INTRODUCTION
The supply of various spinal diseases with a spinal orthosis is an important, but also a hotly discussed part of the conservative spinal column therapy [3,5,6,7]. The evidence of the biomechanical effectiveness of different orthoses, in the sense of the desired changes of thoracic spine (TS) kyphosis and lumbar spine (LS) lordosis, even under normal everyday movement patterns wasn’t produced clear to this day. Therefore, the main criterion for the use of orthoses is usually the subjective experience of the treating physician. For that reason, osteoporosis patients and a control group were examined in this study to find out whether and how strong the changes to the sagittal spinal posture are caused by wearing a semi-rigid reclination brace and a rigid hyperextension brace with 3 point-support.

The aim of this work was, apart from proofing the actual spine-straightening and spine-stabilizing, and supporting effect of orthoses to provide the evidence of validity of the used modified measurement method. To achieve the objectives, a three-dimensional (3D) movement analysis was carried out by using the zebris system [9].

In performing everyday movement patterns, the degree of TS kyphosis and LS lordosis was measured while wearing the afore-mentioned orthoses and subsequently compared to the sagittal spinal posture without orthosis.

To be able to make comments about patient compliance and to examine possible correlations between objective and subjective measurement data, relevant data are gathered by the use of a personal and the SF-36 questionnaire as well as the Visual Analogue Scale (VAS).

METHODS
39 female patients (70 ± 6 years) with the inclusion criteria of (manifest) osteoporosis (DXA T-value <-2.0) or osteopenia (DXA T-value <-1.0), chronic back pain and where applicable singular or multiple stable vertebral body fractures of the 1st, 2nd or 3rd degree were examined as well as a healthy control group (n=17; 56 ± 9 years) [2]. As it was intended to check how the orthoses work in everyday situations on the test subjects, the standing tests were carried out while in a habitual pose, the walking took place at a comfortable self-selected pace on a treadmill and the sit-down and stand-up movements were carried out in a similar manner to the chair rising test. The 3D movement analysis was performed with the ultrasound-supported zebris measuring system CMS-HS and the software WinData (zebris Medical GmbH, Isny, Germany) in accordance with the modified measuring method [9].

The measurement accuracy of the system is ±1 degree and the spatial resolution is in the millimetre range [8,9]. The data compiling was carried out in real time according to the principle of the runtime measurement of ultrasound impulses. The small ultrasound transmitter are usually attached directly to the surface of the skin and are measured in the frontal level. However, in order to be able to record the sensors and the back area with its curvatures from the side, five markers were stuck on the side onto adapters, which were specially made for this study, before they were positioned in the previously determined fixed points. The fixed points were the 7th cervical, the 12th thoracic and the 1st sacral vertebrae. Based on the STAGNARA method (1973) for measuring the spinal index, the last two measurement points were reached by a raised plumb from the sagittal level going over the spinous process and through the Rima ani [1,4]. The point touched by the perpendicular, defined as the apex of the TS kyphosis, hereby represents the fourth measuring point. The curvature apex of the LS at the height of the Flèche lombaire represents the fifth. The orthoses to be measured were prepared in a way that they were not altered in their original form and function.

In order to be able to make a statement regarding the objective of this study and to investigate whether the degree of kyphosis and lordosis changes by wearing orthoses, the data had to be edited appropriately. The parameters mean (M), standard deviation (SD), maximum (Max), minimum (Min) and range (R) were formed from the raw data: 10 seconds of standing, the middle step formed over 10 double steps (interpolation of the steps by using the software LabView) and the mean over two standing-up and sitting down processes each. The use of foot contact switches during the tests made it possible to allocate the measured angular values to the individual walking phases and sub-phases.

A 2-factor (patient vs. control and with orthosis vs. without orthosis) mixed ANOVA was used to detect significant differences for the TS- kyphosis and LS- lordosis (P< .05). Furthermore, it was examined whether there are significant differences between the group effects and whether interactions exist between the factors groups and orthoses.

A non parametric Spearman correlation test was carried out to determine relationships between the significant angle differences and the questionnaire parameters of speed, BMI, loss of body size (as an important characteristic of osteo-porosis) as well as the various categories of the SF-36 questionnaire. The correlation to the subjective orthoses assessment by test subjects was also examined.

RESULTS AND DISCUSSION
Significant differences between the different orthosis conditions were determined for the TS- angle and the LS-angle on all movement patterns. It was possible to make a clear statement about the biomechanical effects of the examined orthoses on the sagittal spine profile with formation of the angular differences in the comparisons with reclination brace – no brace and with 3-point-brace – no brace. The range, as the distance between the largest and smallest angle value, declares the average movement scope in a measurement process. If the difference in the comparison of two movement scopes is negative, a stabilizing and
supporting effect can be inferred from the angle reduction due to the tested orthosis. An angular magnification of M, Max and Min is assessed as spine-straightening on the other hand.

The most significant angle changes for the LS were defined in the comparison 3-point-brace – no brace (Figure 2). While standing, the rigid orthosis had a strong straightening effect to the LS and therefore a reduction of lumbar lordosis of ~14° (M, Max, Min; P<.001).

![Figure 2: Comparison 3-point brace - no brace. Angle differences for the lumbar spine angle (**P<.001; *P<.05).](Image)

Significant angle increases for M, Max and Min of the middle step between ~8° and 10° emerged from the results of the walking measurements (p<.001), which allow us to draw the conclusion that the hyperextension orthosis straightened the LS during the whole gait cycle. Similar results were found for the here not shown sub-phases of the gait cycle. The movement range during walking was significantly reduced by up to ~2.5° (P<.05).

When standing up and sitting down significant increases to the Min of ~15° and significant reductions in the R of ~14° were determined for the rigid brace (P<.001). Consequently, it can be assumed that the 3-point orthosis causes a severe reduction in the movement range of the LS angle and due to its straightening effect in the minimum the LM lordosis is reduced. The causes of this overall strong changes to the lumbar angle are to be seen both in the rigid material of the brace and in the punctual 3-point support. M, Max and Min of the TS was straightened significantly in all movement patterns and in the static condition (~+1°). When standing up there was a significant reduction in the R of 0.6°. Since these small angular differences are in the range of error, they are not discussed, despite of significance.

The semi-rigid back orthoses made no verifiable change to the TS while standing and walking. A significant decrease of the movement range by ~1° was detected while sitting down and standing up. At the same time, the minimum was increased by ~1° (when standing up: p<.01). This could indicate that with more extensive movement, the movement range of the TS angle could be limited, which may be caused by the shoulder strap of the orthosis.

For the lumbar spine, significant minor reductions were determined for the rigid brace (P<.001). Consequently, it can be assumed that the semi-rigid reclination orthosis has an even greater straightening effect that the semi-rigid reclination orthosis.

There were significant differences in the TS angles between the patient and the control group for all examined movements and in the static condition. For the LS angle this was only able to be detected in the static condition (P=.004). The interaction effects during walking in the last stance phase are due to the low angle change values, which are not discussed here (up to ~0.5°) (TS angle: P=.001; LS angle: P=.038).

Significant correlations according to Spearman between the objective significant angle changes of zebris measurements and the subjective orthoses assessments of the probands could not be detected. This is a clear indication that the actual biomechanical and clearly exposed effects of the examined orthoses were not perceived subjectively.

Medium to full significant correlations (Spearman rho r>0.4, P<.05) between the above-mentioned significant angle differences and the BMI, loss of body size, walking speed and the various categories of the SF-36 questionnaire could not be proved.

CONCLUSIONS

The validity of the described modified measurement method could be evidenced clearly in this study. The results of the metrological investigation allow objective comparisons between the orthoses conditions. Therefore the biomechanical effect of the considered orthoses in relation to the thoracic and lumbar curvature of the back could be specified accurately. Furthermore, a strong indication was given that the patient’s subjective perception can be totally different from the actual objective effect of a brace. The easy-to-use and non-invasive technology of the specific measurement methodology can be easily transferred to other types of orthoses and investigation cases.

REFERENCES