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Forced posture of neurology residents in daily routine on the ward in Germany

A pilot study

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Abstract

Background: The aim of this pilot study was to analyze the work of neurologists regarding static posture (> 4 s) and to identify awkward postures.
Methods: A total of 9 neurologists (assistant physicians; 3 male, 6 female) participated in this study. Kinematic data were collected using the computer-assisted acquisition and long-term analysis of musculoskeletal loads (CUELA; IFA, Sankt Augustin, Germany) system. Daily work ("office work," "measures on patients," and "other activities") was analyzed with a computer-based task analysis.
Results: During "measures on patients," more than 80% of the total percentage of non-neutral posture was assumed with a flexed position of the head and entire back, both during "blood collection" (4.7% of the time) and while "placing intravenous catheters" (8.3% of the time). In contrast, long static postures (> 30 s) in the head and neck area, including the thoracic spine, were adopted during "office work." Despite the increased total percentage of non-neutral attitudes during measures on patients, the time share of 3.4% of the total working time is so small that the risk for developing musculoskeletal disorders (MSD) is negligible. In contrast, office work, which comprises 50.8% of the total working time and longer static postures, has a potential risk for the development of MSD.
Conclusion: The present study is the first kinematic pilot analysis in the field of in-patient neurological assistants. Non-neutral as well as static postures in everyday work could be identified. Potential MSD can be reduced by optimizing the working height and by taking regular breaks to loosen the musculoskeletal system.

Keywords
Medical staff · Workplace · Postural control · Kinematics · Musculoskeletal diseases

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Availability of data and materials
All data generated or analyzed during this study are included in this published article (and its supplementary information files).

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Work-related musculoskeletal disorders (MSD) are a global health problem that can have a negative impact on individual wellbeing and lead to significant costs for society [1]. In general, muscular imbalances and the resulting disorders are mainly caused by poor posture at work [2]. These disturbances are most likely caused by continuous work in static postures, but also by repetitive work processes [3].

Extensive studies of various professions, e.g., from the health sector (such as nursing staff [4] or physiotherapists [5]) and the service sector (such as construction workers [6]) verify this.

Particularly in the health sector, medical staff [7, 8] showed a high prevalence of musculoskeletal pain in the neck, shoulder, and lower back area [9, 10].

Basically, the activity of a physician is divided into two parts, namely standing

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Fig. 1 ▲ Image of the computer-assisted acquisition and long-term analysis of musculoskeletal loads (CUELA; IFA, Sankt Augustin, Germany) measuring system

activity with the patient and sitting activity in the office for documentation purposes. This is also the case with neurologists: the neurological patient often shows limited or no cooperation, (e.g., due to stroke or character changes). This often poses great physical challenges for the physician. Like nursing staff [11], the physician must hold, lift, turn, and support the patient in order to carry out examinations or diagnostic measures. Often, these measures are carried out in forced static postures without support. Furthermore, there is a great workload due to increasing administration and documentation obligations [12], particularly for neurologists [13]. Mache et al. [13] demonstrated that on the one hand, there is a high volume of work, and on the other hand, there exists a high proportion of administrative work. An important factor that could not be analyzed in the context of objective activity analysis was the physical workload of a neurologist. The study by Bijanzadeh et al. [14] was able to deliver some initial evidence for the postural analysis of neurologists and the risk assessment for MSD. However, data on static postures are lacking. In previous studies the Rapid Upper Limb Assessment (RULA) [15, 16] was used to measure static postures [15]. Static postures can also be analyzed by means of kinematic analysis, for which the computer-assisted acquisition and long-term analysis of musculoskeletal loads system (CUELA) can be used [2, 13, 17–19].

Therefore, it is useful to first analyze how neurologists work in everyday routine and identify possible ergonomic risk factors (such as forced or static postures) that may favor MSD.

Consequently, the aim of this study was to investigate the neurological workday by kinematic analyses by using a combination of the CUELA measuring system and the already established objective activity analysis to reconstruct the physical activities of the neurological working day. In this context, the CUELA system has already been used successfully in several studies [2, 18, 19].

On the one hand, it was examined whether there is a general difference between the individual body regions with regard to the static postural components, whilst on the other hand, the three categories—I) "office work," II) "measures on patients," and III) "other activities"—were compared with regard to the question of which category and, more precisely, in which body region, the highest proportions of static postures are to be found.

Abbreviations

CUELA	Computer-assisted acquisition and long-term analysis of musculoskeletal loads
MSD	Musculoskeletal disorders
RULA	Rapid Upper Limb Assessment

Materials and methods

Subjects

After presentation of the planned survey within a university hospital and a municipal teaching hospital, a total of 9 (3 male/6 female) assistant physicians in neurology were recruited. Mean age was 32.1 ± 4.9 years and median work experience was 4.0 years (first quantile: 1.0 year; third quantile: 9.0 years). The weekly working hours were 51.6 ± 8.7 h. They were accompanied for an entire shift on the ward on any given workday except weekends. The weekend was omitted because of changes in work assignments, such as additional duties in the emergency department or sole care of the ward. During data collection, a minimum distance of 2 m had to be maintained from the data collector to the physician. In addition, conversations between the data collector and physician were avoided. These measures were taken to reduce any influence on the physician's behavior. In addition, factors such as work in the functional department (diagnostic department in which, e.g., electroencephalography and sonography of the head and neck vessels take place), work in the intensive care unit or emergency room, and acute or chronic complaints of the musculoskeletal system were defined as exclusion criteria. No unusual symptoms were expressed by the neurologists examined; accordingly, this information was not integrated into the evaluation. This study was approved by the Ethics Commission (135/14) of the Goethe University Frankfurt am Main. All participants signed the required informed consent form for participation in the study in advance. All methods were carried out in accordance with relevant guidelines and regulations.

Measurement systems

CUELA system

The CUELA measurement system [20] (IFA; Sankt Augustin, Germany) is a motion-capturing system weighing approximately 3 kg; it is characterized by gyroscopes, acceleration sensors, and potentiometers which enable kinematic reconstruction of the joint angle. Since all sensors are connected via flexible cables, the respondent can easily perform movement in all planes. This allows each individual body segment to be scanned in real time with a frequency of 50 Hz and an angular accuracy of 1° [4]. Based on this information, a 3D avatar is built and the avatar calculates the 3D coordinates of all joints and the relevant joint angles. Algorithms that use these coordinates and angles can calculate postures such as sitting, standing, or walking. Based on these algorithmic assumptions, it is then possible, e.g., to differentiate between sitting with and without leaning on a chair.

Table 1 Presentation of all categories with the respective work steps and their explanations

Interval	Description of the activity
Office work	
Viewing the file/ documentation	View paper file on the rounds trolley, document if necessary
View file/PC	View file on PC
Sort file	Remove file from the visit trolley and file papers
File entries	Entries in paper files at the desk
Physician's letter/final report	Writing a physician's letter on the PC
Morning briefing	Sitting at the table and attending a meeting
PC work	Diagnostic evaluation, e.g., laboratory values, findings, on the PC
X-ray pictures	Discuss radiological images with radiologists in the demo room
Telephone	Telephone calls via mobile phone, fixed network
Measures on patients	
Blood collection	Draw blood from patient
Conversation and notes/ medical history	Visit interview, admission interview with notes
Hygiene	Hands washing and disinfection
Patient education	Informing the patient about planned diagnostics
Lumbar puncture	Puncture of the spinal cord to obtain lumbar fluid
Investigation	Clinical examinations of the patient
Placing intravenous catheters	Placing the intravenous cannula to administer the infusion
Other activities	
Conversation	Conversations/discussions with relatives and colleagues
Way	Way to patients, physician's room, round trolley, wardroom (the "way" takes place mainly on the ward)
Way and stairs	Walking distances for lunch, X-ray discussion, functional department (department where examinations such as electroencephalography and sonography of the neck and head vessels take place)

Possible drift errors resulting from integration of the gyroscope values are compensated by continuous mixing with the accelerometer data so that no relevant drift errors occur with this approach [21]. For the measurements, the participants wear an upper body vest under their working clothes, on the back of which the data storage unit of the posture system is attached. The sensor system for measuring torsion, lateral flexion, and flexion of the upper body is located in the upper thoracic spine area. The lumbar spine area is detected via a flexible shaft that merges into a lower sensor box. Additional sensors are attached to the extremities to measure flexion and extension movements. For analysis of cervical spine posture, the subject wears a headband with a sensor, which is connected to the upper sensor box of the thoracic spine (**Fig. 1**). Applying the setup takes approximately 30 min.

Mini-PC (objective activity analysis)

The objective activity analysis was established as a measurement method by Mache et al. in 2008, and in this context, this group of authors has confirmed its validity and reliability for both intra- and inter-rater comparisons [21]. Prior to the experiment, the work behavior of the neurologists was documented through precise observations and analyses. The respective results were discussed and analyzed in collaboration with two experienced neurologists. These activities were subsequently implemented into the activity analysis software. In accordance with the range of work, the computer program was modified in advance and on the basis of the detailed analysis, so that the various categories of activity corresponded to the neurologist's field of work. In this way, the individual activities can be named directly, and their duration recorded on the portable mini-PC at the same time.

For a better overview, three main categories were formed: "office work," "measures on patients," and "other activities," which reflect all the activities of everyday working life. A total of 19 activities were distributed within the three main categories. The grouping serves to simplify similar movement patterns that can thus be compared. Each category consists of a different number of subcategories (**Table 1**).

Experimental procedure

For this field study, any working day of an in-patient neurologist was randomly selected. Each participant wore the sensors of the CUELA system on their arms and legs as well as on the thoracic and lumbar vertebrae under their clothing.

Parallel to recording via the CUELA system, supporting data collectors with a distance of 2 m accompanied the participants and documented every movement of the neurologist on the mini-PC.

With the software program developed specially for the CUELA system, the data could be synchronized with the CUELA system. Each individual posture and all movement patterns of the neurologists/ participants were thus visible in an angle–time diagram.

Data evaluation

With the help of the CUELA software, the activity analysis data were synchronized with the CUELA measurement and temporal assignment of the resulting movement patterns and the associated activities was thus possible. Each work category was then classified into percentages according to relevance and duration. To compare the measured angles of the different activities, the percentiles 5 (P05), 25 (P25), 50 (P50 = median), 75 (P75), and 95 (P95) were used as output variables. This means that at the percentile of 5 (P05), 5% of all measured angle values within an activity are below this point and 95% are above for all measured values over time.

The angle values for each body region were evaluated according to the percentile intervals according to ergonomic aspects and assigned to a color-coded angle area that represents ergonomic standards (traf-

Body regions	Body area	Degree of freedom according to medical Definitions	Valuation parameters	Evaluation of the angular range according to ergonomic arrangement
Head/neck	Head	Sagittal inclination	Flexion/ Extension Head	Neutral: 0° to 25° Moderate: 25° to 85° Awkward: < 0° & > 85°
		Lateral Flexion	Head tilted to the side	Neutral: -10° to 10° Awkward: < -10° & >10°
	Cervical spine	Flexion/Extension	Neck tilt forwards/ backwards *[Difference between head and thoracic spine]*	Neutral: 0° to 25° Awkward: < 0° & > 25°
		Lateral Flexion	Neck tilt to the side *[Difference between head and thoracic spine]*	Neutral: -10° to 10° Awkward: < -10° & >10°
Back	Thoracic spine	Flexion/Extension	Thoracic spine: inclination forwards/backwards	Neutral: 0° to 20° Moderate: 20° to 60° Awkward: < 0° & > 60°
		Lateral Flexion	Thoracic spine: inclination to the side	Neutral: -10° to 10° Moderate:-10° to -20° Moderate: 10° to 20°
				Awkward: < -20° & > 20°
	Lumbar spine	Flexion/ Extension	Lumbar spine tilt forward / backward	No ergonomic layout available
		Lateral Flexion	Lumbar spine inclination to the side	
	Torso	Flexion/Extension	Back tilt forwards/ backwards *[Difference between thoracic and lumbar spine]*	Neutral: 0° to 20° Moderate: 20° to 40° Awkward: < 0° & > 40°
			Inclination of the torso to the front *[Median flexion of thoracic and lumbar spine]*	Neutral: 0° to 20° Moderate: 20° to 60° Awkward: < 0°& > 60°
		Lateral Flexion	Back inclination to the side *[Difference between thoracic and lumbar spine]*	Neutral: -10° to 10° Moderate:-10° to -20° Moderate: 10° to 20° Awkward: < -20° & > 20°
			Inclination of the torso to the side *[Median lateral flexion of thoracic and lumbar spine]*	
		Torsion	Back torsion to the side *[Difference between thoracic and lumbar spine]*	

Fig. 2 ◀ Display of the recorded body/joint angles of the applied body regions and evaluation criteria according to ergonomic aspects

fic light: system red/yellow/green) [2, 18, 19]. Based on the respective colors in accordance with ISO standards [22–24], postures were classified as awkward, moderate, or neutral (**Fig. 2**).

For each body region, the percentage was calculated and evaluated according to the criteria for classification in order to analyze whether the activities were carried out in a neutral, moderate, or awkward posture for all workday categories (categories I, II, and III). The percentage of moderate and awkward postures were then added and summarized as values that represent a non-neutral posture. The overall statistics show the percentage of static non-neutral posture for each activity and for each body region [19]. In accordance with the ISO ergonomic standards [23, 24], postures were classified as moderate or awkward or even static for longer periods than 4 s. Based on the RULA method [15] for static postures, in addition to the threshold of over 4 s, a distinction was also made between postures that were held for longer than 30 s, between 10 and 30 s, and postures that were held for between 4 and 10 s [25].

To evaluate the kinematic data, all non-neutral movements were considered with a percentage of ≥ 50% of the total activity duration and a conspicuous percentage of static postures ≥ 25%. If there were no abnormalities for the total proportion of static posture, the data material for non-neutral postures was analyzed by ≥ 75%. These thresholds of static postures can then establish in relation to the prior classifications.

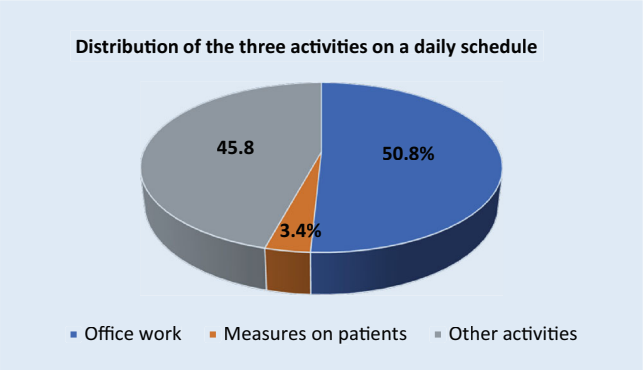

Fig. 3 ◀ Distribution of the three activities on a daily schedule

Fig. 4 ▶ Office work: percentage of neutral, moderate, and awkward postures of the total duration, percentage of awkward postures as the sum of all moderate and awkward postures, and the percentage of static postures ≥ 4 s during the treatment. *Total percentage of static postures* sum of all moderate and awkward postures that occurred during all activities. The non-neutral postures are ranked using a color-coded system according to the appropriate ergonomic standard: *green* neutral; *yellow* moderate; *red* awkward

Results

The total data collected for non-neutral postures amounted to 64.8 h (3885.74 min, excluding breaks and toilet visits because these were not related to the professional activity; often there were no breaks). Thus, nine neurologists were measured for an average of 8 h. The mean value of all nine test persons was always used for data evaluation.

Fig. 3 shows the daily proportions of the three main categories. Category I, "office work," accounted for 50.8% (1972.99 min) of the data material and included nine activities such as computer work, documentation of findings, and treatment plans. Category II, "measures on patients," included eight activities and comprised 3.4% (131.03 min). In category III, "other activities," three activities were listed and comprised 45.8% (1781.72 min) of the time.

Figs. 4, 5 and 6 show the percentage of postures for the corresponding activities within each category, including the ergonomic layout (neutral, moderate, awkward). In addition, they include the sum value of non-neutral postures (moderate + awkward postures). Furthermore, they also contain the proportion of static postures adopted for ≥ 4 s during office work, measures on patients, and other activities.

Category I (office work)

A static posture analysis of the activities during office work (category I) was carried out on the basis of the three most frequent subcategories, "PC work," "morning briefing," and "physician's letter/final report" (**Fig. 4**).

The subcategory "PC" work accounted for the largest share of the time, with a total duration of 29.5%. The neck tilt to the side was significantly increased, with a total percentage of 77.3% of non-neutral posture. Of this, 72.6% of lateral flexion to the left and 4.7% lateral flexion to the right were in an awkward posture. Furthermore, the total percentage of static posture was determined to be 48.1%; 18.1% of the time was held for more than 10 s and 17.0% of the time for more than 30 s. For the thoracic tilt forwards/backwards, the total percentage of non-neutral posture was striking, at 61.0%. The thoracic flexion was 54.5% in the moderate range. The total percentage of static postures was also higher, at 53.9%. Of this, 29.9% of the time was assumed for longer than 30-s duration and for 17.3% of the time for longer than 10 s. Conspicuous values could be documented for the forwards inclination of the back. The total percentage of non-neutral posture was significantly higher, at 81.5%. It was observed that 36.6% of flexion posture was performed in an awkward posture and 42.7% in a moderate posture. The total percentage of static posture was 72.1%. For 44.6% of the time this was held for longer than 30 s, while for 20.1% of the time, this was longer than 10 s.

The "morning briefing" accounted for the second largest share of time with a duration of 17.6%. For the head tilt forwards/backwards, a total percentage of non-neutral posture of 54.5% was documented; 39.4% of the head extension were performed in an awkward posture. The total percentage of static posture was 35.6%. Both the lateral inclination of the head and the neck tilt forwards only represented a small percentage of the total percentage of non-neutral posture and the total percentage of static posture (**Fig. 4**). In contrast, a total percentage of non-neutral posture of 72.5% was documented for the neck tilt to the side. Of this, 59.3% of lateral flexion to the left and 13.2% to the right was performed in an awkward posture. The total percentage of static posture was 48.5%; 19.4% of the duration was longer than 30 s and 17.2% longer than 10 s. The thoracic inclination forwards/backwards showed a total percentage of non-neutral posture of 68.3%. Of this, 29.1% of the extensions were performed in an awkward posture and 39.2% of the flexion in a moderate posture. The total percentage of static posture was 65.0%; of this 55.4% was held for more than 30 s. The trunk inclination forwards/backwards resulted in only moderate values of both awkward and static posture (**Fig. 4**). Equally moderately increased values were shown for the back inclination forwards/backwards in both the total percentage of the non-neutral posture (59.9%) and the total percentage of the static posture (54.7%). For 44.6% of the time, static posture was held for longer than 30 s, while 30.8% of the back inclination forward was performed in an awkward posture.

The subcategory "physician's letter/final report" accounted for the third largest percentage of time, with a duration of 15.9%. Conspicuous values were shown for neck tilt to the left, which was performed in an awkward posture in 65% of cases. The total percentage of non-neutral posture was increased to 70.8%. The total percentage of the non-neutral posture of the thoracic inclination forwards/backwards was 63.9%, whereby 60.9% of flexion was in a moderate and only 3.0% of extension in an awkward

Body region	Activities	Duration	Postures					Static posture:>=4s	Static posture:>=10s	Static posture:>=30s	Total percentage of static posture	Total percentage of non-neutral positions
			Awkward	Moderate	Neutral	Moderate	Awkward					
			Extension/ to the left			Flexion/ to the right						
		% of the time	%	%	%	%	%	%	%	%	%	%
Head tilt Flexion/ Extension	Viewing the file/Documentation	9.5	26.9		34.4	38.5	0.2	12.1	16.3	7.4	35.9	65.6
	View file/PC	1.9	3.2		37.1	59.3	0.3	5.9	13.2	29.2	48.3	62.8
	Sort file	5.3	4.3		37.4	58.2	0.1	10.1	5.7	1.0	16.9	62.6
	File entries	6.6	4.8		30.2	64.5	0.4	17.0	12.4	1.5	30.8	69.7
	Physicians` letter/Final report	15.8	13.7		64.6	21.7	0.0	6.7	5.0	0.4	12.1	35.4
	Morning briefing	17.6	39.4		45.5	15.1	0.0	10.5	14.6	10.5	35.6	54.5
	PC work	29.5	6.5		78.9	14.6	0.1	3.8	2.6	1.3	7.7	21.2
	X-ray pictures	4.3	54.4		43.8	1.8	0.0	2.1	8.9	38.7	49.7	56.2
	Telephone	9.3	4.0		62.0	33.5	0.6	8.0	7.1	1.0	16.2	38.1
Head Lateral inclination	Viewing the file/Documentation	9.5	15.4		68.4		16.2	6.2	8.3	2.6	17.2	31.6
	View file/PC	1.9	9.7		54.2		36.0	2.3	5.4	27.7	35.4	45.7
	Sort file	5.3	13.6		74.1		12.3	4.0	1.9	1.6	7.5	25.9
	File entries	6.6	35.0		58.9		6.1	12.2	5.0	0.4	17.7	41.1
	Physicians` letter/Final report	15.8	1.4		95.6		3.0	0.7	0.1	0.0	0.8	4.4
	Morning briefing	17.6	21.2		72.5		6.3	4.4	7.4	3.9	15.6	27.5
	PC work	29.5	2.8		91.0		6.2	1.3	1.1	1.2	3.5	9.0
	X-ray pictures	4.3	0.9		80.3		18.8	1.1	0.7	16.6	18.4	19.7
	Telephone	9.3	6.3		85.0		8.7	3.1	1.6	0.9	5.7	15.0
Cervical spine Flexion/ Extension	Viewing the file/Documentation	9.5	14.4		76.2		9.4	4.5	5.9	1.3	11.7	23.8
	View file/PC	1.9	12.1		63.8		24.1	1.9	6.5	18.9	27.3	36.2
	Sort file	5.3	14.8		75.8		9.4	3.7	2.2	0.6	6.5	24.2
	File entries	6.6	37.9		56.3		5.8	12.1	5.0	1.0	18.0	43.7
	Physicians` letter/Final report	15.8	14.4		84.3		1.3	2.6	1.9	0.8	5.3	15.7
	Morning briefing	17.6	25.0		70.6		4.4	4.6	7.2	5.3	17.0	29.4
	PC work	29.5	6.7		89.3		4.0	1.8	1.6	1.1	4.6	10.7
	X-ray pictures	4.3	1.8		94.8		3.4	0.6	0.9	1.5	3.0	5.2
	Telephone	9.3	9.9		83.7		6.3	2.9	1.9	1.1	5.9	16.2

Cervical spine Lateral Flexion	Viewing the file/Documentation	9.5	37.9		45.6		16.5	8.6	15.4	6.1	30.1	54.4
	View file/PC	1.9	33.1		45.0		22.0	8.4	13.6	13.9	35.9	55.1
	Sort file	5.3	25.6		44.3		30.0	9.5	6.5	3.2	19.1	55.6
	File entries	6.6	26.4		51.1		22.6	10.8	9.2	2.8	22.8	49.0
	Physicians` letter/Final report	15.8	65.0		29.2		5.8	17.1	14.6	1.8	33.5	70.8
	Morning briefing	17.6	59.3		27.5		13.2	12.0	17.2	19.4	48.5	72.5
	PC work	29.5	72.6		22.7		4.7	13.1	18.1	17.0	48.1	77.3
	X-ray pictures	4.3	92.7		6.6		0.7	9.1	17.0	52.9	79.0	93.4
	Telephone	9.3	46.9		41.5		11.5	11.5	15.3	4.7	31.5	58.4
Thoracic spine Flexion/ Extension	Viewing the file/Documentation	9.5	11.5		66.4	20.8	1.3	4.9	12.6	8.0	25.5	33.6
	View file/PC	1.8	3.4		61.3	35.2	0.0	4.1	11.4	18.9	34.4	38.6
	Sort file	5.5	10.8		62.1	24.2	2.9	7.4	7.9	5.5	20.9	37.9
	File entries	6.8	11.8		43.8	39.3	5.2	11.5	22.3	8.1	41.9	56.3
	Physicians` letter/Final report	15.5	3.0		36.0	60.9	0.0	5.6	17.9	35.8	59.3	63.9
	Morning briefing	18.3	29.1		31.7	39.2	0.0	2.4	7.1	55.4	65.0	68.3
	PC work	29.3	5.7		38.9	54.5	0.8	6.6	17.3	29.9	53.9	61.0
	X-ray pictures	4.1	0.7		96.5	2.8	0.0	0.2	1.7	0.0	2.0	3.5
	Telephone	9.2	9.9		46.9	41.7	1.6	6.5	16.3	22.6	45.4	53.2
Thoracic spine Lateral Flexion	Viewing the file/Documentation	9.5	0.0	2.1	89.1	8.7	0.1	0.8	2.4	7.2	10.4	10.9
	View file/PC	1.8	0.0	0.2	82.7	16.8	0.3	0.5	1.8	27.4	29.6	17.3
	Sort file	5.5	0.1	1.9	92.2	5.1	0.7	1.0	1.4	0.0	2.4	7.8
	File entries	6.8	0.0	1.6	91.0	7.3	0.1	0.6	1.7	4.4	6.7	9.0
	Physicians` letter/Final report	15.5	0.0	0.1	94.2	5.6	0.1	0.4	1.3	2.8	4.6	5.8
	Morning briefing	18.3	0.0	0.3	98.4	1.2	0.1	0.2	0.1	0.4	0.7	1.6
	PC work	29.3	0.0	0.3	96.1	3.3	0.3	0.5	1.0	1.2	2.8	3.9
	X-ray pictures	4.1	0.0	0.1	99.1	0.7	0.0	0.0	0.3	0.0	0.3	0.8
	Telephone	9.2	0.2	1.3	87.6	10.4	0.5	1.4	3.3	4.6	9.3	12.4
Torso Flexion/ Extension	Viewing the file/Documentation	9.5	19.3		72.7	7.9	0.1	2.5	7.5	11.8	21.7	27.3
	View file/PC	1.8	10.7		89.1	0.1	0.0	0.4	2.9	0.0	3.3	10.8
	Sort file	5.5	19.8		69.9	9.9	0.3	4.7	5.8	8.3	18.8	30.0
	File entries	6.8	18.3		58.4	21.3	2.0	5.9	14.3	14.8	35.0	41.6
	Physicians` letter/Final report	15.5	19.2		77.6	3.3	0.0	0.9	2.0	17.4	20.3	22.5
	Morning briefing	18.3	33.2		61.8	5.0	0.0	1.2	2.9	30.3	34.4	38.2
	PC work	29.3	13.9		78.1	8.0	0.0	1.7	5.3	11.2	18.1	21.9
	X-ray pictures	4.1	88.7		11.0	0.3	0.0	0.3	1.1	86.4	87.8	89.0
	Telephone	9.2	17.7		76.7	5.6	0.0	3.6	6.9	6.2	16.8	23.3

Fig. 4 ▲ (cont.)

Torso Lateral Flexion	Viewing the file/Documentation	9.5	0.0	1.9	97.6	0.5	0.0	0.2	0.7	0.3	1.2	2.4
	View file/PC	1.8	0.0	0.2	94.4	5.4	0.0	0.3	0.0	0.0	0.3	5.6
	Sort file	5.5	0.0	1.4	96.1	2.2	0.4	0.3	0.5	0.0	0.7	4.0
	File entries	6.8	0.0	1.2	94.0	4.7	0.0	0.1	0.8	4.5	5.4	5.9
	Physicians` letter/Final report	15.5	0.0	0.0	99.1	0.8	0.0	0.0	0.1	0.0	0.2	0.8
	Morning briefing	18.3	0.0	0.2	99.0	0.8	0.0	0.0	0.1	0.4	0.5	1.0
	PC work	29.3	0.0	0.3	97.9	1.7	0.0	0.2	0.6	0.5	1.3	2.0
	X -ray pictures	4.1	0.0	0.1	99.7	0.2	0.0	0.0	0.0	0.0	0.0	0.3
	Telephone	9.2	0.1	1.8	94.8	3.1	0.3	0.5	0.9	1.5	2.9	5.3
Back torsion to the side	Viewing the file/Documentation	9.5	0.0	5.0	93.7	1.3	0.1	1.1	1.3	1.1	3.5	6.4
	View file/PC	1.8	0.0	7.2	79.2	9.5	4.0	2.8	2.1	6.4	11.3	20.7
	Sort file	5.5	0.1	2.8	91.1	4.4	1.6	1.1	1.6	0.7	3.4	8.9
	File entries	6.8	0.2	5.6	87.5	6.6	0.1	1.5	3.4	4.2	9.1	12.5
	Physicians` letter/Final report	15.5	0.0	3.8	94.6	1.5	0.0	0.5	1.1	1.3	2.9	5.3
	Morning briefing	18.3	0.6	6.8	81.4	10.4	0.9	1.1	2.1	12.1	15.4	18.7
	PC work	29.3	0.3	8.6	87.8	2.9	0.5	1.0	2.9	5.5	9.3	12.3
	X -ray pictures	4.1	0.0	1.6	98.0	0.3	0.0	0.2	1.4	0.0	1.6	1.9
	Telephone	9.2	0.3	3.6	88.9	6.7	0.5	1.6	3.6	1.7	6.9	11.1
Back inclination Flexion/ Extension	Viewing the file/Documentation	9.5	22.2		50.3	20.3	7.2	6.4	16.6	16.7	39.7	49.7
	View file/PC	1.8	2.9		11.4	60.7	25.0	5.9	19.8	55.7	81.4	88.6
	Sort file	5.5	16.1		39.4	30.8	13.7	12.0	13.4	12.5	37.9	60.6
	File entries	6.8	13.7		31.0	29.6	25.7	10.6	23.5	17.8	51.9	69.0
	Physicians` letter/Final report	15.5	0.2		18.5	39.7	41.7	4.1	16.0	56.2	76.3	81.6
	Morning briefing	18.3	4.2		40.1	24.9	30.8	2.9	7.3	44.6	54.7	59.9
	PC work	29.3	2.2		18.5	42.7	36.6	7.4	20.1	44.6	72.1	81.5
	X -ray pictures	4.1	0.2		3.3	63.1	33.4	1.6	7.2	85.6	94.4	96.7
	Telephone	9.2	5.2		28.8	30.4	35.6	9.5	18.6	29.9	58.0	71.2
Back inclination to lateral	Viewing the file/Documentation	9.5	0.9		76.8		22.3	1.5	3.8	16.1	21.4	23.2
	View file/PC	1.8	0.4		86.4		13.3	1.5	3.8	5.2	10.5	13.7
	Sort file	5.5	1.3		90.7		8.0	1.5	2.5	0.5	4.5	9.3
	File entries	6.8	0.9		85.9		13.2	0.9	4.8	6.9	12.6	14.1
	Physicians` letter/Final report	15.5	0.0		70.6		29.4	0.7	2.1	24.8	27.7	29.4
	Morning briefing	18.3	0.1		97.2		2.7	0.2	0.9	0.4	1.5	2.8
	PC work	29.3	0.2		89.9		9.9	0.9	2.2	5.0	8.1	10.1
	X -ray pictures	4.1	0.0		92.9		7.1	0.0	0.0	3.1	3.1	7.1
	Telephone	9.2	0.9		83.1		16.0	2.5	3.3	8.8	14.6	16.9

Fig. 4 ▲ (cont.)

posture. The total percentage of static posture was 59.3%, of which 35.8% was held for more than 30 s. The most noticeable values in this subcategory were found for back inclination forwards. The total percentage of non-neutral posture was clearly increased at 81.7%, and the total percentage of static posture was 76.3%. Whereas 41.7% of flexion was performed in an awkward posture, 39.7% was performed in a moderate posture. In addition, for 56.2% of the time, postures were held statically for durations of more than 30 s.

Category II (measures on patients)

The static analysis of measures on patients was carried out on the basis of the two longest activities, "lumbar puncture" and "investigation" in addition to the shortest activity, "blood collection" (**Fig. 5**).

With a duration of 33.8% of the total time, "investigation" made up the largest share in the category. For the head tilt forwards/backwards, the total percentage was 56.7%, with only 1.9% of extension and 48.3% of flexion performed in a moderate posture. The total percentage of static posture was very low. The most conspicuous posture was back inclination forwards/backwards, with a total percentage of non-neutral posture of 64.3%. Of these, 33.4% of extension was carried out in an awkward posture and 21.2% of flexion in a moderate posture.

"Lumbar puncture" was found to be the second longest subcategory, with a duration of 20.0% of the time. It is evident from the neck tilt forwards/backwards that 64.9% of the extensions were performed in an awkward posture. The static proportion, on the other hand, was low to moderate. However, a significantly increased total percentage of non-neutral posture of 79.4% was observed for the thoracic inclination forwards/backwards. The total percentage of static posture was 51.9%. Of this, 29.6% was held for more than 30 s and 14.0% for more than 10 s. Similarly, increased values were documented for the back inclination forwards/backwards. The total percentage of non-neutral posture was 88.6%, of which 71.9% of flexion was performed in an awkward posture. Equally striking was the total percentage of static posture of 59.5%; 36.0% of the time this was held for more than 30 s. Within the other body regions, there were only slight to moderate abnormalities in the total percentage of non-neutral posture and total percentage of static posture (**Fig. 5**). The lowest percentage of the workday time was spent with the subcategory "blood collection," with which 4.7% of the time was spent. However, the head tilt forwards showed a total percentage of non-neutral posture of 98.0%, whereby this was carried out in a moderate posture. The total percentage of static posture was low, at 36.4%. When the neck was tilted forwards/backwards, the total percentage was 79.3%, with 79% of the extension performed in an awkward posture. The total percentage of static posture was rather moderate at 49.0%. The thoracic tilt forwards/backwards showed a high total percentage (92.4%) of non-neutral posture. Of these, 75.8% were in flexion. The total percentage of static posture was rather moderate at 56.1%. A similar picture was obtained with the inclination forwards/backwards of the trunk. Again, the total percentage of non-neutral posture was significantly higher at 86.5%. Only 20.4% of flexion was performed in an awkward posture, while 66.1% of flexion was in a moderate posture. The total percentage of static posture was similar to the thoracic inclination forwards; however, a difference occurred in the duration of static posture. For the trunk inclination forwards/backwards, 31.2% of the time posture was held for longer than 30 s and for the thoracic inclination, 33.2% of the time the posture was held for longer than 4 s. The total percentage of non-neutral posture was also significantly higher for the back inclination forwards/backwards, at 88.1%. Of these, 78.2% of flexion was performed in an awkward posture. Similar to the trunk inclination, the total percentage of static posture was 68.5%. Of this, 32.5% was held for more than 30 s.

Category III (other activities)

In this category, "conversation" (most frequent subcategory) and "way and stairs" (least frequent subcategory) were analyzed in more detail (**Fig. 6**).

Fig. 5 ▶ Measures on patients: percentage of neutral, moderate, and awkward postures of the total duration, percentage of awkward postures as the sum of all moderate and awkward postures, and percentage of static postures ≥ 4 s during the treatment. *Total percentage of static postures* sum of all moderate and awkward postures that occurred during all activities. The non-neutral postures are ranked using a color-coded system according to the appropriate ergonomic standard: *green* neutral; *yellow* moderate; *red* awkward

The subcategory "conversations" accounted for the largest share of time (75.7%). The total percentage of non-neutral posture was low to moderate over all the body regions measured. With a total percentage of 40.6% static posture, the torso inclination forwards/backwards during "conversations" was the highest measured value in the main category "other activities." During "conversations," back inclination forwards/backwards was held for 18.0% of the time and for longer than 30 s. The remaining body regions were rather inconspicuous in terms of the total percentage of non-neutral posture and total percentage of static posture.

Discussion

So far there exists one kinematic analysis [14] regarding the constrained postures of neurologists during their daily work on wards. Deliberately, specific activities such as sonology [26] were excluded, as previous studies have already provided insight into the risk of developing MSD during ultrasonography. The aim of this work was to identify possible forced postures and analyze the risk of development of MSD in the inpatient daily routine. In line with the results of Mache et al. [13], the working day of neurologist assistants is largely determined by non-medical tasks, such as documentation or conversation (50.8%). In all three categories, it can be seen that in the head and neck region up to the thoracic spine, the non-neutral range is more frequent in the "measures on patients" and "other activities" than in the trunk region. This, however, is not the case for "office activities." Here, all body regions are approximately equally observed in the non-neutral angular range. Although the overall proportion of non-neutral posture

Body region	Activities	Duration	Postures					Static posture:>=4s	Static posture:>=10s	Static posture:>=30s	Total percentage of static posture	Total percentage of non-neutral position
			Awkward	Moderate	Neutral	Moderate	Awkward					
			Extension/ to the left			Flexion/ to the right						
		% of the time	%	%	%]	%	%	%	%	%	%	%
Head tilt Flexion/Extension	Blood Collection	4.7	0.0		2.0	98.0	0.0	27.3	9.1	0.0	36.4	98.0
	Conversation and notes/ anamnesis	12.8	0.4		83.8	15.8	0.0	1.1	0.0	0.0	1.1	16.2
	Hygiene	12.8	6.0		37.8	56.1	0.2	2.0	0.0	0.0	2.0	62.3
	Patient education	14.2	1.4		53.3	36.8	8.4	9.0	2.3	0.0	11.3	46.6
	Lumbar puncture	20.0	1.6		50.1	48.3	0.0	5.1	3.0	5.5	13.6	49.9
	Investigation	33.6	1.9		43.3	54.4	0.4	7.5	4.4	0.0	11.9	56.7
	Place intravenous catheters	8.3	1.2		1.6	88.0	9.2	13.8	16.2	0.0	29.9	98.4
Lateral head tilt	Blood Collection	4.7	5.7		88.7		5.5	1.5	0.0	0.0	1.5	11.2
	Conversation and notes/ anamnesis	12.8	11.3		83.4		5.3	3.0	7.4	0.0	10.4	16.6
	Hygiene	12.8	11.5		77.2		11.3	0.0	0.0	0.0	0.0	22.8
	Patient education	14.2	11.4		59.2		29.3	9.8	2.5	0.0	12.3	40.7
	Lumbar puncture	20.0	28.8		67.5		3.6	1.8	7.4	0.0	9.2	32.4
	Investigation	33.6	11.9		66.0		22.2	4.1	3.5	0.0	7.6	34.1
	Place intravenous catheters	8.3	20.1		67.5		12.5	5.1	4.2	0.0	9.2	32.6
Cervical spine Flexion/Extension	Blood Collection	4.7	79.0		20.7		0.3	32.1	17.2	0.0	49.2	79.3
	Conversation and notes/ anamnesis	12.8	40.0		50.9		9.1	5.3	11.9	6.7	23.8	49.1
	Hygiene	12.8	24.5		43.3		32.2	4.8	0.0	0.0	4.8	56.7
	Patient education	14.2	44.5		33.9		21.7	16.2	3.7	0.0	19.9	66.2
	Lumbar puncture	20.0	64.9		32.0		3.1	8.2	12.2	16.6	37.1	68.0
	Investigation	33.6	23.8		48.1		28.1	10.0	5.5	0.0	15.4	51.9
	Place intravenous catheters	8.3	30.9		42.8		26.3	14.8	9.3	0.0	24.1	57.2
Cervical spine lateral flexion	Blood Collection	4.7	3.9		73.9		22.3	6.9	9.6	0.0	16.4	26.2
	Conversation and notes/ anamnesis	12.8	16.9		82.4		0.7	3.0	9.2	0.0	12.2	17.6
	Hygiene	12.8	14.7		76.3		9.0	0.0	0.0	0.0	0.0	23.7
	Patient education	14.2	14.5		69.5		16.1	7.1	1.0	0.0	8.2	30.6
	Lumbar puncture	20.0	33.9		65.0		1.1	3.1	7.4	0.0	10.6	35.0
	Investigation	33.6	15.2		70.3		14.4	3.7	2.2	1.3	7.1	29.6
	Place intravenous catheters	8.3	21.3		68.0		10.7	5.0	4.2	0.0	9.2	32.0

Thoracic spine Flexion/Extension	Blood Collection	4.6	0.0		7.6	16.6	75.8	33.2	8.8	14.1	56.1	92.4
	Conversation and notes/ anamnesis	12.7	21.5		41.5	35.3	1.8	3.8	9.1	39.0	51.9	58.6
	Hygiene	6.8	25.7		49.7	16.9	7.8	14.5	2.6	0.0	17.1	50.4
	Patient education	14.0	1.0		31.9	67.2	0.0	17.2	21.9	11.2	50.2	68.2
	Lumbar puncture	19.8	2.5		20.6	60.9	16.0	8.4	14.0	29.6	51.9	79.4
	Investigation	33.8	13.9		50.4	32.4	3.3	7.8	15.5	2.8	26.1	49.6
	Place intravenous catheters	8.2	0.8		11.9	48.0	39.3	27.2	8.1	13.8	49.0	88.1
Thoracic spine lateral flexion	Blood Collection	4.6	0.0	0.1	99.4	0.5	0.0	0.0	0.0	0.0	0.0	0.6
	Conversation and notes/ anamnesis	12.7	0.1	1.0	97.3	1.6	0.0	0.0	0.0	0.0	0.0	2.7
	Hygiene	6.8	0.0	2.0	89.3	8.1	0.6	0.0	0.0	0.0	0.0	10.7
	Patient education	14.0	0.0	0.1	90.5	9.4	0.0	1.8	2.3	2.9	7.0	9.5
	Lumbar puncture	19.8	0.4	1.6	93.0	4.4	0.6	0.8	0.0	0.0	0.8	7.0
	Investigation	33.8	0.0	1.6	86.5	11.0	0.9	0.7	4.4	3.0	8.1	13.5
	Place intravenous catheters	8.2	1.0	3.7	88.9	6.0	0.4	0.6	2.4	0.0	3.0	11.1
Torso Flexion/ Extension	Blood Collection	4.6	0.0		13.5	66.1	20.4	20.2	0.0	31.2	51.4	86.5
	Conversation and notes/ anamnesis	12.7	29.9		60.5	9.6	0.0	1.9	6.0	25.6	33.4	39.5
	Hygiene	6.8	27.3		55.3	12.9	4.5	16.4	2.7	0.0	19.1	44.7
	Patient education	14.0	10.0		81.8	8.2	0.0	5.4	3.3	0.0	8.7	18.2
	Lumbar puncture	19.8	7.8		69.1	20.7	2.4	5.5	3.3	6.9	15.8	30.9
	Investigation	33.8	17.3		59.8	20.9	2.0	8.3	13.6	2.6	24.5	40.2
	Place intravenous catheters	8.2	1.2		18.0	78.7	2.2	21.3	18.3	14.1	53.6	82.1
Torso Lateral Flexion	Blood Collection	4.6	0.0	0.1	99.8	0.1	0.0	0.0	0.0	0.0	0.0	0.2
	Conversation and notes/ anamnesis	12.7	0.0	0.9	98.4	0.6	0.0	0.0	0.0	0.0	0.0	1.5
	Hygiene	6.8	0.0	1.2	93.6	4.9	0.3	0.0	0.0	0.0	0.0	6.4
	Patient education	14.0	0.0	0.1	98.9	1.0	0.0	0.0	0.0	0.0	0.0	1.1
	Lumbar puncture	19.8	0.1	1.6	96.0	1.8	0.5	0.6	0.0	0.0	0.6	4.0
	Investigation	33.8	0.0	1.3	91.9	6.6	0.2	0.0	2.2	2.7	4.9	8.1
	Place intravenous catheters	8.2	0.2	2.7	94.6	2.4	0.0	0.0	0.0	0.0	0.0	5.3
Back torsion to the side	Blood Collection	4.6	0.0	0.0	76.0	23.9	0.1	6.5	7.3	0.0	13.8	24.0
	Conversation and notes/ anamnesis	12.7	0.0	0.1	84.7	9.8	5.4	0.4	3.6	6.9	11.0	15.3
	Hygiene	6.8	0.2	2.7	85.7	5.9	5.4	0.8	0.0	0.0	0.8	14.2
	Patient education	14.0	0.0	0.9	88.1	10.7	0.3	1.2	4.3	0.0	5.4	11.9
	Lumbar puncture	19.8	0.1	1.3	81.1	13.1	4.4	3.1	0.9	0.0	4.0	18.9
	Investigation	33.8	1.5	5.6	84.4	5.4	3.1	1.3	4.7	1.1	7.1	15.6
	Place intravenous catheters	8.2	0.0	0.8	87.1	11.3	0.8	2.4	0.0	0.0	2.4	12.9

Fig. 5 ▲ (cont.)

Back tilt Flexion/ Extension	Blood Collection	4.6	0.2		11.9	9.9	78.0	25.4	10.6	32.5	68.5	88.1
	Conversation and notes/ anamnesis	12.7	6.1		52.9	13.9	27.1	4.6	5.9	37.0	47.4	47.1
	Hygiene	6.8	30.9		51.6	8.9	8.6	15.4	2.4	0.0	17.7	48.4
	Patient education	14.0	0.1		13.8	56.2	30.0	22.5	20.8	17.9	61.3	86.3
	Lumbar puncture	19.8	1.8		11.3	14.9	71.9	11.0	12.5	36.0	59.5	88.6
	Investigation	33.8	33.4		35.7	21.2	9.7	9.8	19.7	7.2	36.7	64.3
	Place intravenous catheters	8.2	1.2		8.0	24.5	66.3	20.0	29.0	14.6	63.5	92.0
Back inclination to lateral	Blood Collection	4.6	53.7		46.3		0.0	6.1	10.8	31.7	48.6	53.7
	Conversation and notes/ anamnesis	12.7	0.1		56.6		43.3	0.4	3.7	36.2	40.3	43.4
	Hygiene	6.8	4.3		88.4		7.4	2.8	0.0	0.0	2.8	11.7
	Patient education	14.0	0.0		81.0		19.0	3.7	10.2	0.0	13.9	19.0
	Lumbar puncture	19.8	0.2		81.5		18.3	3.3	0.0	0.0	3.3	18.5
	Investigation	33.8	0.4		84.5		15.1	1.2	2.4	7.7	11.4	15.5
	Place intravenous catheters	8.2	17.1		75.0		7.9	7.2	6.8	4.8	18.8	25.0

Fig. 5 ▲ (cont.)

is higher in "measures on patients," the time share of 3.4% of the total working time is nevertheless low. By contrast, static postures in the head and neck area up to the thoracic spine occur more frequently during "office work" than during patient interventions or other activities. Furthermore, in the lower back area, there are high static proportions within the two categories (I and II), but they are approximately the same. These high proportions are not present in "other activities." Within the isolated analysis of the category "measures on patients," there is a kyphotic posture in the head area and the whole back, where the neck is extended corresponding to the total percentage of non-neutral posture. It should be emphasized that over 80% of the total percentage of non-neutral posture is performed in an inflected position of the head and the entire back during "blood collection" (4.7% of the time) and "placing intravenous catheters" (8.3% of the time). During the assumed position, the determined data reveal that there are short static postures (of 4–10 s) in the head and neck area, up to and including the thoracic spine, while there are long static postures (> 30 s) in the lower back. However, there are exceptions: "lumbar puncture" and "conversations and notes/anamnesis," which show long static postures during flexion of the thoracic spine. Another exception is the "back inclination to the side," which is to the left during "blood collection" and to the right during "conversations and notes/anamnesis." Here, too, long static postures are adopted. Whether these postures were taken by force cannot be clarified by the data. The results show that individual activities such as "placing intravenous catheters," "blood collection," "lumbar puncture," and "conversations and notes/anamnesis" could have a strong influence on the development of MSD, but are negligible due to the low proportion of time spent on these activities in the total working day. Furthermore, it can be seen from the data that both "lumbar puncture" and "blood collection" were performed only occasionally and that there are likely to be interindividual differences in skill. Therefore, the current data may be inaccurate at this time. Because this is a pilot study, these data reflect a trend. Accordingly, the specific activities ("lumbar puncture," "blood collection") should be investigated separately in further studies. Nevertheless, the neurologist can ensure an optimal working height. In contrast to the kyphotic posture during "measures on the patient," during "office work," and especially during "X-rays" (4.1% of the time), a posture with the back leaning backwards, the upper body tilted forwards, extension of the head, and a laterally inflected posture of the neck to the left is preferred. During "PC work" and "physician's letters" there is also lateral flexion of the back to the right. Within this assumed position, the data show short static postures (4–10 s) in the head and neck area and long static postures (> 30 s) in the entire back. Exceptions are observed during "X-rays" and "view file," where long static postures are also assumed in the head and neck area. Here, the question arises as to whether the sitting posture during "office work" is an individually accustomed posture, or whether it is predetermined. By contrast, static postures in the head and neck area up to the thoracic spine occur more frequently during office work than during patient interventions or other activities. In the lower back area, too, there are high static proportions within the categories "office work" and "measures on patients," but these are approximately the same; these high proportions are not present in "other activities."

Body region	Activities	Duration	Postures					Static posture:>= 4s	Static posture:>= 10s	Static posture:>= 30s	Total percentage of static posture	Total percentage of non-neutral position
			Awkward	Moderate	Neutral	Moderate	Awkward					
			Extension/ to the left			Flexion/ to the right						
		% of the time	%	%	%	%	%	%	%	%	%	%
Head tilt Flexion/ Extension	Conversation	75.7	19.9		62.1	17.8	0.2	5.1	3.8	2.0	11.0	37.9
	Way	21.4	14.0		59.7	26.1	0.3	1.7	0.4	0.2	2.3	40.4
	Way and stairs	3.0	25.0		54.6	20.4	0.0	1.1	1.3	0.0	2.4	45.4
Head Lateral inclination	Conversation	75.7	6.9		78.6		14.5	3.1	2.1	1.2	6.4	21.4
	Way	21.4	8.4		78.4		13.2	1.0	0.3	0.0	1.2	21.6
	Way and stairs	3.0	9.6		70.5		20.0	1.9	0.7	0.0	2.7	29.6
Cervical Spine Flexion/Extension	Conversation	76.5	49.8		41.2		9.0	9.0	7.7	3.6	20.3	58.8
	Way	20.8	30.9		42.8		26.3	14.8	9.3	0.0	24.1	57.2
	Way and stairs	2.7	34.9		51.5		13.6	3.7	1.6	0.1	5.5	48.5
Cervical spine Lateral Flexion	Conversation	76.5	11.7		76.8		11.6	3.1	2.7	1.7	7.5	23.3
	Way	20.8	11.7		78.8		9.5	0.8	0.4	0.0	1.1	21.2
	Way and stairs	2.7	11.1		71.0		17.9	1.7	1.2	0.0	2.9	29.0
Thoracic spine Flexion/ Extension	Conversation	76.5	16.0		61.0	22.3	0.7	5.8	10.7	11.8	28.3	39.0
	Way	20.8	19.1		66.9	12.8	1.2	2.8	2.8	0.8	6.3	33.1
	Way and stairs	2.7	35.7		55.6	7.6	1.1	2.4	4.2	1.2	7.7	44.4
Thoracic spine Lateral Flexion	Conversation	76.5	0.0	1.2	92.2	6.2	0.3	0.8	1.6	2.2	4.6	6.6
	Way	20.8	0.3	3.0	87.7	8.3	0.7	0.7	0.5	0.2	1.4	10.7
	Way and stairs	2.7	0.1	1.5	93.0	4.5	0.9	0.6	0.4	0.0	1.0	6.0

Fig. 6 ▲ Other activities: percentage of neutral, moderate, and awkward postures of the total duration, percentage of awkward postures as the sum of all moderate and awkward postures, and the percentage of static postures ≥ 4 s during the treatment. *Total percentage of static postures* sum of all moderate and awkward postures that occurred during all activities. The non-neutral postures are ranked using a color-coded system according to the appropriate ergonomic standard: *green* neutral; *yellow* moderate; *red* awkward

Torso Flexion/ Extension	Conversation	76.5	17.2		43.2	22.9	16.7	8.4	14.2	18.0	40.6	56.8
	Way	20.8	22.6		57.8	14.2	5.4	4.2	4.2	1.6	10.0	42.2
	Way and stairs	2.7	41.7		47.4	7.1	3.8	2.0	5.2	1.1	8.2	52.6
Torso Lateral Flexion	Conversation	76.5	27.5		67.5	4.7	0.2	3.9	7.5	13.6	25.0	32.4
	Way	20.8	24.7		68.7	6.1	0.5	2.2	1.2	0.4	3.9	31.3
	Way and stairs	2.7	29.1		67.7	3.0	0.1	2.1	3.6	1.2	6.9	32.2
Back inclination Flexion/ Extension	Conversation	76.5	0.0	1.3	96.4	2.2	0.1	0.3	0.8	0.8	2.0	2.3
	Way	20.8	0.2	2.7	92.8	4.2	0.3	0.7	0.1	0.0	0.8	5.2
	Way and stairs	2.7	0.0	1.2	95.3	3.4	0.1	0.4	0.9	0.0	1.3	3.5
Back inclination to lateral	Conversation	76.5	0.7		83.0		16.3	1.7	4.2	7.7	13.6	17.0
	Way	20.8	1.9		85.9		12.2	0.9	1.1	0.2	2.3	14.1
	Way and stairs	2.7	1.2		93.4		5.4	0.5	1.1	0.0	1.6	6.6
Back torsion to the side	Conversation	76.5	0.3	3.4	91.0	4.8	0.6	1.5	1.5	1.8	4.8	23.4
	Way	20.8	1.6	4.9	85.8	5.8	2.0	0.6	0.5	0.0	1.1	14.3
	Way and stairs	2.7	2.2	8.7	80.7	4.3	4.2	0.7	1.4	0.0	2.1	19.4

Fig. 6 ▲ (cont.)

During "office work," a posture reclined backwards with the upper body tilted forwards, extension of the head, and lateral flexion of the neck to the left is preferred. Again, the question arises as to whether this sitting posture is an individually accustomed or whether it is predetermined. It should be noted, however, that the data do not provide information on the support provided by, e.g., the backrest of the chair.

Although these postures have been classified as forced postures, it should be noted that forced postures are not serious, in principle, as long as they are not performed permanently. An optimization of the workplace by, e.g., a correspondingly adjusted PC height or PC size or chair height could reduce forced postures in non-neutral angle categories. The link between the number of hours worked at a computer workstation and the risk of MSD is proven [27, 28]. Additionally, neurologists' work is persistently similar to office workers in longer, uncomfortable postures and high static muscle loads during documentation/PC work/writing of physician's letters, which can entail a risk for the development of MSD [29]. However, there is also a high level of activity change, which can be triggered by telephone calls, requests from colleagues, or measures taken on patients [13, 30]. It must be taken into account that frequent interruptions of work may reduce the time the body remains in static positions [13, 31] and thus reduce the potential risk of musculoskeletal disorders. Therefore, the increased potential risk from a static posture of more than 30 s is mainly referred to the thoracic spine and back area. This conclusion was also reached by Park et al. [32] using the RULA method.

The analysis of whether static forced postures occur in all regions simultaneously during an activity is limited by the current software. A further limitation is the lack of evaluation of the neutral posture, because here, too, static postures are possible. The CUELA evaluation program measures the total duration and frequency of the static posture. Movement breaks between tasks can lead to faster recovery of the back muscles, which is important for maintaining spinal stability. However, these breaks in movement cannot be measured in the current study design. In addition, conclusions cannot be drawn from the software alone as to whether the participant leans against a chair or sits freely, or whether or not they lift a weight. However, the authors assume that the participant uses a backrest when sitting for a long time, tilting slightly backwards, but this can only be proven by video material. Since the neurologist's activity permanently alternates between office work and work on the patient, it should be taken into account that the patient would also be recorded. The patient's right to privacy

and confidentiality may prevent the use of video recordings, as not every neurological patient wishes to be filmed during treatment.

Another possible influencing factor is the Hawthorne effect [33], which can change movement behavior when a participant notices being observed. However, since the observer carried out the objective activity analysis at a distance of 2 m and the measurement was conducted for at least 5 h in a familiar work environment, this effect should have had little impact on this study.

The available data and their ergonomic classification into predefined standards can identify forced postures in non-neutral positions. For identification of preventive and/or therapeutic measures, this method would be suitable in the context of a different study design, in particular a longitudinal study with several measurement points and an additional control group.

Conclusion

The present pilot kinematic analysis showed that specific activities on the patient were carried out in a clearly forced posture. However, it should be emphasized that direct patient activity accounts for only 3.4% of the total working time and that the proportion of static postures during this time is low. Non-medical tasks were performed in long static postures. Neurological physicians should be advised to pay attention to an optimal working height and reduce static postures by taking regular breaks to loosen the musculoskeletal system.

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Author Contribution. A. Bijanzadeh conducted the study design, collected the kinematic data, analyzed and interpreted the data, and contributed to major parts of the article; I. Hermanns contributed substantially to the analysis and interpretation of the data; R. Ellegast supervised the interpretation of the data analysis and the concept of the article; L. Fraeulin and F. Holzgreve substantially revised the article; D.A. Groneberg supervised setting up the study design and the interpretation of the data; D. Ohlendorf supervised the designing of the study, data acquisition, analysis and interpretation of the data, and writing of the manuscript. All authors read and approved the final manuscript.

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Declarations

Conflict of interest. D. Ohlendorf, A. Bijanzadeh, I. Hermanns, R. Ellegast, L. Fraeulin, F. Holzgreve, and D.A. Groneberg declare that they have no competing interests.

All procedures performed in studies involving human participants or on human tissue were in accordance with the ethical standards of the institutional and/or national research committee and with the 1975 Helsinki declaration and its later amendments or comparable ethical standards. This study was approved by the Ethics Commission (135/14) of the Goethe University Frankfurt am Main. All participants signed, in advance, the required informed consent form for participation in the study. All methods were carried out in accordance with relevant guidelines and regulations.

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Zusammenfassung

Zwangshaltung von Assistenzärzten in der Neurologie im Stationsalltag in Deutschland. Eine Pilotstudie

Hintergrund: Ziel dieser Pilotstudie war es, die Arbeit von Neurologen in Bezug auf statische Haltungen (> 4 s) zu analysieren und ungünstige Haltungen zu identifizieren.
Probanden und Methoden: Insgesamt nahmen 9 (3 m/6 w) Neurologen (Assistenzärzte) teil. Kinematische Daten wurden mit dem CUELA-System (computergestützte Erfassung und Langzeitanalyse muskuloskeletaler Belastungen) erhoben. Die tägliche Arbeit („Büroarbeit", „Maßnahmen am Patienten" und „sonstige Tätigkeiten") wurde mit einer computergestützten Aufgabenanalyse analysiert.
Ergebnisse: Bei den „Maßnahmen am Patienten" wurden sowohl bei der „Blutentnahme" (4,7 % der Zeit) als auch beim „Legen intravenöser Katheter" (8,3 % der Zeit) mehr als 80 % des Gesamtanteils der nichtneutralen Körperhaltung in einer gebeugten Position des Kopfes und des gesamten Rückens eingenommen. Lange statische Haltungen (> 30 s) im Kopf- und Nackenbereich einschließlich der Brustwirbelsäule wurden dagegen bei der „Büroarbeit" eingenommen. Trotz des erhöhten Gesamtanteils an nichtneutralen Haltungen während der „Maßnahmen am Patienten" ist der Zeitanteil von 3,4 % der Gesamtarbeitszeit so gering, dass das Risiko für die Entwicklung von Muskel-Skelett-Erkrankungen (MSE) vernachlässigbar ist. Im Gegensatz dazu birgt die „Büroarbeit", die 50,8 % der Gesamtarbeitszeit und längere statische Haltungen umfasst, ein potenzielles Risiko für die Entwicklung von MSE.
Schlussfolgerung: Die vorliegende Studie ist die erste kinematische Pilotanalyse im Bereich der stationären neurologischen Assistenten. Es wurden sowohl nichtneutrale Haltungen als auch statische Haltungen im Arbeitsalltag identifiziert. Mögliche MSE können durch eine Optimierung der Arbeitshöhe und durch regelmäßige Pausen zur Lockerung des Bewegungsapparats reduziert werden.

Schlüsselwörter
Medizinisches Personal · Arbeitsplatz · Haltungskontrolle · Kinematik · Muskuloskeletale Erkrankungen