- a computer-supported preventative and therapeutic training of the spine-stabilising musculature and of the sensomotor systems of the lumbar spine motoricity

Performance characteristics of 3D Pegasus

Active principle
- Isometric strength measurement and generation of controlled demands on the spine-stabilising upper body musculature under isometric strain conditions

Aim
- Objectification and eradication of muscular dysbalances and deficits of the spine-stabilising musculature in the lumbar and thoracic spine area

Method
- Measurement of the isometric maximum strength of the spine-stabilising musculature in the anatomical main plains (sagittal plain [flexion/extension], frontal plain [lateral flexion left/right] and transversal plain [rotation left/right])
- Isometric strength training of the spine-stabilising musculature (maximum strength, strength differentiation training)

General performance characteristics of 3D Pegasus
- easy handling
- time and space saving
- great turnover of probands

Potential applications of 3D Pegasus
3D Pegasus is mainly used in clinics and institutions for rehabilitation, orthopedic and physiotherapeutic departments, fitness and health centers, in workplace, sport and military medicine and in research as well as for prevention of back problems in schools, in large companies, IT-businesses, banks and civil service institutions.

CTT 3D Centaur – General Characteristics

Centaur is a three-dimensional computer-supported test and training device system, a robot system (figure 7 and 8).

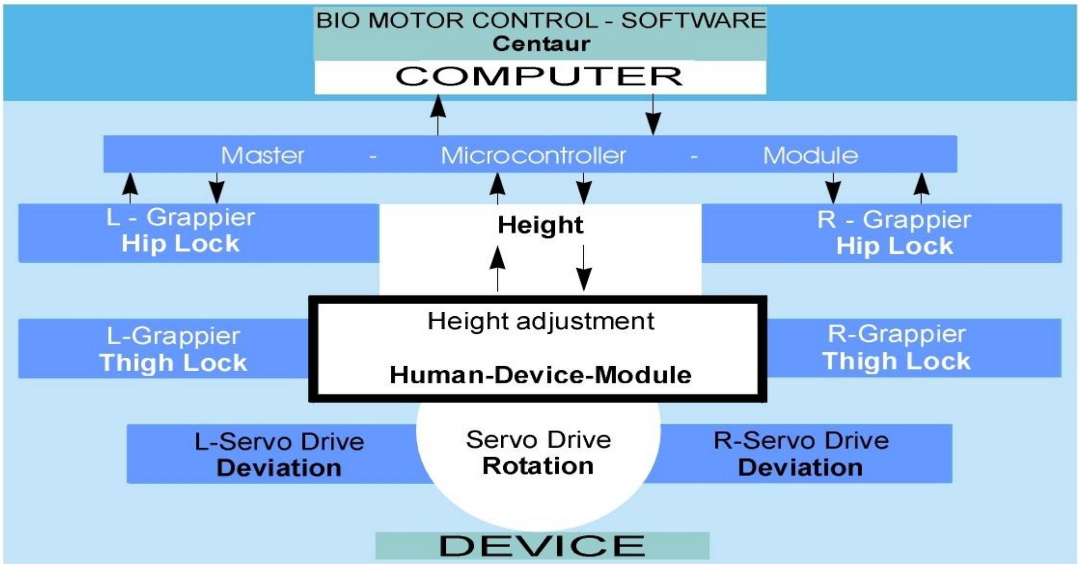


Figure 7: Functional structure of CTT 3D CENTAUR

Figure 8: Morphological structure of CTT 3D CENTAUR

Function and application of CTT 3D Centaur

3D Centaur was developed as training device for a new approach, that means a new, methodically unconventional approach to conduct a highly efficient “functional strength training”, which is able to train the global and local (autochthonic) musculature. This is targeted with regard to their spatial structure and their functional cooperation. Centaur has two independent movement axes. The movement of each axis is realised through two independent, programme controlled and regulated servomotor systems. Through a combination of the movements of both the independent movement axes of Centaur very accurate and well reproducible positioning of the proband is possible. This is a very important prerequisite for the conduct of an efficient strength training.

The BioMC Software for Centaur allows sending the complex control programme directly from a computer to the device.

The BioMC Software for Centaur also supports diagnostic problems, for example the identification of the range of maximum load of the spine-stabilising musculature when tasked with holding an upright body posture in various tilt angles in space. In the development of Centaur great emphasis was placed on rational handling and time saving. A complex test to identify the range of maximum load can be undertaken in just 12 min approx. (figure 9). A training session of the entire spatial back musculature takes approx. 10min.

Training of the autochthonic musculature of the spine with 3D Centaur

The new approach

With 3D Centaur, developed especially for the "functional strength training" of the spine-stabilising musculature, very differentiable and well dosed demands on the global musculature of the spine can be achieved. Furthermore, it is also possible to activate the local (autochthonic) spine musculature directly and thus train it as well. This is done by controlled programmed changes of the body's tilt in the gravitational field of earth. For this the proband is fixed in the machine up to the hip. The upper body is free. The movement task is to keep the body posture, regardless of the body's tilt (figure 10). The maximum body tilt is the horizontal plain (tilt sequence 5, 6 and 9).

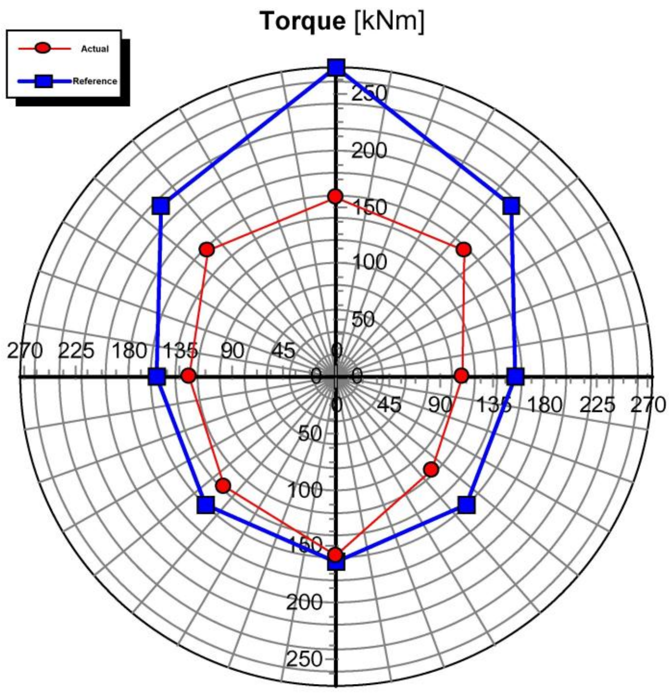


Figure 9: Test result 8 point test with CTT 3D CENTAUR

Next to the generation of defined demands on the lumbar and thoracic spine through the body tilt (the weight of the upper body is working as load in the gravitational field of earth), the tilting also leads to the activation of the balance analyser. This stimulates the deeper lying autochthonic musculature with the aim to block the individual vertebrae of the spine skeleton (reduce their degrees of freedom) to stabilise the spine. The thus created control activities of the balance analyser act as demand that is sending training stimuli to the autochthonic musculature. In this manner, the autochthonic musculature can be trained.

Figure 10: Graphic depiction of different tilt angles of CTT 3D CENTAUR

On the basis of good reproducibility of the body's position and the involved muscle activity in addition to the use of accordant surface EMG recordings of the spine-stabilising musculature, a differential diagnosis for the objectification of muscular dysbalances can be deduced.

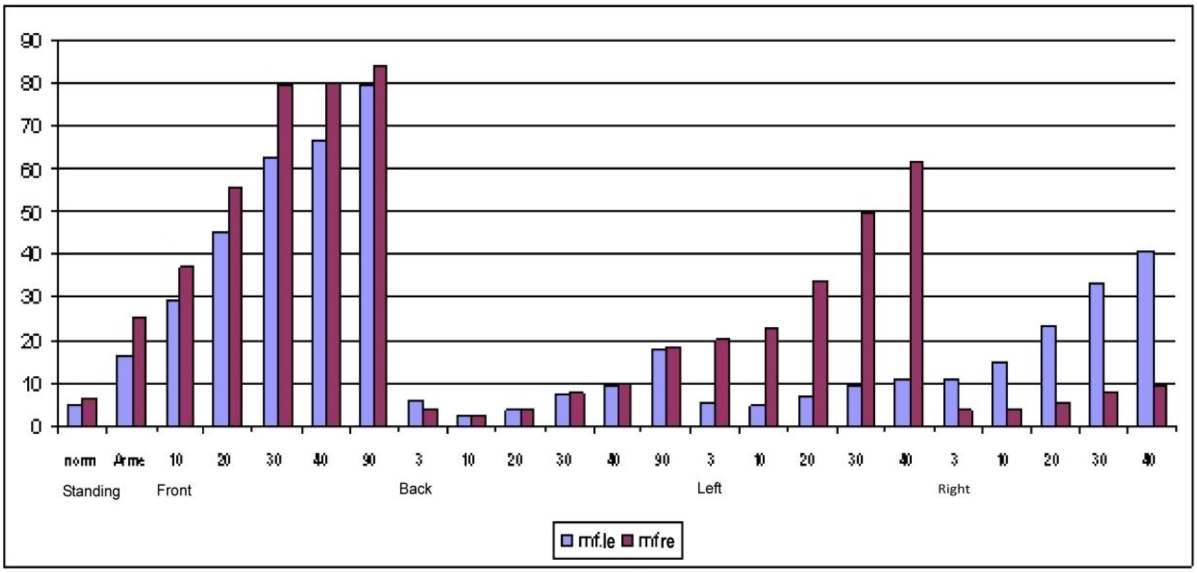


Figure 11a: Activity of the Multifidus muscle (blue: left, red: right) in tilt angles from 0° to 90° (sagittal plain, tilt to the front), 0° to -90° (tilt to the back) and 3° to 40° (frontal plain left/right)

In figure 11a and 11b the activities of two muscle groups in body tilts of various tilt angles in the sagittal plain (extension/flexion) and in the frontal plain (left/right) are shown. Through left-right-comparison of the muscle activities (left: blue, right: red) existing dysbalances can be deduced. In this it has to be noted that a larger activity shows a greater strain and thus a weaker performance.

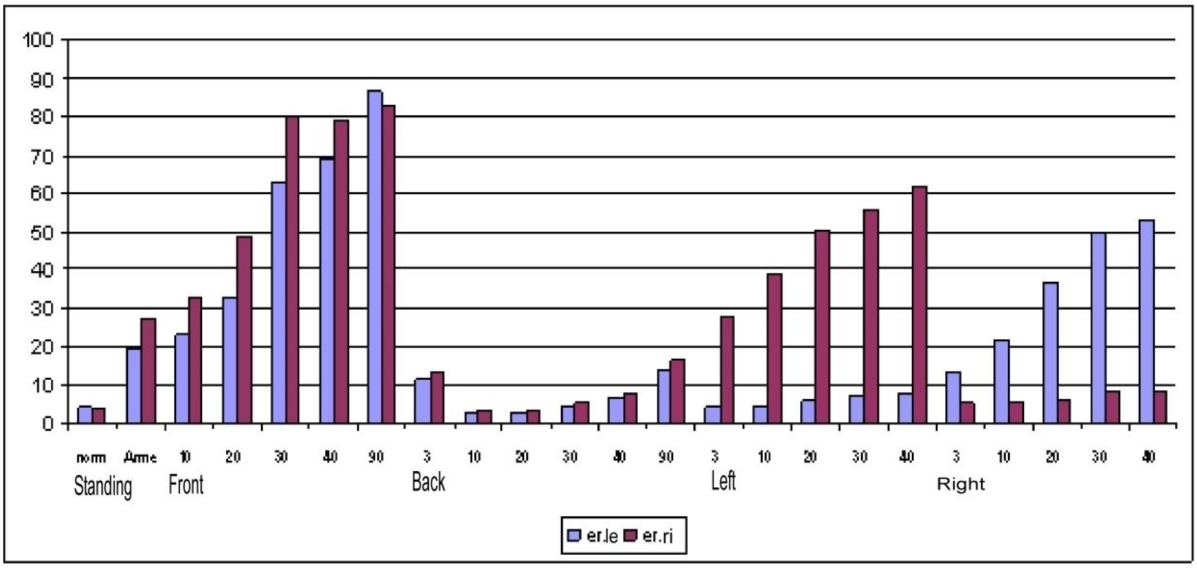


Figure 11b: Activity of the Erectus Spinae muscle (blue: left, red: right) in tilt angles from 0° to 90° (sagittal plain, tilt to the front), 0° to -90° (tilt to the back) and 3° to 40° (frontal plain left/right)

Performance profile of 3D Centaur

3D Centaur allows

- a computer-supported preventative and therapeutic training of the spine-stabilising musculature

- a gravitation-initiated controlled activation of the autochthonic back musculature; an Instrumental Proprioceptive Neuromuscular Facilitation (PNF)
- a functional strength training through synergetic demand on the balance analyser and the sensomotor systems of the lumbar spine motoricity.

Performance characteristic of 3D Centaur

Active principle

- Instrumental PNF – initiated activation of the autochthonic back musculature through activation of the balance analyser

Aim

- Spatial training of the spine-stabilising musculature through changing the body's position in the gravitational field of earth

Method

- Computer-supported seamless control of the movement processes of the training demand and the neuromuscular strain on the lumbar spine motoricity

General performance characteristics

- easy handling
- time and space saving
- great turnover of probands

Potential applications of 3D Centaur

3D Centaur is mainly used in clinics and institutions for rehabilitation, orthopedic and physiotherapeutic departments, fitness and health centers, in workplace, sport and military medicine, in research as well as for prevention of back problems in schools, in large companies, IT-businesses, banks and civil service institutions.

"Functional strength training" of the back's musculature outside of clinical institutions

General Notes

For the maintenance of an achieved result after the conclusion of treatment with a "functional training" in a clinical institution, a daily training of the spine-stabilising musculature is necessary, either at work or at home (figure 12).

To enable a strength training along the lines of the medically controlled "functional strength training" for prevention, minimize the necessary material and time requirements and ensure a high efficiency, Dr. Bluemel developed the method of biofeedback-led strength training on virtual "training devices" using the TN BioMC Software.

Method of the biofeedback.-led strength training on virtual "strength training devices" for the conditioning of the back's musculature

Training on a virtual "strength training device" means the conduct of a real strength training (real use of energy) on an imaginary, not physically present strength training device.

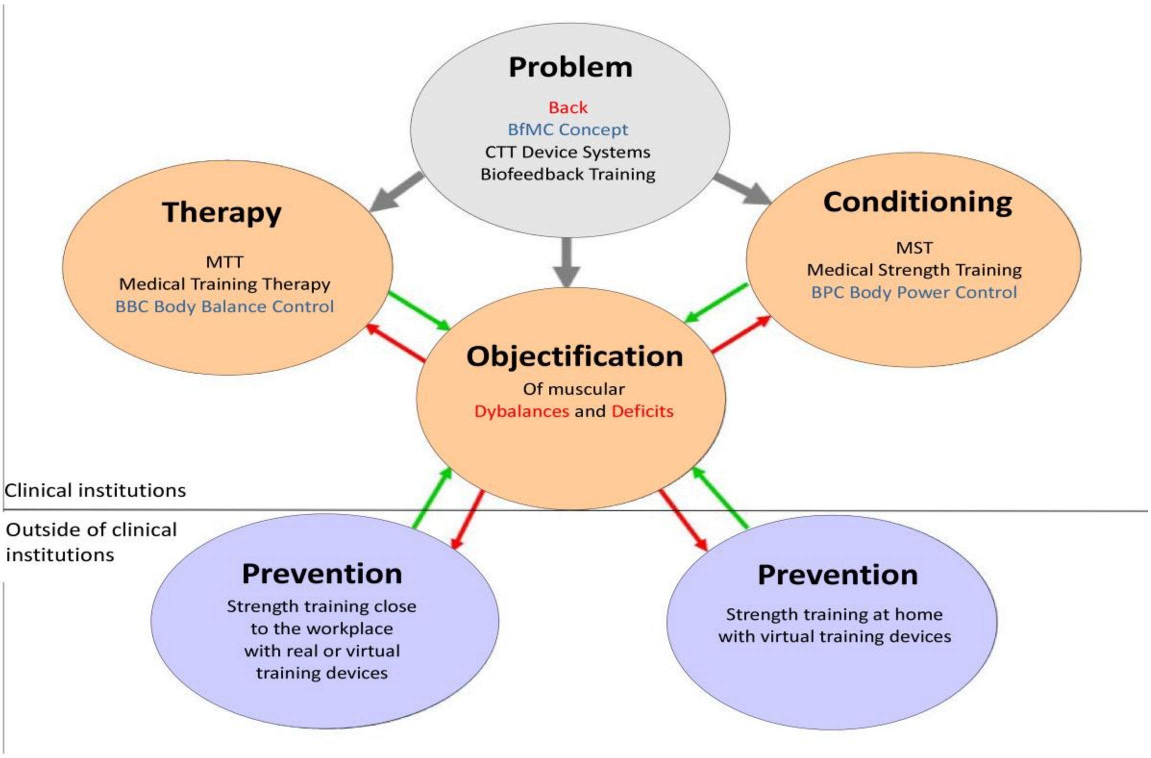


Figure 12: CTT Device Systems for rehabilitation and prevention as used inside and outside of clinical institutions

The conduct of such a training only requires
- a seat and computer with the TN-BioMC Software
- training experience at real strength training devices, which allow the conditioning of the spine-stabilising lumbar and thoracic spine musculature in the three anatomical plains (e.g. 3D Pegasus)

The method of virtual strength training

In the development of the method of strength training at virtual strength training devices, the following considerations came into play: If there is training experience with a strength training device, the proband is able to picture the training situation in his mind and simulate the movement without the device. That means that he/she is able to feel his position in the device and the concrete movement process and even the resistance in the various movement points, depending on how well the proband's imagination is working. Generally, the proband is able to create a resistance against the movement himself by tensing the joint-stabilising musculature and the involved antagonists (muscles). These activities by the proband are the functional basis of yoga and Asian martial arts. In this manner both the drive musculature (agonists/antagonists) and the joint-stabilising musculature can be trained.

The efficiency of the strength training is highly dependent on the movement process, the movement amplitude, movement speed and number of repetitions. For this reason it is necessary to organise a strength training on virtual "strength training devices" along the lines of a computer-supported, biofeedback-led strength-training on real strength training devices. To illustrate the method of strength training on virtual "strength training devices", it is useful to take a look at the differences in the information flow of the sensomotor control paths in a biofeedback-led strength training on real strength training devices versus that of a training on virtual "devices".

Figure 13 shows the information flow of a computer-supported biofeedback-led strength training on real strength training devices.

Sensomotor control paths (real device)

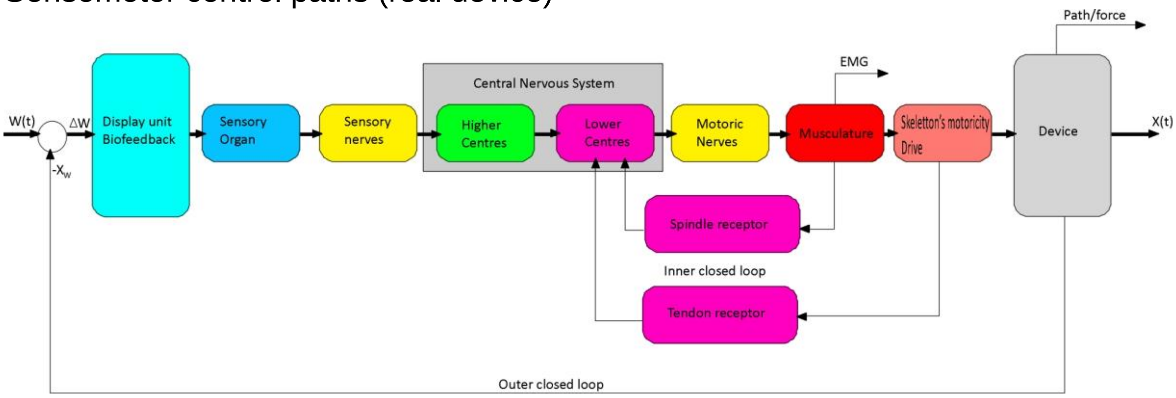


Figure 13: Structure of the information flow of a biofeedback-led strength training (W(t) is the reference value, X(t) is the actual value and $\Delta W(t)= W(t)-X(t)$ is the difference between reference and actual value with $\Delta W(t)\geq 0$)

As shown in figure 13, the leading function W(t) (movement instruction relating to the movement task) is shown as curve on a computer screen. The information gathered by the eye (sensory organ) is passed to the higher levels of the central nervous system (CNS). From there it is forwarded to the lower levels of the CNS (spinal chord) and from there it is send as control signal to the musculature and generates a muscle contraction. The contraction of the muscles creates a force, which is passed through the skeleton to the strength training device (machine) and leads to the respective movements. The contraction state of the musculature is measured through the muscle and tendon receptors and sent to the CNS by sensory nerves (inner closed loop). The movements of the strength training device and the involved forces can be measured and displayed on the screen as follow-up function X(t) through feedback (outer closed loop).

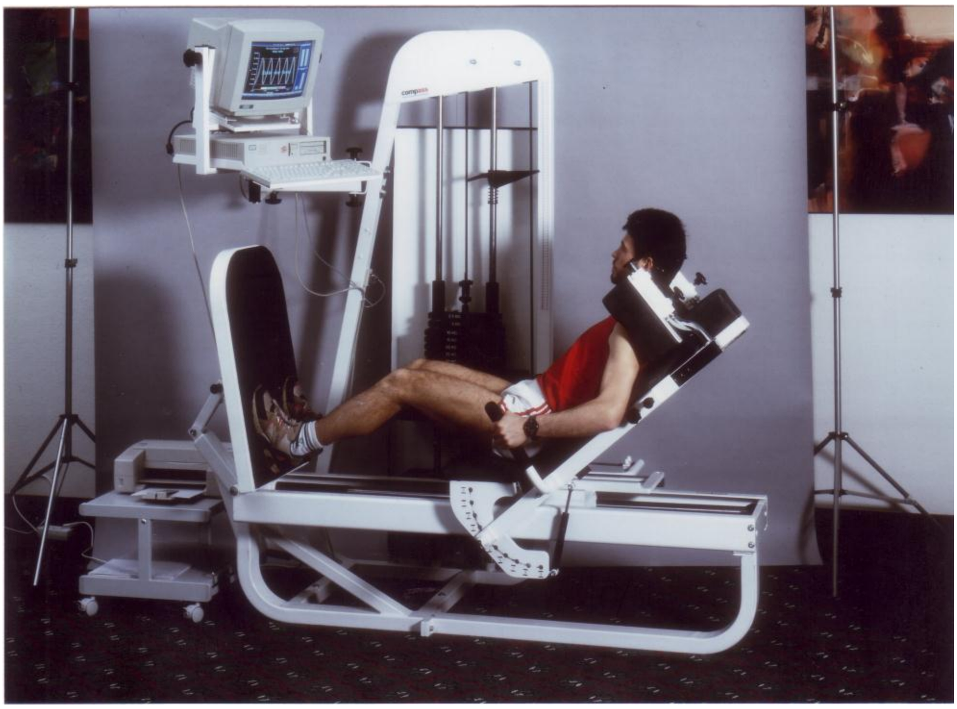


Figure 14: Biofeedback-led strength training on a sequence training device (Leg press) with weights acting as movement resistance

Fulfilling a movement task X(t) on a training device, the proband is the movement regulator, the movement resistance (e.g. the weight that is moved) is the disturbance. The regulator (proband) has to fulfill the movement task X(t) as accurate as possible (follow the leading function W(t) as closely as possible) in spite of the disturbance. The proband seeks to carry out the movement at the device in such a way that the difference between the leading function W(t) and the follow-up function X(t) is minimized (figure 15).

Figure 15: Progress of template function (W(t) [white] and following function X(t))

Training with real strength training devices is a regulated movement process as feedback information about the quality of the movement exists and thus a correction is possible in case of a deviation ∆W(t) of the follow-up function X(t) from the leading function W(t). The aim of the correction is to minimize ∆W(t).

In the realisation of the motoric task movement is usually carried out against a resistance from the outside (generated by the training device). It is mainly a training of the agonists (muscles).

Sensomotor control paths (virtual device)

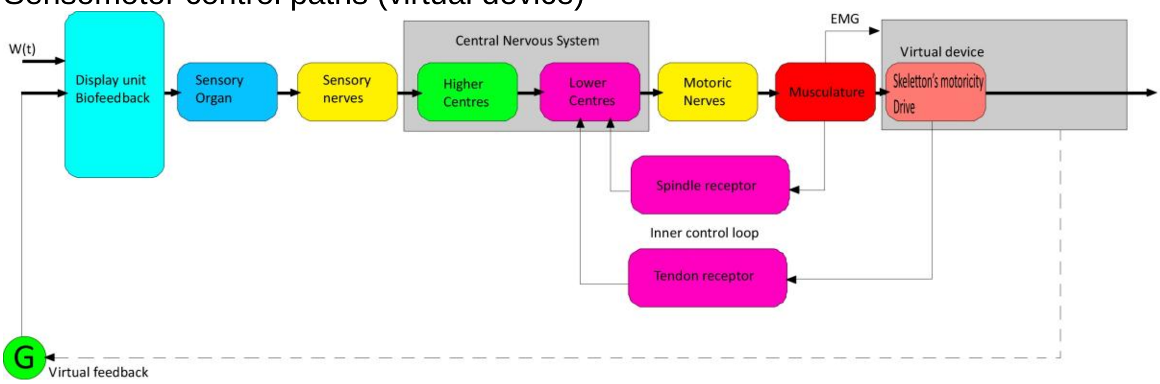


Figure 16: Information flow of a computer-supported strength training with virtual biofeedback on virtual "strength training devices", ∆W(t) =0, as W(t) = G(t) → W(t)=0

Figure 16 depicts the information flow of a computer-supported strength training on virtual “strength training devices”. As can be seen the feedback information about the conducted movement is missing as this is a virtual training with an imaginary device. The information about the actually conducted movement is initiated through the artificially created feedback function, generated by the function generator (G). It is to be understood as virtual “feedback information”.

Fulfilling the movement task on a virtual “strength training device”, the proband is functioning as regulator who generates the disturbance S(t), that means the movement resistance through deliberate activation of the joint-stabilising musculature and the antagonists. Furthermore, he attempts to fulfill accurately the movement task that is given by the leading function W(t) through controlled, deliberate activation of the drive musculature (agonists) (figure 17).

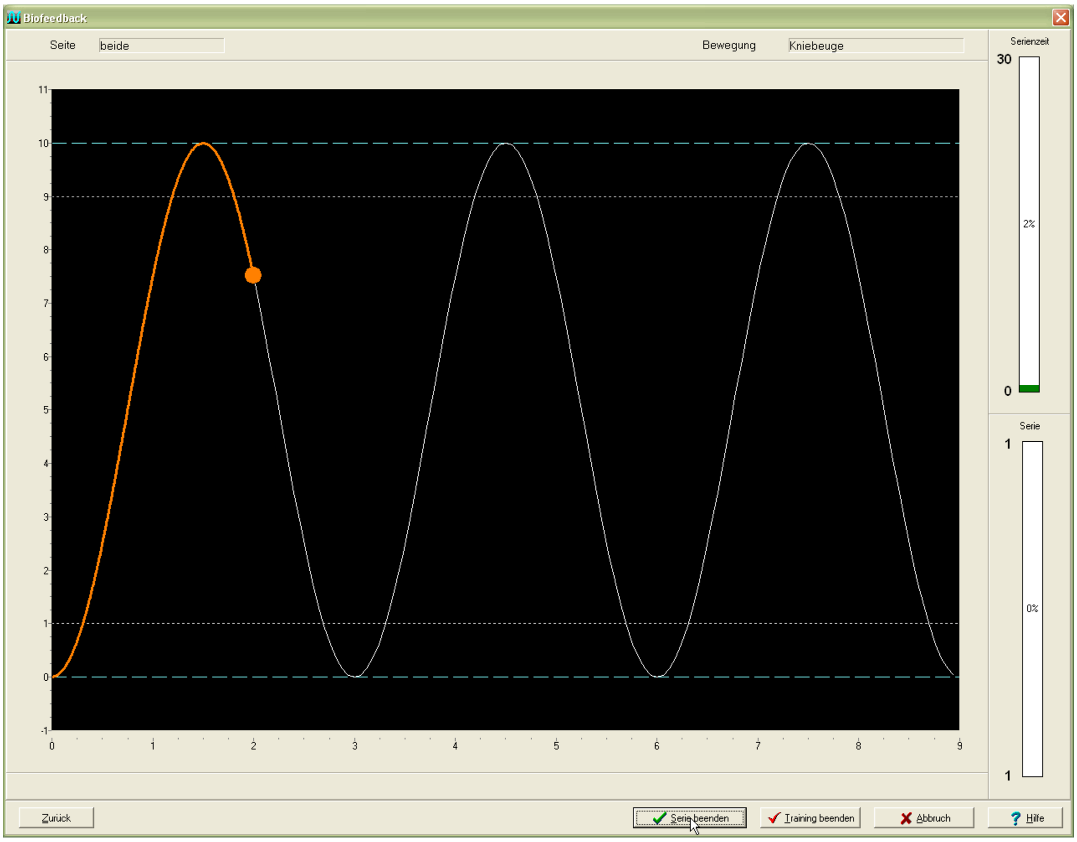


Figure 17: Progress of the reference value [white] W(t); G(t) [orange] is the virtual feedback, substituting for X(t)

G(t) is understood and felt by the proband to be X(t), the process of his own movement. The proband usually feels that his own movement X(t) is accurately depicted through G(t), the virtual feedback (orange), and the leading function W(t) is ideally followed (figure 17)

The training on a virtual “strength training device” is a controlled movement process as there is no real feedback and thus an active correction not possible. The accuracy with which the movement task can be fulfilled is dependent on the movement experience that has been gained during the training on the respective real strength training devices.

The motoric task is realised working against an inner resistance generated through the controlled activation of the antagonists. In this manner both agonists and antagonists are used and thus trained.

In contrast to the strength training on real strength training devices, the proband as regulator on a virtual “strength training device” has to fulfill two movement tasks.

1. Generation of movement resistances through deliberate activation (tension) of the joint-stabilising musculature and the respective antagonists. This movement task is preferably realised through the inner closed loop (figure 16)
2. Realisation of a movement on the virtual strength training device against the resistance of the joint-stabilising musculature and the respective antagonists (figure 18).

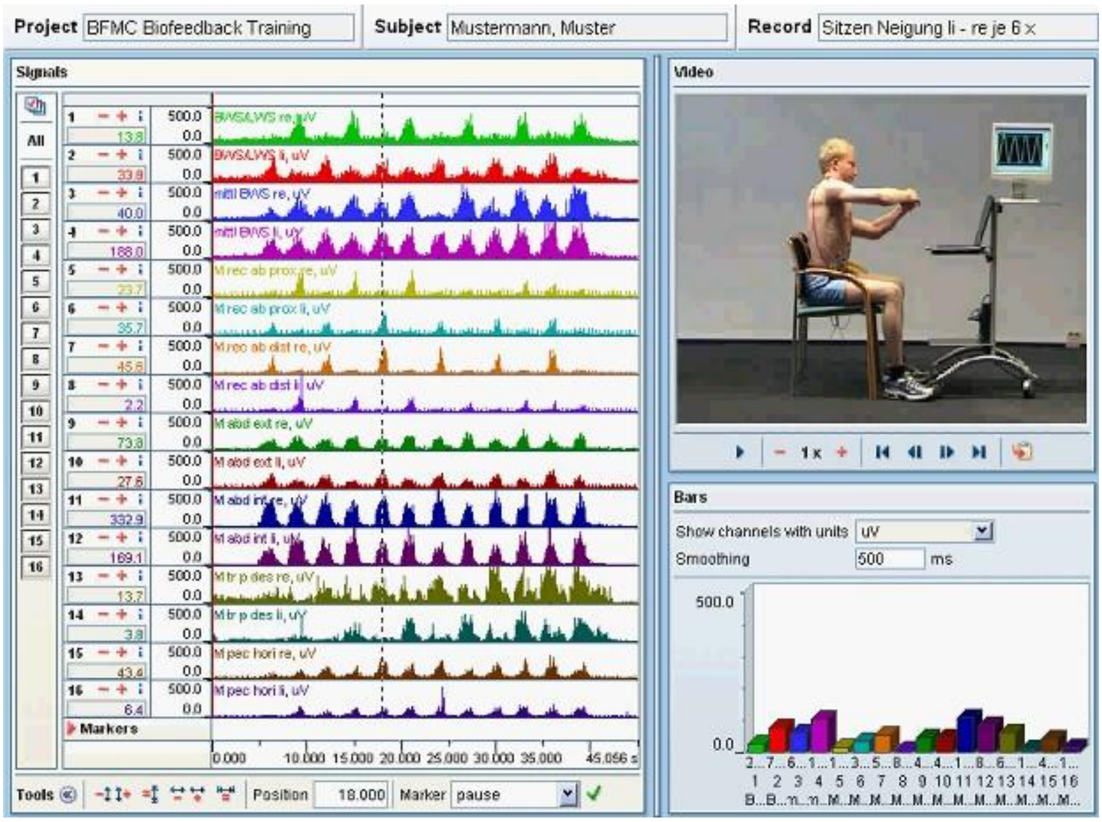


Figure 18: Activation of the torso’s muscles while training on a virtual “strength training device”. EMG records of 8 symmetrically ordered corresponding muscles (left and right of the spine respectively)

Concluding remarks

A computer-supported biofeedback.-led strength training on real CTT strength training devices enables a planned and well reproducible dosage of a complex strain through determination of the quality of the movement execution and the used energy. The aim of such strength training is to achieve therapeutic effect in terms of rehabilitation through eradication existing muscular dysbalances and deficits. Strength training of this kind is to be understood as “functional strength training” and is usually carried out in clinics and institutions. CTT strength training devices that allow a biofeedback-led strength training also fulfill all criteria of a perfect ergometer.

A computer-supported strength training on a virtual “strength training device”, however, aims to maintain the existing, balanced state of the neuromuscular functional systems of the musculoskeletal system and in terms of prevention counteract any potential negative developments (i.e. renewed development of dysbalances and deficits). A computer-supported strength training on a virtual “strength training device” is led by an optical and/or acoustic leading function W(t) and enables a controlled qualitative and quantitative energy expenditure (work). The energy expenditure is generated as a result of deliberate activation (contraction) of the drive musculature (agonists) involved in the movement against the movement resistance of the antagonists and the joint-stabilising autochthonic musculature. In such a strength training both the joint-stabilising musculature as well as the drive musculature is used and thus trained. This kind of strength training fulfills the function of a “functional strength training”, ensures the maintenance of an existing performance standard of the neuromuscular systems and prevents the development of dysbalances as result of false strain, often occurring during uncontrolled training on real strength training devices.

Significant characteristics of the strength training on virtual “strength training devices”:

1. The strength training can be carried out without the physical existence of strength training devices, independent of appointments and location
2. In contrast to the training on real strength training devices, the training on virtual “strength training devices” trains the joint-stabilising musculature (isometric), the agonists (auxotonic) and the antagonists (plyometric) simultaneously.

The special, innovative tools developed by BfMC GmbH Leipzig especially for the “functional strength training” (test and training devices and methods) for the use in clinics and institutions as well as outside of these fulfill all requirements of a functional strength training for a medically controlled conditioning of the spine-stabilising musculature.

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