

# Representation of Solutions by Mechanical Engineering for the Prevention and Control of Health-Problems Due to Lack of Exercise and Wrong Posture while Sitting

Gisela Schon<sup>1</sup>

Mittelstr. 51, 52379 Langerwehe, Germany

**Abstract.** To remedy and prevent health problems resulting from lack of exercise and the associated wrong posture while sitting, it is proposed to move sitting surfaces by means of drive modules in accordance with the natural gait of the sitting person. In this connection, the individual gait of walking impaired and walking disabled persons is determined on the basis of their biometric data and the drive module is then set to the thus determined gait.

**Keywords:** lack of motion, sitting, moving seats, human gait,

## Introduction

While the engineering technology of mechatronics combines the fields of mechanical engineering, electro-, system- and information technology and opens large potentials for the development of future products, bionics concerns itself with solutions that already exist in nature and with their conversion into innovative products. Biomechatronic - one of the most recent fields of activity at technical universities – deals with the interaction between both fields: “nature for technology” as well as “technology for nature”.

## The Medical Problem to be Solved

### Present Situation

Lack of exercise and the associated wrong posture while sitting lead to back-problems like back-pain, damage to vertebrae and intervertebral disks plus cause digestion- and circulation-problems.

At present nearly 70 percent of the total population in industrial nations world-wide suffer from these back-problems - with upward tendency. In Germany as well this is the health problem number 1 and has pushed out the heart-/circulation diseases from first place, which also have a close connection to lack of exercise.

### Historical and Medical Background

From the time our earliest ancestors rose up to become “Homo Erectus” nearly two million years ago, they have “gone” on search for food each day. As hunters and gatherers they spent a mayor part of their day walking, thus in motion and with an “obligatorily” upright posture of the torso.

It has been established that appearance and function of the human back – as an important part of the movement apparatus – represent an adjustment to persevering walking on two legs, the human body shape is a result of this selection process.

In each individual human life this evolution process is reflected:

While with children the metabolism of the vertebral disks is ensured by the disks still being directly connected to the blood supply, at the adult age the exchange of nutrients and waste products of the disks takes place only with the surrounding liquid and functions only by a different

pressure resting on them between lying in bed at night and a necessary upright posture of the torso in daytime.

Only in the last decades we “civilised ones” have turned more and more into a “Homo Sedens”, due to our increasingly sitting lifestyle and working method, with the corresponding back problems. And this is the resulting *circulus vitiosus*:

Sitting motionless and with a bent back for a long time results in cramping of the back- and slackening of the abdominal muscles. This untrained trunk musculature then does not offer the necessary, strong muscle corset for an upright body posture and thus intensifies the painful slouched sitting posture.

## Solutions

### Presently Available Solutions

For humans capable of walking the most logical, simplest, cheapest and at any time passable way out of this vicious circle is regular daily exercise like walking, which is recommended by orthopaedists and pain management therapists even in a state of acute back-pain. The equally effective alternatives to walking, such as dancing, therapeutic riding, cross-country-skiing, back-stroke-swimming or the attendance of back exercise classes entail a still higher temporal, organisational or financial expenditure.

The movements specified above are passive for the pelvis – the pelvis is being moved - with walking, dancing and cross-country-skiing the movement is realised by ones own legs, when riding it is provided by the back of the riding animal and besides in sitting position. Humans adjust such pelvic movements by active muscle work of the entire trunk musculature, to be able to keep head and shoulders calm and this is possible only with an upright posture with the back in its natural double-S-curve.

Yet apparently people with back-problems do not take sufficient advantage of these possibilities from own insight and of their own accord and neither physicians nor employers can “move” them to take up regular exercise in their spare time, so the number of the affected people constantly rises.

For walking impaired and walking disabled people no solution is available at all, they are not able to keep themselves up on a horse, as a horse does neither provide

any kind of upper-body support, nor arm rests or firm supports for the legs.

### **The Innovative Technological Solution**

Problems caused by lack of exercise can be solved by exercise.

The object of the invention is to convert a bionic solution found in nature into innovative technical products by providing the desired movement by means of a seating device, whose sitting surface and thus the sitting person is being moved by mechatronic drive modules.

So any kind of motion pattern is possible, yet especially the combined advantages of riding - being moved while sitting - and walking - being moved in one's own individual gait - shall be provided: on the job, at the working place, during working hours and on top of that with an even better concentration on the actual professional activity.

For disabled people such seating devices offer an opportunity for healthy movement and strengthening of the musculature in an upright sitting posture for the first time ever.

### **Theoretical Solutions – Protection by Patent**

Extensive research in the run-up to the first patent application has shown, that to convert the above idea into seating devices whose sitting surface is moved by a drive module cyclically, continuously and in at least two directions of movement periodically, fulfils the requirements for a patent in reference to novelty (N), inventive step (ET) and commercial applicability (GA).

So the following actions were taken:

- German Patent Application 10/98,
- International PCT-Application 10/99
- Positive International Examination Report 12/00
- Patents granted in 2004

The protection by the conception patents refers to complete seating devices with moving sitting surfaces, including various innovative upper-body supports and if applicable with innovative arm rests and leg supports. Each of these three kinds of supports has its own medical benefit, therefore divisional patents have been applied for, so that these supports are protected with non-moving sitting surfaces as well, and in addition they may be used independently of seats as a resting support with beds and couches.

In order to keep the danger of an evasion of these conception patents low, the area of protection was chosen rather large, protected are:

- all three-dimensional movements of sitting surfaces (on of these is the human gait)
- generated by any kind of drive module (electromechanical, hydraulic, pneumatic, etc.)
- for all kinds of seating devices plus standing supports, footstools, etc. (the result is a multitude of fields of application and target groups)

The movement-pattern for the sitting surface is not limited by the patents and is freely selectable. For non handicapped persons even the quite violent riding

movements on a camel, dromedary or a horse are conceivable, also dance movements to music in the same rhythm. Such standard motion pattern can be produced by rather simple-built electromechanical drive-modules, individualising is not required here. Only the speed shall remain infinitely variable by altering motor performance. In addition the posture of the sitting person and the duration of the operation is to be observed by sensors (1/2 hour daily per person).

Yet movements such as a riding and a dancing are not only too strange and too violent for handicapped people, they might even be disturbing with users of work chairs and have a negative effect on their working performance. The most natural movement for humans is persevering walking, which actually happens completely unconsciously, therefore the sitting surface of the different seating devices shall preferably be moved in the individual gait of the sitting person.

Now walking impaired and walking-disabled persons do not have a gait at all, that may be determined conventionally by means of markers attached to the hips, recorded by cameras and evaluated by computer programs. Therefore the gait shall be determined on basis of the individual biometric data, by simply and quickly taking their body measurements, like length of leg, width of pelvis and size of foot. Users that are able to walk like buyers of work- and office-chairs would profit from a simple and fast determination of their gait as well.

As no studies exist on the relation between the individual gait of a person and the corresponding biometric data, at the Mechatronics Congress of the Association of German Engineers 2001 in Frankenthal and during the Bionics Congress at Saarbruecken contacts were taken up to institutes of the fields of activity specified in the introduction, concretely to the Human Biologists of the University of the Saarland, to Germanys first field of activity Biomechanics at the Technical University of Ilmenau and also to Germanys largest Orthopaedic Hospital of the Friedrich-Schiller-University Jena in Eisenberg.

### **The Project "Spinemover"**

For the financing of the research and development project, which in the meantime was baptised "Spinemover", a participation in the Innovation Contest for the Promotion of Medical Technology 2003 took place and all three institutes offered their services as co-operation partners. With the prize money the project that started on April 1st, 2004, is supported now for two years by the German Federal Ministry of Education and Research, BMBF.

First results of sub-experiment a of the project are already available, in which is being examined with 100 male and 100 female volunteers, whether the already proven systematic use of the trunk movement with walking humans is allometric - can the trunk movement of people, of which they are not measurable, be predicted by means of body measurements.

### **Motion Drive Systems**

With the results of this study the preconditions for the development of two completely different motion drive systems are established.

**Hexapod drive module** for clinical chairs - for frequently changing users - (up to 24 persons in 12 hours) with daily use of ½ hour per person, for persons, that are , not in the position for active, persevering walking, either temporarily after an operation, or permanently because of handicap, or simply for age reasons.

The Hexapod drive module with electronic control unit should be adjustable to other gait patterns by smart card, which will - next to the gait data of the user - save and control the selection and position of the respective required upper-body- and leg supports. In addition monitoring of the sitting duration and the sitting conduct by means of sensors with automatic switching-off mechanism and emergency-call key will provide, that the continuous presence of expensive hospital personnel during the 12-hour operation daily is not absolutely necessary.

Major potential fields of application are: orthopaedic and surgical hospitals, rehabilitation centres, physio-therapeutic practices and old peoples homes. Users of this clinical Hexapod solution are: patient after hip- or knee surgery, rheumatism patients, children with weak posture or problems with the spinal column, patients with general back pain, distortion of the spinal column or the pelvis, in addition, patients after stroke, heart-attack or during dialysis or chemotherapy etc..

Hexapod drives, with which all conceivable motion patterns may be generated – including the human gait - are state of the art (flight simulators, machine tools). As a drive solution for the movement of sitting surfaces however they are protected by the conception patents.

**The mechatronic drive module** for all other seating devices - for only rarely changing users - shall be identical (here also with daily use of 1/2 hour per person = daily duration of operation), in particular for wheelchairs, office chairs, or standing seats, also remobilization aids and footstools, vehicle seats for trucks and busses, driver's seats for trains and ships, in aviation passenger and pilot seats, seats for the space program ISS and therapeutic armchairs for individual use. It shall be developed preferably according to the following specifications: a mechatronic drive module with only mechanical adjustment to switch to other gait patterns, low-build < 120 mm, one electric drive only, with 12 or 24 V DC.

For this most economical, and in reference to its market potential most relevant conversion of the movement of sitting surfaces by the simplest motion drive system with coupled gear, adjustable in three directions of motion to an individual gait, a construction patent has been applied for.

At present in the project “Spinemover” the selection of this technical principle solution has to be made. The module is to be manufactured by order in close co-operation with the universities involved, and it will be integrated into a working model of the “Spinemover”. The volunteers from sub-experiment a will then be examined in sub-experiment b in sitting thereupon, whether the “Spinemover” can provoke the same trunk movements as ones own walking.

In sub-experiment c of the project, in first clinical tests at the Orthopaedic Hospital of the University of Jena will be established if the applied passive movement is tolerable even by patients (with permission of the ethics commission for field tests on humans).

## Scientific Outlook

Further research approaches for the “Spinemover” and/or for various seat versions which can be built according to the patents are:

Testing of other passively induced motion patterns (e.g. camel riding, belly dance, standard dances, etc.) in the connection with psycho-motoric and psychological aspects

Employment of the height-adjustable version "standing seat" or the standing aid compared with existing "walking and remobilization devices", which the aim of making patients walk again

Prevention of falling asleep and of the negative effects of the vibrations while driving (train-, bus- and truck seats)

Employment for patients with paralysis and movement disturbances after a stroke

## References

[ 1 ] Witte, H. (1992): Ueber mechanische Einflüsse auf die Gestalt des menschlichen Koerpers. – Diss. Bochum.

[ 2 ] Witte, H. (2002): Hints for the construction of anthropomorphic robots based on the functional morphology of human walking. - journal of the Robotic Society of Japan 20(3): 247-254.

[ 3 ] Witte, H. & Fischer, M. S. (2000): Evolutionsbiologische Betrachtungen zu den Entstehungsbedingungen menschlicher Wirbelsaeulenerkrankungen. in: Radandt, S., Grieshaber, R. & Schneider, W. (Hrsg.) Praevention von arbeitsbedingten Gesundheitsgefahren und Erkrankungen. Monade Konzept & Kommunikation, Leipzig, 64 - 72.

[ 4 ] Witte, H., Hoffmann, H., Hackert, R., Schilling, C., Fischer, M. S. & Preuschhof, H. (2004): Biomimetic Robotics should be based on Functional Morphology. - J. Anat. 204: 331-342.

[ 5 ] Witte, H., Schilling, N., Hoffmann, H., Hackert, R., Voges, D., Lilje, K. E., Schmidt, M. & Fischer, M. S. (2002): Der Rumpf wird vom Menschen und von anderen Saeugetieren systematisch für die Fortbewegung genutzt. – In: Grieshaber, R., Schneider, W., Scholle, H.C. (Hrsg.) Praevention von arbeitsbedingten Gesundheitsgefahren und Erkrankungen. Monade Konzept & Kommunikation, Leipzig, 291-304.