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ORIGINAL PAPERS

International Journal of Occupational Medicine and Environmental Health 2012;25(3):265–274
DOI 10.2478/S13382-012-0034-6

PROFESSIONAL EXPERIENCE AND ERGONOMIC ASPECTS OF MIDWIVES' WORK

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Abstract
Objectives: The most frequent manner of attending childbirth imposes on midwives assuming poor body position affecting the musculoskeletal system. Long professional experience does not mitigate the negative effects. The adopted movement habit, as well as the type, number and frequency of actions influence the body posture. The aim of the study was to identify ergonomic threats of basic occupational midwives activities and how particular spinal segments arrangements while attending childbirth using the same technique in senior midwives differ from those of junior ones. It was also checked whether pain influences the working position assumed by midwives. **Materials and Methods:** Examinations were conducted in 95 midwives aged 21–50 (X = 29.25±9.34): 51 graduates of BSc midwifery who worked 680 h in delivery rooms during obligatory practical classes and apprenticeship and 44 senior midwives with professional experience of 7–27 years (X = 14.84±5.98). The study was threefold. The spinal alignment while performing work activities associated with attending childbirth was assessed using the OWAS system and the SonoSens Monitor, the center of gravity projection on basal plane – using the AccuGait AMTI stabilometric platform. The measurements were taken during a simulation of attending childbirth (on examination model). A survey was conducted aimed at identifying spinal pain. **Results:** Midwives' working postures require unnatural body alignments. Postural instability in the working position and no maximal usage of basal plane were observed. The work overload may afflict the musculoskeletal system, which was confirmed by different pain discomforts in 67.3% of the examinees. **Conclusions:** Spinal alignment while attending childbirth is individually differentiated and in every case non-ergonomic. Identifying explicitly spinal overloads is difficult, but the most prevalent ones affect lumbar and cervical regions altogether. Spinal pain is frequently noted, both in junior and senior midwives, and is characteristic for midwives working in maximal movement ranges.

Key words:
Midwives, Working positions, Spinal alignment, Pain discomfort, Stabilometry, Sonometry

Received: Decmember 1, 2011. Accepted: April 3, 2012.
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INTRODUCTION

The mode of performing work activities due to its repetitive nature becomes gradually set in the body musculature, which once formed and continually repeated is difficult to modify. Postural patterns can be either correct or incorrect. The latter, mainly as a result of locomotor system overload, might have a significant impact on workers' general health [1]. Therefore, it seems to be of major importance to develop proper (i.e. ergonomic) postural patterns within the framework of midwifery studies and to comply with basic rules of ergonomics at the workplace.

Generally, it is estimated that work activities constitute half of human active life during people's best psychophysical development. Consequently, providing occupational health and safety has become a social priority and has been established in Polish legislation. However, a great responsibility for health and safety lies with the employees themselves. The employment law regulates in detail occupational health and safety laws and the requirement of compliance with them is the basic obligation of employees [2]. Nonetheless, no directives will cause an improvement of working conditions unless the employees realize their significance in this area. It might be achieved by increasing the awareness of occupational hazards associated with performing work tasks improperly and by educating the employees in the scope of the conditions of ergonomic working.

Scientific and technological progress eliminated, or at least lowered to acceptable levels, hazardous factors present at the workplace. It is assumed that increasing work efficiency ought not to be achieved at the cost of an increased effort, but by reducing needless load [2].

Some of health hazards and health problems of medical staff, including midwives, result from the fact that ergonomics guidelines are not followed due to various reasons. It may be caused by a lack of adequate information or skills or bad working conditions (for instance, no equipment available for lifting and carrying). Midwives' occupational duties involve various tasks. Excluding those connected with nursing care it may be generalized that a continual and a recurrent component of their work is attending childbirth. A characteristic feature of midwives' work is the requirement of adopting a specific body position which has adverse effects on their musculoskeletal system. This motivates for seeking the causes of locomotor system overloads and finding possibilities to alleviate them.

OBJECTIVES

The aim of the study was to identify ergonomic hazards associated with routine basic occupational activities performed by midwives and how particular spinal segments arrangements while attending childbirth using the same technique differ in senior midwives from those of the young graduates of BSc midwifery. It was also checked whether experiencing pain influences the working position of midwives.

MATERIALS AND METHODS

Examinations were conducted in 95 midwives aged 21–50 (X = 29.25±9.34). There were 51 graduates of BSc midwifery (aged 21–23, X = 21.51±0.7) whose work experience totaled 680 hours and involved working in delivery rooms during obligatory practical classes and apprenticeship (group A). The second group (group B) consisted of 44 senior midwives (aged 30–50, X = 40.25±4.91) with a professional experience of 7–27 years (X = 14.84±5.98).

The inclusion criteria were not met by study subjects in which the application of the ultrasounds was contraindicated and in which complete measurements were not conducted. Except the occupation criterion and the above mentioned criteria of exclusion no additional restrictions were imposed on the study subjects.

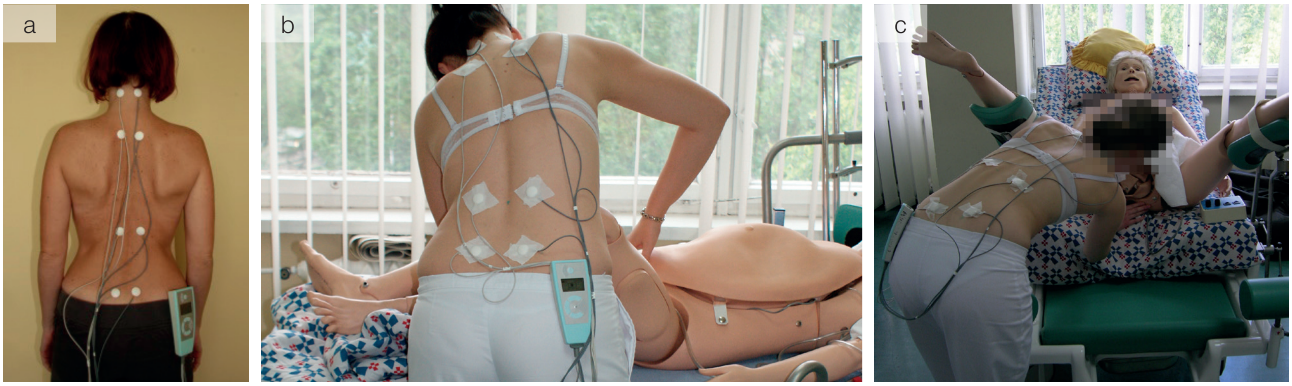


Photo. 1. Location of the sensors on the midwives' back during calibration in a) upright body positionand change of their positions relative to each other, depending on the trunk position, during childbirth simulation (b, c)

The study encompassed three areas of analysis. First, spinal alignment while performing routine work activities associated with attending childbirth was assessed using the Ovako Working Posture Analysis System – OWAS [3,4] and the SonoSens Monitor device. The OWAS method was used to evaluate the values of static overload in workplaces including back position, arms arrangement, work of the legs and the value of exterior overload. Measurements were taken simultaneously at childbirth simulation (by utilizing an examination model) – all the time using the SonoSens Monitor and every 5 min using OWAS. Additionally, a survey was conducted among the study participants aimed at identifying back pain incidence.

The measurements of spinal alignment in working posture were conducted by utilizing an ultrasonic device SonoSens Monitor 8 (Friendly Sensors AG, Jena, Germany) [5], which allowed for three dimensional assessment of individual spinal regions alignment and time-related distribution of the values. This device is equipped with four pairs of sensors which are stuck to the examinees' skin along the spine (on both sides, within 5 cm of each other on the levels C_3-C_4, Th_2-Th_3, Th_{12}-L_1, L_5-S_1). The sensors work as transmitter-receiver, measuring reciprocal locations and they are connected with a small, mobile data collection apparatus. The device was always calibrated – to describe individual lengths between the sensors whilst maintaining an upright position for 10 sec and in extreme values of spinal locations in six basic directions (flexion, extension, lateral flexion to the right and to the left and both sides rotations). During multidirectional torso movements whilst working reciprocal sensors arrangement is changed. The system automatically registers and calculates individual spinal segments arrangements in every plane in regard to the upright position and the range of motion maximal values registered during the calibration of the device as well as the repetitiveness of these arrangements (RI). After calibration, midwives' spinal arrangement was registered in their working positions when they were assisting childbirth using frontal birth assistance technique. The height of the childbirth bed was adjusted to the height of the examinee. The Żywiec Medical Trading LM-01childbirth bed was used so that the examination reflected the Polish reality. Because of the fact that attending childbirth was simulated, the complete unified midwife uniform was not used and the time was shortened to 30 min. The measurements were taken during the simulation of midwife activities typical for the second and third stage of the childbirth. These stages were chosen due to the specific character of midwives work – in the static, forced and most uncomfortable working position which is additionally accompanied by exertion of getting the baby's head and body as well as the placenta and membranes.

The assessed parameters included the percentage values of max range of motion in the following spinal segments: cervical (CSC), thoracic (TSC), lumbar (LSC) their medians and regularity indices (RI) illustrating the repetitiveness of a particular arrangement (movement) during the attempt, graded on the scale from "0" (irregular) to "10" (regular).

The centre of pressure (COP) projection on the basal plane was evaluated by the use of the stabilometric AMTI's AccuGait Balance Platform (AMTI, Watertown, USA) cooperating with the Balance Clinic software which documented and analyzed the obtained data. The center of pressure is the recorded subject pressure position being tracked by the platform as the subject sways. Further analysis involved parameters pertaining to the sway area (the bounding rectangular area which encompasses 100% of the data), path length (the trajectory of COP – the distance which the centre of the mass projection travels on the basal plane) and velocity (the path length per time unit – an average speed of COP on the basal plane). Additionally, in each working position the maximal sway of the centre of the mass projection was measured in the frontal plane (max sway X) and in the sagittal plane (max sway Y) and the limits of stability were identified, i.e. the limits which when they are exceeded the loss of the balance occurs (anterior limit of stability, posterior limit of stability, right limit of stability and left limit of stability). The results of the stabilometric measurements obtained in the working position were compared to the results obtained in a relaxed upright body position (providing that in a relaxed upright position a human being is not only influenced by gravitational forces but also by the forces generated by their balance system).

The conducted surveys provided data referring to back pain, especially its localization and duration were evaluated. To assess the frequency and pain intensity Jackson and Moscovitz scheme was used in which clinical characteristics are graded on a 6-point scale (0–6) including no pain discomforts, sporadic pain, periodic pain, frequent pain, very frequent pain and constant pain. It describes also the limitations of everyday activities imposed by pain [6].

The obtained data was put in one database and analyzed with Statistica v. 7.1 StatSoft software [7]. The analysis focused primarily on assessing to what extent the recordings obtained in the working posture differed from the analogical measurements taken in a relaxed position. Furthermore, it was evaluated whether, in what respect, and to what extent the body arrangement of junior midwives differed from the body arrangement of senior midwives (i.e. the impact of long experience and preserved fixed habits was analyzed). For data analysis, descriptive statistics were used; to compare the median values, test t for unrelated data was used; and to assess the relations between non-parametric characteristics, test $\chi 2$ was used. The statistical significance of $p < 0.05$ was assumed in all analyses.

The Bioethical Commission of the Medical University of Silesia expressed its consent for the tests to be performed.

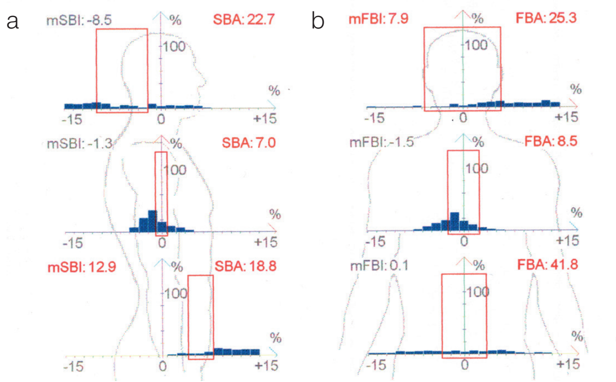
RESULTS

The analysis of the measurements based on the OWAS system did not contribute anything specific since all the positions were qualified to the third category implying a heavy load and a negative impact on the musculoskeletal system. The static load was assessed as moderate due to the fact that maintaining the working position (forced) normally took less than 30% of the work time.

The calibration process of sonometric recordings revealed restrictions of spine mobility which were registered in 40% of the subjects. Most frequently they concerned straightening of the spine, less frequently – spinal rotation and most rarely – spinal lateral flexion (respectively 14.73%; 13.68% and 9.47% of these results). The restrictions were insignificant and their distribution in the sample was in no respect specific. They were equally characteristic for junior and senior midwives.

The results of the measurements conducted in the working position showed certain general tendencies. Apart from some exceptions (ca 7% of all results), absolute values of all measurements in the whole sample definitely exceeded the norms for a standard spinal alignment. The median values of the measurements in the sagittal plane showed the prevalence of a significant neck hyperextension and a slight thoracic spine hyperextension, while in the lumbar spinal region a visible flexion was noted. The frontal plane analysis revealed in 9 cases (9.47%) the incidence of lateral cervical spinal flexion (right-sided) affecting all spinal segments. In the remaining subjects, three variants of spine arrangement were noted, namely, a single lateral flexion of two adjacent spinal regions (cervical and thoracic spine or thoracic and lumbar spine) and a double major curve of subsequent regions. With reference to the incidence of right versus left flexions in adjacent spinal regions their distribution turned out to be identical. In the horizontal plane, a different distribution of values was noted. The least common scoliotic form was a single lateral rotation of extreme spinal regions (cervical and lumbar 17.89%). A more frequent spine arrangement (37.88%) was a single lateral rotation of all spinal regions (left-sided), while the most frequently prevailing arrangement turned out to be an unidirectional rotation of two adjacent vertebral regions, i.e. cervical and thoracic spine (37.89%) or thoracic and lumbar spine (24.21%). The above-described spinal configurations had a characteristic pattern and the median regularity indexes measured in each spinal region ranged between 6.207–7.233.

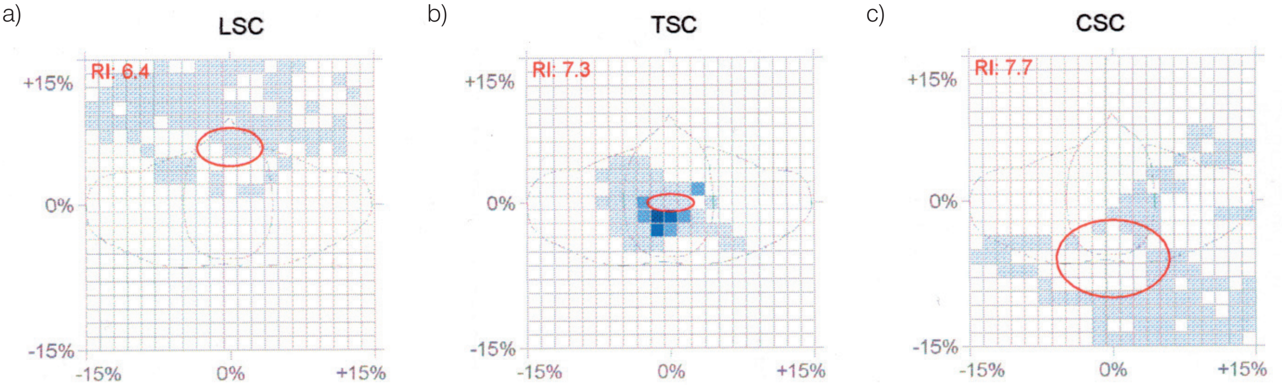
Because of a varied configuration of individual spinal regions, the median values of the discussed parameters turned out to be in no respect specific. Furthermore, they were lower due to negative values of some results (the system utilizes the sign 'minus' with reference to the direction of bend). Only the analysis based on absolute values gave the actual picture. The assessment of the values allowed to conclude that the most significant spinal arrangement



SBI – Sagittal Bending Index – represents the range of movement: positive values represent flexion, negative values – extension; mSBI – median SBI, SBA – Sagittal Bending Amplitude (indicates the width of the distribution of SBI), graphically presented as the blue diagram; FBI – Frontal Bending Index – represents the range of movement: positive values represent lateral flexion to the right, negative – to the left; mFBI – median FBI; FBA – Frontal Bending Amplitude (indicates the width of the distribution of FBI) graphically presented as the blue diagram.
The reference values of a test conducted in a healthy person are graphically presented as a red rectangle.
The values beyond the standard range are marked in red.

Fig. 1. Illustrations presenting the spine arrangement in midwives' working position in sagittal plane (a) and frontal plane (b)

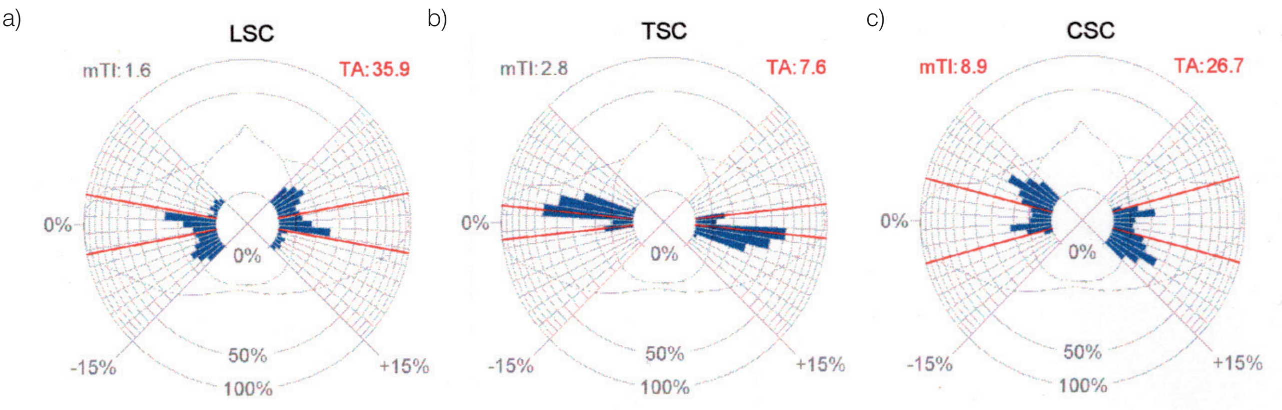
in the working position in the sagittal plane involved lumbar spine bending. In group A – the values recorded in 11 midwives (21.56%) were exceeded by on average 103% in relation to the maximal range of movement in the free standing position, in group B – the values in 33 of the examined midwives (75%) were exceeded by 96.72%. Slightly lower extreme values concerned hyperextension in the cervical segment (exceeded in both groups by more than 73%) and the mildest arrangements involved hyperextension in the thoracic spine (exceeded by on average 40.84% in junior midwives and by 36.83% in senior midwives). The distribution of the results referring to lateral spinal bending was identical. Again, the most affected was lumbar spine, cervical spine was moderately affected and the mildest arrangements were noted in the thoracic spine. The extreme values with reference to an upright



LSC – lumbar spine (a), TSC – thoracic spine (b), CSC – cervical spine (c). The reference values of a test conducted in a healthy person are graphically presented as a red oval. The values beyond the standard range are marked in red.

Fig. 2. Examples of graphs reflex bending work of the spine in horizontal section with regularity indication RI (in the upper left corner)

body position were 66.4; 33.3 and 16.7% respectively. The results pertaining to spine rotation had different distributions. In a working position, the cervical spine was rotated by 99.8 % in group A and by 91.31% in group B of the maximal movement range. In the lumbar spine, the values were similar – in both groups they were exceeded by 85%, and in thoracic spine they were exceeded only by 52.41%. The results of stabilometric measurements conducted in the working position revealed the worsening of almost all parameters when compared to the results obtained in the upright body position (Table 1). The analysis of the working position showed a distinct decrease of the sway area values, however, a significant increase in the path length and velocity was observed, which might point to a sort of postural instability in the working posture. Moreover, postural limits of stability were reduced, which is the evidence of the lack of possibility to fully utilize the basal plane. The only exception noted referred to the left limit of stability



LSC – lumbar spine, TSC – thoracic spine, CSC – cervical spine, TI – range of rotation, mTI – median of rotation values (positive values – left rotation, negative values – right rotation), TA – amplitude of rotation (width of distribution of TI), graphically presented as the blue diagram.
The reference values of a test conducted in a healthy person are graphically presented as the area between the red lines. The values beyond the standard range are marked in red.

Fig. 3. An example of spine rotation in the working position

Table 1. Results of basic stabilometric measurements

Parameter	Upright body position				Working position				t	p
	min	max	X	SD	min	max	X	SD		
Max sway X (in frontal plane)	0.011	2.26	0.51	0.45	0.08	1.41	0.5	0.34	0.175	0.863
Max sway Y (in sagittal plane)	0.131	4.03	1.63	1.05	0.03	10.2	2.53	2.65	3.704	0.0008
Sway area (the bounding rectangular area)	0.15	2.16	0.59	0.46	0.15	3.91	1.28	1.04	4.469	0.00008
Path length (trajectory of COP)	3.371	22.3	6.87	4.06	5.64	49.5	19.4	10.8	9.752	0
Velocity (average speed of COP)	0.36	2.22	0.65	0.39	0.42	2.48	0.98	0.51	6.615	0
Anterior limit of stability	0	6.21	2.65	1.52	0.11	6.32	3.20	1.46	1.455	0.159
Posterior limit of stability	0	5.18	2.96	1.29	0.10	7.21	3.50	1.910	1.638	0.113
Right limit of stability	0.74	4.42	3.08	0.82	1.55	7.42	4.14	1.27	5.335	0.000006
Left limit of stability	0.51	5.465	3.36	0.95	0.40	6.22	2.75	1.42	1.857	0.081

Min – minimal values, max – maximal values, X – mean arithmetic, SD – standard deviations.
COP – centre of pressure projection on the basal plane.
Limits of stability – limits which when they are exceeded loss of balance occurs.
Sway area in cm^2. Velocity in cm/sec, other values in cm.

which, together with higher left sway values, may indicate left side overload.

Examinations revealed that 67.3% of the examined midwives (including 54.9% from group A and 81.81% from group B) suffer from spinal pain discomforts. Among almost half of the examined junior midwives such problems appeared before the beginning of the study and they occurred, in total, for more than 5 years. The discomforts mentioned were variously localized and intensified. They occurred most frequently in both segments of the spine altogether: cervical and lumbar or thoracic and lumbar (15.68% and 31.81%, respectively). Pain localized only in one place was less frequent – in the lumbar or cervical segment of the spine (23.15% and 10.52%, respectively) and the least frequent pain occurred in all three segments (3.45 %) or in several segments of the spine and in upper and lower limbs at the same time (respectively 6.31 %, 5.26 %). The time of pain duration in the group composed of junior midwives did not exceed the range of 1–10 years (X = 4.35±2.12) and in the group of senior midwives – 1–24 years (X = 7.1±5.58). In group A, in 25.41% of the examinees, pain discomforts occurred throughout the period shorter than 2 years, in 15.68% – from 3 to 5 years and in the remaining 13.71% pain discomforts lasted more than 5 years. Analogous distribution was observed in group B – i.e. 18.18%, 11.36%, 52.27%, respectively. The frequency and intensity values were various: from sporadic pain, occurring several times per year – especially after efforts and not limiting the examinees' activity (15.68% in group A and 9.09% in group B) and periodical pain occurring several times per month – especially after work (37.25% in group A, 53.65 % in group B) to frequent pain occurring several times per week and limiting the examinees' every day activities (5.88% in group A, 17.07% in group B), and constant pain (occurring only in group B in 1 examinee).

Pain discomforts occurring in midwives were significantly different in the examined groups ($t = 2.47$; $p < 0.016$). It turned out that the period of time of occurring pain depends on the time of professional experience ($r = 0.37$, $p < 0.005$), the longer the professional experience is, the longer the pain discomforts last. On the other hand, no relation was observed between the frequency and intensity of pain (respectively: $\chi^2 = 3.28$, $p > 0.77$ for group A and $\chi^2 = 4.27$, $p > 0.36$ for group B; df = 6)

Pain did not influence directly the manner of performing the working position in midwives included into both groups ($\chi^2 = 1.32$, $p > 0.58$ and $\chi^2 = 2.59$, $p > 0.27$). People with back pain usually restrict the range of their movements. Nonetheless, in group A, 27.45% of midwives exceeded their maximal movement range (obtained during the calibration) or approached its values despite spinal pain discomforts. In group B, more than a half of the examinees (51.42%) exceeded the maximal range despite the pain. In the examinees from both groups (A and B) without pain discomforts, work was performed within the median ranges of movement. It can be therefore said that the forced working position is performed despite pain discomforts. The occurring pain discomforts did not depend on the height or body weight, but consequently on BMI of the examinees ($\chi^2 = 1.04–3.26$, $p > 0.46$). However, among junior midwives, in 23.53%, BMI values indicating overweight were observed (BMI: 25–28) and in 3.92% – values indicating obesity were observed (BMI: 30–31).

DISCUSSION

Back pain is considered to be a serious medical problem in present-day medicine. It is classified as an industrial disease and factors which increase the risk of developing back pain are sedentary lifestyle and limited physical activity. In addition to this, performing occupational activities in unnatural body positions increases the risk of developing back pain [8,9]. Ergonomic working might prevent back pain [6], however, since it is impossible to eliminate all risk factors, limiting the most harmful factors and soothing the effects of others may be a solution. It can be achieved by, among others, identifying hazards associated with unergonomic working positions and optimizing the workplace area [1,2].

The issue of ergonomics has gained interest and conducting ergonomic measurements has become widespread, nonetheless, the assessment of such hazards in specific medical professions is not common. One of the obstacles is the lack of appropriate measurement tools. The main tool is the OWAS system [3] which offers general information in that field. The development in measuring techniques and in computer science gives the possibility of monitoring a worker. An example illustrating this solution is the SonoSens Monitor – which allows for a detailed analysis of spine alignment while performing work activities and which offers a possibility to transmit data to the OWAS system. However, with reference to midwives, conducting such measurements within the specific conditions of a delivery room seems to have impediments. That is why the authors decided to resort to a simulation of childbirth on an examination model.

In accordance with our expectations, the obtained data confirmed the unfavorable spine alignment in midwives assuming working postures when attending childbirth. This tendency was unambiguously showed by the OWAS method, although it did not contribute specifically to the overall picture since all the adopted body positions were equally incorrect and forced to the same extent. This fact implies that midwifery work areas ought to be modified as soon as possible and it is not possible in practice.

Sonometric measurements revealed that, despite the fact that the study participants were performing a standard midwifery activity, their spatial spinal configuration might distinctively vary among midwives both with reference to the location and to the body plane in which the most unergonomic spine arrangement was recognized. It is due to individual-specific spinal flexibility and habitual movement patterns [10,11]. Multisegmental and multiplane spine movement abilities present favorable conditions for compensatory movements of body segments which secure body stability. This was confirmed by stabilometric results. Compensatory movements cause overload of a part of the body that is difficult to foresee. Each working position – different from the erect one – presents conditions for a different from normal distribution of forces which affect the spine. It refers to not only specific distribution of the forces of gravity – compressive and shear forces – but also to the elevation mechanism in which rotation of the gravitational forces is increased and heavier work of antigravitational muscles is required – usually the tonic ones [12,13]. If the situation repeats, it causes overloading and it is a matter of time when the symptoms manifest themselves, typically as pain.

This possibility was confirmed by the results of our study. Although the common almost prevalence of back pain was not surprising, reporting its onset before becoming a student by almost half of junior midwives arises anxiety. It implies other primary causes of back pain and, at the same time, poses a threat that working in unergonomic positions might worsen the ailments. This is confirmed by the prevalence of back pain in 100% of senior midwives.

Occupational hazards associated with attending childbirth pose a basic component of midwives' work. Their tasks are in part analogous to nurses' work and ergonomic threats of nursing occupations are equally serious [8]. Due to the above-mentioned hazards, while training midwives, an emphasis is put on performing occupational activities in positions close to ergonomic ones. Back pain self-prevention experiences might be of value in this area [2].

CONCLUSIONS

1. Spinal configuration assumed by midwives while attending childbirth significantly deviates from its normal alignment and is individual-specific.
2. Because of individual-specific spine alignment, it is difficult to unambiguously identify overloads in midwives' spines, but the most significant ones affect lumbar and cervical spine.
3. The incidence of back pain in midwives is high and most commonly it affects the most overloaded spinal regions altogether.
4. Back pain is manifested both in junior midwives and in senior midwives, but in the latter group developing back pain is certain.
5. Working position assumed by midwives imposes a characteristic arrangement of the body and is adopted in maximal movement ranges despite pain discomforts.
6. The occurring pain is characteristic for midwives working in maximal or close to maximal movement ranges.

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