

Teachers' working postures and their effects on the voice

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Abstract

Objective To evaluate associations between voice and working postures used during teaching.

Methods A researcher assessed 30 teachers' typical working postures of the torso, head, shoulders, upper back and arms by observing and/or asking questions about them. Teachers' options to rest and to adjust furniture according to their needs were also elicited. Voice symptoms were evaluated through two self-assessment forms. Fundamental frequency, sound pressure level (SPL) and alpha ratio were calculated from voice samples recorded before, during and after teaching.

Results The head was most typically in an unergonomic posture while speaking (in 60% of participants). Other frequently used unergonomic postures were hunched upper back (55%), raised shoulders (46%) and twisted torso (43%). Head and torso twisted and arms upheld were associated with specific voice symptoms and head postures and hunched upper back with voice use. The number of postures was also connected with voice use: if the teachers used over three unergonomic postures, their SPL was higher and the voice broke more often than in those with a lower number of postures.

Conclusion Unergonomic postures during speaking affect the voice. It is important to evaluate working postures as a part of voice ergonomic assessment in voice patients.

Introduction

An ergonomically good posture is not an inherent ability [1]. All parts of the body are connected with each other, thus any force causing a change in one segment will move other segments to compensate for loss of balance in the body [1, 2]. This especially concerns the human larynx, which is at “the center of a constant battleground between the deep extensor and flexor groups of muscles of the neck and torso” as Rubin et al. [3] graphically describe it. Furthermore, the movements and postures of body segments are inseparable from communication behaviour and voice use and are intrinsic parts of it [4].

In voice therapy, exercises to improve postural alignment are often included in therapy aims. According to a survey, 37% of speech therapists guide their clients to do these exercises [5], which have been found to improve clients' body balance [6]. However, associations between voice use and speaking postures have been studied only rarely, particularly from the perspective of voice ergonomics. One reason for this may be the lack of practical tools or protocols for assessing working postures, which is also a common problem in the field of general ergonomics [7]. In an attempt to redress this shortcoming in voice ergonomics, we composed a list of the most typical speaking postures and instructions on how to evaluate them. This protocol can be found in the *Voice Ergonomic Assessment in Work Environment—Handbook and Checklist* (VEAW) compiled by a team of representing different fields of ergonomics and voice care [8]. The VEAW can be used to evaluate risk factors for voice disorders such as background noise, indoor air quality, working postures and practices. The information is gathered by means of observations, asking questions and making measurements. The VEAW was originally developed for the clinical use of occupational health care experts, but it can also be used in research. The assessment procedure has been described in more detail in the article by Rantala et al. [9]. Data for the present study was collected

from teachers and their classrooms at the same time as the whole voice ergonomic assessment was made. In earlier reports we have analysed the effects of working postures as a single entity [9, 10]. In the present study, we scrutinized separate postures and their effects in greater detail.

Another reason for studying the effect of working postures on voice is that musculoskeletal disorders are one of the most typical occupational health problems in teachers [11] and these problems are connected to voice symptoms [12]. It has been shown that 67% of teachers suffer from neck pain, 33% from upper limb pain, and 30% from both [13]. Further, upper back (37%) and lower back pain (44%) are also typical problems in teachers [14].

Although voice researchers have had no systematic protocols to assess working postures, there are studies assessing the associations between postures and voice use. A survey of 78 female teachers revealed no association between working postures and voice symptoms [15] while studies on 25 dysphonic teachers [16] and 40 elementary school teachers [9, 10] revealed that ergonomically undesirable postures exacerbated the severity of voice symptoms and affected voice production.

One of the most typical undesirable head postures people use is thrusting the head forward (Figure 1). This is common, especially among dysphonic teachers: about 75% use it [16]. When thrusting the head forward or rotating it, one of the most important muscles in play is the sternocleidomastoid muscle [17]. If the muscle is strained, the incidence of voice symptoms increases [16]. It has been claimed that the forward head posture elevates the larynx by shortening the supra hyoid musculature; especially the stylohyoid and the posterior belly of the digastric muscle [18]. These alterations change the shape of the vocal cavity and moreover impair the resonance of the voice [18, 19]. Head thrust forward may also impede the forward movement of the thyroid cartilage, which inhibits the use of high tones and limits the pitch range of the voice [3, 18]. In the fine adjustments

of F_0 it is particularly important for a speaker to be able to move the larynx vertically freely [20, 21].

FIGURE 1 ABOUT HERE

The ideal body posture for speaking is upright. This allows the internal abdominal organs to sink down with the help of the force of gravity creating more space for breathing movements with higher lung volume [17]. A standing posture commonly used in dysphonic speakers involves the weight being distributed posteriorly: the pelvis is anterior to the torso with increased thoracic kyphosis and to some extent lumbar lordosis [16, 22]. In this posture, the lumbopelvic stabilizing musculature is passive, while in optimal posture it ought to work actively [23]. Straight posture of the pelvis enables proper weight distribution and balance in the body, thereby sustaining an ergonomic position. An upright position also enables the most favourable posture for the head [24].

External factors affecting speakers' postures are the furniture and devices they use. For instance, projectors or smart boards may cause teachers to twist their heads and torsos. Teachers working with young children are at especially elevated risk of low back pain due to activities requiring awkward and static postures, such as using child-sized furniture, sitting on the floor, or bending at the waist [25]. According to kindergarten teachers' own appraisals, a bent torso affects the voice most negatively [26].

Even short rest periods in the middle of voice loading tasks help the vocal organs to recover from loading changes [27]. Regular pauses also relieve neck and upper-limb pains if a worker has to look at the screen a lot [28]. Breaks as short as three minutes after every 20 minutes of work have been shown to relieve muscle tension in the region of the neck and shoulders [29].

On the basis of earlier studies and clinical experience, it can be assumed that ergonomically undesirable working postures may be deleterious to teachers' vocal well-being in the long term even if their postures are not as static as those of people in certain other occupations. Thus the aim of this research was to explore what kinds of ergonomically undesirable working postures teachers adopted during teaching and if these were associated with the occurrence of voice symptoms and acoustic features of the voice. We also ascertained if the number of working postures adopted had an impact on the voice.

Materials and methods

Participants and their working environment

Thirty-two female teachers (mean age 45 years, range 27–57 years) and eight male teachers (mean age 39 years, range 31–45 years) from 14 different schools participated voluntarily in the study. Twenty-three teachers had been working for more than ten years, seven for between five and ten years and others for less than five years; one participant did not provide this information. Four teachers were smokers. One male teacher had a benign mass lesion in the vocal folds. The number of pupils in the classrooms varied from 10 to 28 (mean 20 pupils). The recruitment of the participants has been reported in more detail in the article of Rantala et al. [9].

The participants taught pupils aged between seven and 13 and used teacher-centred pedagogy. The mean number of pupils per classroom was 19 (range from 9 to 27). Eleven per cent of the pupils had a language other than Finnish as their first language, seven per cent had learning difficulties but no medical diagnosis, five per cent had some kind of speech-language impairment and two per cent

had attention deficiency disorder. The sizes of the participants' classrooms were similar: the rooms were on average 8.4 metres long (SD 1.0 m), 7.5 metres wide (SD 0.9 m) and 3.2 metres high (SD 0.24 m).

The mean of background noise level ($L_{Aeq1min}$) in the classrooms caused by appliances attached to the buildings was 35 dB (SD 5.6 dB), which slightly exceeds the limits in the Finnish standards. Activity sound levels ($L_{Aeq2-4\text{ hours}}$) were also high for speech communication (mean 69 dB, SD 6.2 dB). Nor did the acoustic indices fulfill the recommendations in the most of the classrooms: reverberation time was satisfactory in 35 % of the classrooms and the index for speech clarity (speech transmission index) in only one class. Information on classrooms is presented in more detail in an article by Sala and Rantala [30].

Working postures

Participants' working postures and related issues after a working day were assessed in their classrooms without the pupils. The evaluation was made at the same time as the whole voice ergonomic risk assessment with the VEAW. Altogether the assessment took about 40–60 minutes, of which the evaluation of the postures took 10–20 minutes.

The assessment (Table 1) comprised 11 items: a general evaluation of working postures (item 1), eight specific assessments from five different parts of the body (items 2–9), one assessment of the effect of furniture (item 10) and a question about opportunities to recover from loading (11). Items 1, 10 and 11 were elicited directly from the participants. A researcher (speech therapist) trained in the use of the assessment requested a participant to go to all the typical working sites used while teaching and demonstrate how the most characteristic tasks were performed. To help the researcher

in making evaluations, the assessment form included written explanations and photos of desirable and undesirable postures (Figure 1 for unergonomic postures). When needed, participants were asked about their working postures such as ‘Do you talk with your pupils when you use your blackboard/overhead projector? Please show how you do that? Is this posture typical for you?’ If a posture was ergonomically desirable, the finding was scored zero (0 = no risk to the voice) otherwise it was scored one (1= likely to cause a voice disorder). Thus, the maximum risk index was 13 points.

To calculate the inter-rater reliability of the posture assessments, three researchers watched videos where 10 people showed their most typical speaking postures while working. To assess intra-rater reliability, two researchers repeated the assessment after one month. According to the analysis, the inter-rater (Cronbach’s α was 0.8) and intra-rater coefficients (Spearman’s rank order correlation coefficients 0.86 and 0.9) expressed that the assessments were sufficiently reliable.

TABLE 1 ABOUT HERE

The research was conducted with the approval of the relevant municipal education authorities. According to the legal advisor of the study organization, the study setting did not require ethical approval. The participants were anonymized with code numbers.

Voice symptoms

After the voice ergonomic assessment the participants were asked to complete two questionnaires about their voice symptoms . The first was the Finnish version (31) of the Voice Handicap Index (VHI). (32) The VHI is a questionnaire with three domains each comprising ten items: physical (VHI-P), functional (VHI-F) and emotional (VHI-E). The responses were scored on a five-point

scale (0 = never, 1 = almost never, 2 = sometimes, 3 = almost always, and 4 = always; 120-point total). In the second questionnaire, the occurrence of seven voice symptoms was elicited. The voice symptoms were (1) voice tires easily, (2) hoarseness, (3) voice breaks, (4) aphonia lasting at least a couple of minutes during speaking, (5) difficulty in audibility due to voice problems, (6) throat clearing and (7) sore throat or globus in the throat. The participants responded on a five-point scale (4 = symptoms occur daily or almost daily; 3 = weekly or almost weekly; 2 = monthly or almost monthly; 1 = more seldom; and 0 = no symptoms during the last 12 months). This questionnaire has been shown to effectively reveal voice disorders (33) and has also been used in several voice studies [33–35].

Voice samples and variables measured

Two different voice samples were recorded: a one-minute long text reading of 102 words from a book ‘People from Hemsö’ by August Strindberg (in Finnish) and speech during lessons of one working day. The text is easy to read and commonly used in Finnish voice studies. The reading was recorded 30–60 minutes before work (morning sample) and 5–15 minutes after it (afternoon sample) in a quiet, unoccupied room at each school. The recordings were made with a digital H2 recorder (Zoom Corporation, Tokyo, Japan) and a headset microphone (C555 L, AKG, Vienna, Austria) at a distance of three centimetres from the corner of the mouth. The calibration for the measurements of voice SPL was made using a sound generator (BOSS TU-120, Roland Corporation, Los Angeles, CA) and a sound level meter (Brüel & Kjær 2206). One female participant did not provide the afternoon voice samples.

Speech during lessons was recorded with a portable accelerometer (Ambulatory Phonation Monitor, APM, 3200 model 1.04, Kay-Pentax, Lincoln Park, NJ). The participants recorded one whole

working day but only the recordings from the first and last lessons were included in the analysis of the present study.

Fundamental frequency (F_0) and sound pressure level (SPL) were analysed from the text readings and speech during lessons. F_0 and SPL from the two voice samples were measured as voice use measured outside classroom work seemed to better typify a teacher's habitual voice use, while speech during lessons revealed direct vocal reactions to the environment and vocal load [36]. The changes in F_0 and SPL during work were calculated (difference between the values of the parameters measured from the first and the last lessons). F_0 s of the morning and afternoon samples were studied separately for females and males. Further, the tilt of the sound spectrum slope called the alpha ratio (relationship of voice energy levels between SPL of 50 Hz–1 kHz and SPL of 1–5 kHz) was calculated from the reading sample. This ratio expresses voice quality on a continuum of hypo-to-hyperfunctional mode of voice production. The change in the alpha ratio during a working day was also studied. The acoustic analyses were conducted with Praat software for Windows (Version 5.3.79) [37].

Statistical analysis

To study the effects of individual working postures the participants were divided into groups: one group consisted of those not using any ergonomically undesirable postures and the other group of those using one or more ergonomically undesirable postures. A similar categorization was made to study the effects of different numbers of postures. Wilcoxon signed-ranks test (independent samples) was used for the analyses. The group comparisons were computed separately for females' and males' F_0 s. A significance level of .05 was adopted because this study was essentially exploratory in nature. Too strict criteria might have led to missed findings. Effect size for the group

differences was calculated with Cohen's d [38]. Interpretation of the values was as follows: 0.2 = small, 0.5 = medium and 0.8 = large effect. The analyses were carried out with PASW Statistics 23.0 software for Windows operating system (SPSS, Inc., Chicago, IL).

Results

Working postures during teaching while speaking

Most of the participants (90%, $n=36$) reported that their working postures felt good. Everyone was also able to rest during the working day. However, according to the researcher's observations many participants used speaking postures which were likely to predispose them to a voice disorder (Figure 2). The most typical unergonomic posture observed was that the head was out of its neutral position: 60% ($n = 24$) of the participants turned, thrust or tilted their heads or used an undesirable head posture because of varifocal or reading glasses. The head turned to the side was the most common of these postures, while the least typical (7.5%, $n = 3$) head posture was that caused by wearing glasses. Other frequently used unergonomic working postures were hunched upper back, raised shoulders and twisted torso. Most of the participants (75%, $n = 30$) were able to adjust the tables and chairs in their classrooms.

FIGURE 2 ABOUT HERE

The participants mostly used 3–5 unergonomic working postures while speaking (40%, $n = 16$). Thirteen teachers (30%) used one or two unergonomic postures and seven (18%) used 6–8 poor postures. Of the participants, 12% ($n = 5$) did not use any ergonomically undesirable posture while speaking in the classroom.

Voice symptoms and acoustic features of the voice

The mean of the total scores of the VHI was 18 (SD 13.5). On the subscales, the mean of the physical domain (VHI-P) was highest at 8.6 (SD 5.9). The means for the other subscales were 5.4 (SD 4.46) for the VHI-F and 4.0 (SD 4.36) for the VHI-E. The most typical individual voice symptom for the participants was 'voice tires easily' (Table 2).

TABLE 2 ABOUT HERE

The SPL means were 72 dB (SD 5.0 dB) for the morning and 73 dB (SD 4.1 dB) for the afternoon voice samples (text reading). The F_0 means were 182 Hz (SD 15.7 Hz) for the morning and 185 Hz (SD 17.2 Hz) for the afternoon samples among the female participants and 97 Hz (SD 11.6 Hz) and 102 Hz (SD 14.9 Hz) among the males. The means of alpha ratios were -15.7 (SD 2.56) for the morning and -15.2 (SD 2.06) for the afternoon samples.

For speaking in the classroom (all lessons) the mean SPL was 75 dB (SD 5.5 dB) and this changed only slightly between the first and last lessons (mean for the change 0.3 dB, SD 6.6 dB). The F_0 mean for all the lessons was 225 Hz (SD 22.3 Hz) among the female participants and 130 Hz (SD 15.0 Hz) among the males. F_0 changed during lessons by 6.5 Hz (SD 18.7 Hz) among all participants.

Effects of working postures: comparisons between teachers who used or did not use ergonomically undesirable postures

Only a small number of the participants did not use any unergonomic postures ($n=5$). Their voices did not tire as easily (mean score 2.4, SD 1.14) and they did not have so many difficulties in audibility (mean score 1.2, SD 0.45) as did the teachers speaking while using unergonomic postures (mean score 3.68 and SD 1.27 for the voice tiring and 2.5 and 1.18 respectively for difficulties with audibility). In addition, the alpha ratios of the voices decreased (became more hypofunctional) in the participants using ergonomic postures (-1.6 dB, SD 1.69 dB) but increased somewhat (became more hyperfunctional) in those adopting harmful postures (0.7 dB, SD 1.48 dB). Because the group size was small for the teachers using ergonomic speaking postures, the results are only indicative.

The results showed that those participants who turned their heads, twisted their torsos and raised their arms while speaking were more likely to experience specific voice symptoms than were those who did not use these postures (Table 3). The effect sizes for the differences between the two groups were medium except that the difference for aphonia was small (-0.027). In addition, a small group ($n=5$) were in the habit of talking with the head tilted. They scored higher on the physical subscale of the VHI (mean 13.4 scores, SD 5.72) than did those who did not use that posture (mean 7.9 scores, SD 5.32).

TABLE 3 ABOUT HERE

If the participants thrust their heads forward while talking in the classroom their F_0 decreased on average 4 Hz and SPL decreased 4 dB (measured during lessons; Table 4). In those teachers who did not adopt this head posture the values of the variables increased (F_0 mean: 9 Hz) or remained almost the same (SPL mean: 1 dB). Post hoc analysis showed that the F_0 change was significant only for the teachers adopting an ergonomic head posture ($p=.004$) while the SPL change was significant for the teachers adopting an unergonomic head posture ($p=.021$). The alpha ratio

increased on average 0.83–1 dB (voice became more hyperfunctional) in those teachers who hunched their upper backs and turned their heads but decreased 0.2–0.5 dB in those did not adopt these postures while speaking. SPL was 3 dB higher in those participants who talked with hunched upper back. The effect sizes of the head positions on the acoustic variables (ES -0.89 for alpha ratio change and 0.84 for SPL change) were large.

A small group (n=3) using unergonomic head posture due to wearing spectacles or varifocal glasses had a tendency to lower their F_0 (decreased 18 Hz, SD 16.5) and SPL (decreased 7 dB, SD 5.6) measured during lessons, whereas these variables increased in the teachers (n=37) who did not use this posture (rise for F_0 8 Hz, SD 17.5 and SPL 0.4 dB, SD 6.2). Because of a low sample size, no significance level was calculated.

TABLE 4 ABOUT HERE

Effects of the number of ergonomically undesirable working postures

The participants who used two or more ergonomically undesirable working postures while speaking suffered more often from physical voice symptoms (measured with the VHI) than did those who used only one or none these postures (Table 5). Using four or more unergonomic postures was particularly associated with the symptom of voice break: the participants with this number of postures experienced the symptom on average weekly, while those with less than four undesirable postures suffered the symptom monthly or more seldom. The effect size was also large (-0.90). The number of postures also affected voice production (Table 6). The greatest effect size for the number of postures (-1.1) was found in the morning voice samples if the teachers used four or more unergonomic working postures. The SPL of these teachers was on average 5 dB louder than those

teachers with fewer than four unergonomic postures. The effect size was also large for change in F_0 during lessons (1.05). The value of this variable increased much more (18 Hz) in those teachers who used one or no unergonomic posture than in those using more undesirable postures (increase only 2 Hz). According to post hoc analysis, the F_0 change was significant ($p=.003$) for those teachers who used only one unergonomic posture. The SPL also changed differently in those groups but the change was not statistically significant in either group.

TABLE 5 AND 6 ABOUT HERE

Discussion

We introduced a tool for assessing speaking postures used during teaching. In clinical work, improving postures is a relevant part of voice therapy and education. However, a tool for assessing unergonomic postures in voice patients has been lacking and scientific evidence on the effects of speaking postures has also been sparse. Although the results of the present study raised rather more questions than providing specific answers, trends regarding speaking postures and their impacts on voice could be discerned.

According to the results, teachers typically used from three to five unergonomic speaking postures during teaching and about one fifth of the teachers used as many as six or more poor postures. The most common ergonomically undesirable postures were turned head and hunched upper back. The results also revealed that unergonomic postures were associated with more frequent occurrence of self-reported voice symptoms and potentially harmful vocal adaptations. The teachers' own evaluations of their postures were that they generally felt good. This finding suggests that teachers may mostly be unaware of the voice loading caused by the postures they use. Only five participants

(13%) did not use any risky speaking postures. These teachers' voices tended to endure better and their voice quality did not become hyperfunctional as happened to the voices of those using unergonomic postures.

The good news of the present study was that all the teachers had opportunities to rest in the course of their work, which is known to support vocal health [27]. Because every participant could take breaks, the connection between rest and voice could not be studied here. Most of the teachers were also able to adjust tables and chairs to suit their needs and this may explain why the effect of the variable could be found on neither the voice symptoms nor voice use.

The postures were not associated with the voice variables in the same way; some were connected to the occurrence of voice symptoms while others were connected to voice production. The postures causing voice symptoms were turned torso and head and raised shoulders and arms, whereas acoustic features of the voice were affected by forward thrust head and hunched upper back. Only one posture – the turned head – affected both voice symptoms and acoustic features. Because voice symptoms mostly indicate more serious voice problems (expressing possible alterations in vocal organs) than changes in acoustic features of voice (not necessarily changes in vocal organs but may express changed vocal behavior due to loading), the results suggest that that turned postures and raised upper limbs may load more vocal organs more severely than do other speaking postures.

One reason why twisted postures load the voice organs may be increased tension in the muscles causing unequal distribution of biomechanical loading on the spine [1, 2, 39]. This stress has also been shown to lead to back pain [39]. Asymmetrical postures also bring unequal stretching forces to bear on the components of the larynx and hence disturb voice use and may cause voice symptoms in

the course of time. The voice symptoms found in the present study – particularly voice breaks – may be one manifestation of this.

Raised shoulders and arms were another posture group increasing the occurrence of voice symptoms (higher scores in VHI-P and aphonia respectively). The harmful effect of the postures is corroborated in the work of Koojiman et al. [12], showing that pain in the shoulders raises the occurrence of voice symptoms. The present study showed specifically that raised arms were associated with a serious voice symptom, that is, aphonia. Although the connection was only tenuous, it nevertheless suggests that this posture may cause a risk for a voice disorder.

The hunched upper back posture in particular may affect voice use by restricting the breathing movements. This posture inhibits the lateral expansion of the ribs and the descent of the diaphragm by shortening the pectoral muscles and adaptively the abdominal muscles [2]. Weak activity in the diaphragm may lead a speaker to talk at the end of normal expiration thereby increasing laryngeal muscle tension [40]. The finding that voice quality became more hyperfunctional during work among those teachers with hunched upper back may reflect this phenomenon. It moreover seems that the same teachers also used higher SPL before work. Could it be so that hyperfunctional voice use had irritated the teachers' vocal organs causing poor voice quality and/or increased phonation threshold pressure the next morning and this was why they had to increase their voice loudness? Earlier research supports this explanation: for instance, teachers whose classrooms have many voice ergonomic risk factors use higher SPLs, particularly before work, than do teachers with better voice ergonomic environments [41, 42].

The forward thrust head affected F_0 . If the teachers used this head posture, their F_0 decreased somewhat (-4 Hz) during lessons but if they did not use it their F_0 rose (9 Hz). According to Rubin

et al. [3, 18] the forward head posture elevates the larynx by shortening the muscles attached to the hyoid bone and the processes of the temporal lobe of the skull that, in turn, leads to the shortening of other suprahyoid musculature, thereby affecting pitch. However, it is not clear how the raised larynx affects F_0 because the evidence of a relationship between these two factors is inconclusive. A positive correlation between the height of the larynx and F_0 was found in studies where vocally healthy participants produced sustained vowels [20, 21, 43]. In turn, clinical studies have shown that although patients with voice disorders held their larynges high, they did not, however, use high F_0 [44] or their F_0 did not systematically decrease although their larynges were lowered during the treatment of manual laryngeal reposturing and circumlaryngeal massage [45]. It, therefore, seems that imbalance in the neck muscles interferes with the natural physiological co-operation between the vertical laryngeal position and F_0 . This explanation gains support from Rubin et al. [3, 18], who have contemplated musculoskeletal patterns in voice patients, and suggest that the high held larynx may restrict the use of higher frequencies because it resists the upward and forward movement of the hyoid bone and thyroid cartilage. They also conjectured that the raised larynx may cause chronic contraction of the cricothyroid muscle which, by inhibiting forward movement of the thyroid cartilage, limits voice pitch variation. Note that we did not palpate our participants' larynges and can therefore not state for sure if their larynges were elevated.

A parallel but greater difference in F_0 change was found between the groups of teachers with different numbers of ergonomically undesirable postures (group ≤ 1 unergonomic posture vs. group ≥ 2 unergonomic postures). Thus, it seems that the rise of F_0 may rather represent the capacity of a muscle to change and hence a health physiological reaction to daily loading caused by speaking than it would unambiguously indicate a pathological alteration. Rubin et al. [3, 18] regarding the shortening tendency in the musculature caused by unergonomic postures suggest that this may also explain this phenomenon. Furthermore, results from earlier studies also support the conclusion that

the F_0 increase has to do with a normal loading reaction [46-48]. To better understand loading effects, more research is needed to ascertain the different reaction patterns of people using unergonomic speaking postures.

The forward head thrust was associated with another acoustic parameter in addition to F_0 , namely SPL. This decreased (-4 dB) during lessons in the teachers speaking with the unergonomic head posture while it increased slightly (1 dB) in those who did not. Decreased SPL may derive from difficulties in vocal projection because of unfavourable changes in the vocal tract: the lifted chin bends the pharyngeal region in the mouth, which effectively narrows the resonance and amplifying chamber at the base of the tongue [18, 19]. Moreover, elevated position of the larynx due to muscle tension may also have decreased voice loudness [18]. In the other hand, decreasing voice levels may also indicate the teachers' attempt to protect their voice organs from the consequences of loading caused by the unergonomic head posture. Because the number of teachers in the group with extended heads was small ($n=9$), the result remains tentative.

The results of the present study do not permit us to propose a critical number of ergonomically undesirable postures having an effect on voice. Although the number of unergonomic postures was connected to both voice symptoms and voice production, there was no specific level after which the effect of unergonomic postures became consistent. In spite of this, a tendency did emerge: the effect size of the posture rate was greatest when the teachers used four or more unergonomic working postures. The number of speaking postures was associated with voice SPL in particular. The more unergonomic postures the teachers used, the higher were their SPLs before and after work (measured from text reading). This suggests that speakers react to loading changes by increasing voice SPL in the long term.

Although the differences between the values of the acoustic variables in the present study were not great, the effect size of several differences was large, indicating that even small changes in voice features may constitute a risk for a voice disorder if a speaker uses the same speaking postures for years. The finding that the associations were not detected simultaneously between a specific posture and voice symptoms and production is difficult to explain. One reason may be that the most of the teachers used several unergonomic speaking postures. Another reason may be the nature of the muscle loading, the magnitude of which was low but long-lasting. This kind of loading leads to a long latency time for a disorder [7, 49]. A third reason may result from individual reaction patterns. For instance, workers who suffer from work-related muscle pain have been found to use muscles differently from those who have no pain [50]. Further, the sensitivity of the structures for loading differs across individuals; tense laryngeal muscles may cause dysphonia in one speaker but not in another [51]. Lastly, selecting other acoustic parameters for scrutiny might have resulted in a more consistent picture of the associations between postures and voice variables than we found now.

Methodical considerations

In spite of many computations the significance level of .05 was accepted which caused a risk of type I error. Hence, this study rather screened postures associated with voice symptoms and voice use than presented robust evidence of the effects of the postures on the voice. To improve the analysis we also computed the effect size to establish the clinical relevance of the findings.

Obviously, many factors other than postures affected the participants' voices. Further, the validity of the results is impaired due to some groups being small and to differences in the numbers of participants in the groups. To improve the reliability of the results, a control group without any unergonomic speaking postures would have been needed. Unfortunately this may often be

impossible if one wants to study occupational voice users such as teachers, whose working postures are not static.

A reliable evaluation of working postures during speaking is not easy. This has also challenged researchers in general occupational ergonomics and only few scientific papers on working postures and their effects have been presented [7]. Although in the present study the assessment was made outside classroom work, the concreteness of the instructions may have served as a cue for the participants to monitor their postures (cued recall) [52]. The teachers were requested to go to their typical working spots and show how they used their hands, moved their bodies, looked in different directions and so on. This was, indeed, what our participants did. The usefulness of concrete cues when studying postures gets support indirectly from two internet surveys using data collected by questionnaire. The studies revealed no associations between speaking postures and voice symptoms [15, 26].

Exposure factors for loading are intensity, duration and frequency of postures [49], and it would have been relevant to measure the last two of these. Although this was not done the factors were implicitly included in the procedure by asking the participants to demonstrate their typical postures. Furthermore, because the participants used teacher-centred pedagogy, their postures were not very diverse: they used blackboards, audio-visual equipment and computers, gave instructions and helped pupils. Hence, it may be assumed that the most common postures were detected, most of them, at least.

Video recording could have been used to learn more about postures during speaking, but the disadvantage is that analysis is time-consuming and analytical methods are lacking. Moreover, video recording in a classroom may change a teacher's behaviour and requires permission from

every pupil's parent or guardian; a single refusal would prevent it. A video recording lasting only one day might not give a comprehensive picture of the working postures because we do not know how much data is needed to determine a teacher's typical postures during lessons. This also calls for further research.

Conclusions

The results of this study showed that teachers' unergonomic postures during teaching were associated with voice production although teaching postures are not as static as postures in certain other occupations, and the teachers themselves evaluated their postures to be good. This suggests that even low levels of prolonged muscle contraction may predispose to disorders, as demonstrated in rehabilitative medicine [7]. Furthermore, the results also imply that evaluating postures and offering workers advice on correcting them should be an essential part of voice ergonomic assessment. In order to take care of the voice, a speaker ought to understand the value of a good postural alignment while speaking, learn to pay attention to it and find means to use ergonomically optimal working postures.

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Conflicts of Interest

Authors have no conflicts of interest.

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TABLES

Table 1. Questions on parts of the body and related matters in the assessment of wocorking postures.

Parts of the body or factors affecting postures	Targets for observation or elicitation	Supplementary questions
1 Overview of working postures (question to a worker)	Does a worker say that a working posture feels bad?	
2 Torso	Does a worker twist the torso to the side while speaking?	E.g. when using a smart board
3 Head	Is a worker's head turned	E.g. while speaking to people at the side or behind
4	Does a worker thrust the head or chin upwards, forwards or backwards?	E.g. while playing a piano and singing
5	Does a worker tilt the head toward the shoulder while speaking	E.g. when using a telephone
6	If a worker uses spectacles or varifocal glasses, is the head or neck in a bad posture?	E.g. when trying to look at a screen or books or to look at pupils
7 Upper back	Is the worker's upper back hunched and shoulders rounded?	E.g. while working on a computer
8 Shoulders	Are the worker's shoulders tense or raised?	
9 Arms	Does a worker raise the arms while holding things in the hands or lifting heavy objects?	E.g. while reading to children
10 Factors affecting postures	Can chairs and tables be adjusted for a worker in different speaking situations?	
11 Recovery from loading	Can a worker rest and move around from time to time?	

Table 2. Occurrence of voice symptoms in participants (percentages in parentheses). N=39

Voice symptom	Daily	Weekly	Monthly	More seldom	No symptoms
Voice tires easily	12 (31)	9 (23)	8 (21)	7 (18)	3 (8)
Voice gets low	8 (21)	6 (15)	11 (28)	11 (28)	3 (8)
Voice breaks	3 (8)	2(5)	7 (18)	18 (46)	9 (23)
Aphonia	1(3)	0	1 (3)	7 (18)	30 (77)

Difficulty in audibility due to voice	2 (5)	4 (10)	2 (5)	16 (41)	15 (39)
Throat clearing	7 (18)	9 (23)	10 (26)	11 (28)	2 (5)
Sore throat or globus	4 (10)	8 (21)	12 (31)	7 (18)	8 (21)

Table 3. Differences between the occurrences of voice symptoms in teachers who used a specific unergonomic posture (unE group) and those who did not (E group). Group sizes (n) are given in the first column. Note only 5 participants did not use any unergonomic postures.

Posture and n for groups		VHI-P		Difficulty in audibility due to voice ¹		Voice breaks ¹		Aphonia ¹	
		E	unE	E	unE	E	unE	E	unE
Head turned E=18; unE=21	Mean	6.8	10.8	1.6	2.38				
	SD	4.92	6.35	0.85	1.28				
	p (Z-value) ES	.031 (-2.161)		.032 (-2,14)					
Body turned E=22; unE=17	Mean					1.14	1.59		
	SD					0.47	1.0		
	p (Z-value) ES					.025 (-2.24)			
Shoulders raised E=20-21; unE=18-19	Mean	6.8	10.8						
	SD	4.92	6.35						
	p (Z-value) ES	.031 (-2.161)							
Arms raised E=26; unE=13	Mean							1.27	1.46
	SD							0.87	0.52
	p (Z-value) ES							.033 (-2.13)	
									-0.27

VHI-P = physical subscale of VHI, SD=standard deviation, Z=test statistic for Wilcoxon signed-ranks test, p=probability value, ES= effect size. N=39

¹ Range of scores for specific voice symptoms 0-4

Table 5. The effect of the number of unergonomic postures on teachers' voice symptoms. Groups using few (F) or several unergonomic postures (S) were compared with each other. Group sizes (n) are given in the first column.

Number of poor postures in groups F and S		VHI-P		Difficulty in audibility due to voice ¹		Voice breaks ¹	
		F	S	F	S	F	S
F: ≤1 posture (n=10)	Mean	5.4	9.9				
S: ≥2 postures (n=29)	SD	(3.47)	(6.24)				
	p (Z-value)	.031 (-2.16)					
	ES	-0.74					
F: ≤2 postures (n=18)	Mean			1.7	2.3		
S: ≥3 postures(n=21)	SD			(1.0)	(1.3)		
	p (Z-value)			.04 (-2.050)			
	ES			-0.70			
F: ≤3 postures (n=27)	Mean					1.7	3
S: ≥4 postures (n=12)	SD					(0.9)	(1.28)
	p (Z-value)					.011 (-2.557)	
	ES					-0.90	

VHI-P = physical subscale of VHI (range of scores 0-40), , SD=standard deviation, Z=test statistic for Wilcoxon signed-ranks test, p=probability value, ES= effect size. N=39-40.

¹ Range of scores for specific voice symptoms 0-4

Table 6. The effect of the number of unergonomic postures on teachers' voices. Group using few (F) or several unergonomic postures (S) were compared with each other. Group sizes (n) are given in the first column.

Number of poor postures in groups F and S	Before and after a working day				During lessons			
	SPL before		SPL after		F ₀ change		SPL change	
	F	S	F	S	F	S	F	S
F: ≤1 posture (n=11)	70	73			18	2	3	-1
S: ≥2 postures (n=28-29)	(5.0)	(4.8)			(10.5)	(19.3)	(5.0)	(6.8)
p	.05 (-1.961)				.008 (-2.65)		.044 (-2.014)	
ES	-0.71				1.05		0.62	
F: ≤2 postures (n=19)	70	74	71	74				
S: ≥3 postures (n=20-21)	(4.8)	(4.8)	(4.2)	(3.6)				
p	.023 (-2.27)		.043 (-2.023)					
ES	-0.83		-0.77					
F: ≤3 postures (n=27-28)	71	76	72	75				
S: ≥4 postures (n=12)	(4.9)	(4.4)	(4.4)	(2.3)				
p	.003 (-2.947)		.033 (-2.129)					
ES	-1.1		-0.85					

VHI-P = physical subscale of VHI, SD=standard deviation, Z=test statistic for Wilcoxon signed-ranks test, p=probability value, ES= effect size. N=39-40.



Figure 1. Unergonomic working postures while speaking: torso twisted to the side and head turned (photo 1), head/chin thrust forward (photo 2), head/chin thrust downwards (photo 3), head tilted toward the shoulder (4), unergonomic head/neck posture due to varifocal glasses (photo 5), upper back hunched (photo 3); shoulders raised/tense (photo 6); arms raised while holding things in the hands (photo 7) (photo: E. Sala©).

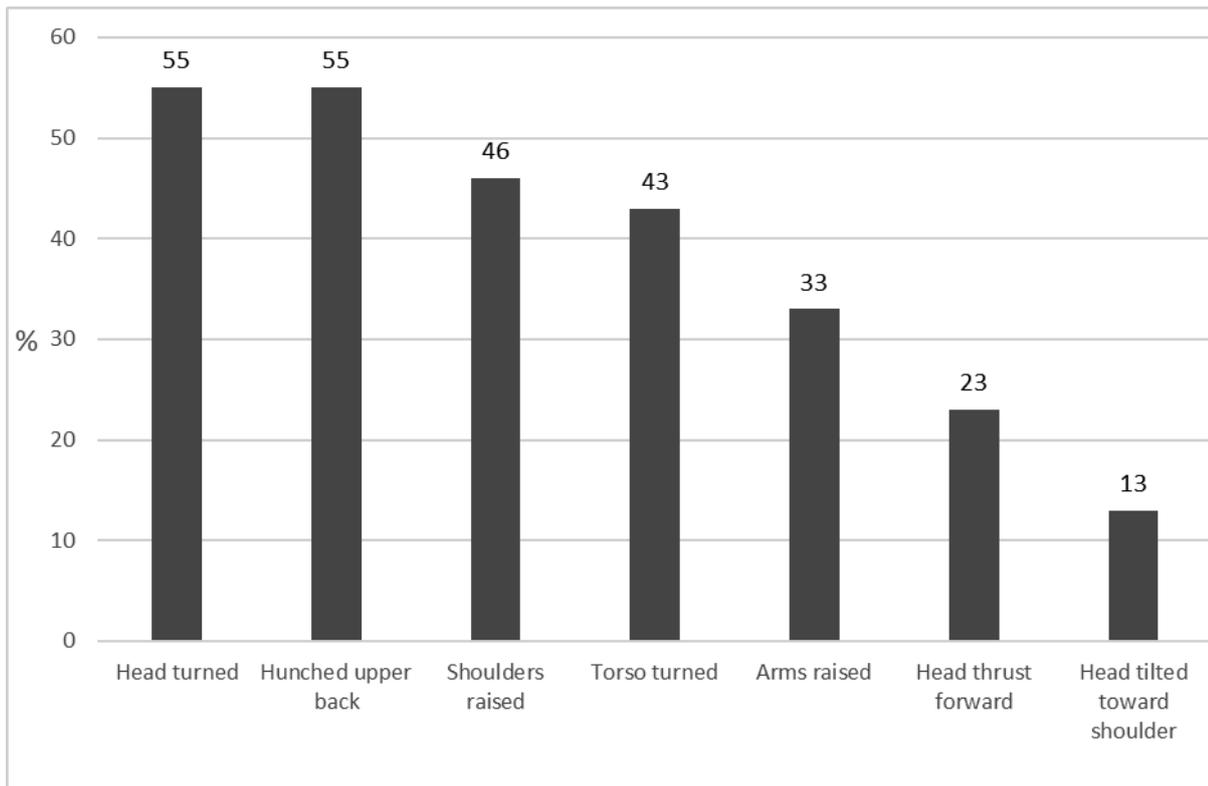


Figure 2. Participants' most typical working postures while talking in class. N=40.