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Original Article

Trapezius Muscle Load, Heart Rate and Time Pressure during Day and Night Shift in Swiss and Japanese Nurses

Corinne NICOLETTI[1]*, Christian MÜLLER[2], Itoko TOBITA[3], Masaru NAKASEKO[3, 4] and Thomas LÄUBLI[1, 4]

[1] Department of Health Sciences and Technology, ETH Zurich, Switzerland
[2] Occupational Health Management, SBB AG, Switzerland
[3] Occupational Ergonomic Unit, Management in Health Care Sciences, Graduate School of Health Sciences, Jikei Institute, Japan
[4] Holistics Prosthetics Research Center, Kyoto Institute of Technology, Japan

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Abstract: The aim of the present study was to analyze the activity of the trapezius muscle, the heart rate and the time pressure of Swiss and Japanese nurses during day and night shifts. The parameters were measured during a day and a night shift of 17 Swiss and 22 Japanese nurses. The observed rest time of the trapezius muscle was longer for Swiss than for Japanese nurses during both shifts. The 10th and the 50th percentile of the trapezius muscle activity showed a different effect for Swiss than for Japanese nurses. It was higher during the day shift of Swiss nurses and higher during the night shift of Japanese nurses. Heart rate was higher for both Swiss and Japanese nurses during the day. The time pressure was significantly higher for Japanese than for Swiss nurses. Over the duration of the shifts, time pressure increased for Japanese nurses and slightly decreased for those from Switzerland. Considering trapezius muscle activity and time pressure, the nursing profession was more burdening for the examined Japanese nurses than for Swiss nurses. In particular, the night shift for Japanese nurses was characterized by a high trapezius muscle activity and only few rest times for the trapezius muscle.

Key words: EMG, Muscle activity, Trapezius muscle, Workload, Nurse

Introduction

The nursing profession is challenged with high physical loads, high mental loads and special organizational factors such as shift work. These factors lead to high physiological and psychological burden in nurses all over the world[1–5].

*To whom correspondence should be addressed.
E-mail: corinne.nicoletti@hest.ethz.ch

The prevalence of musculoskeletal disorders (MSDs) in nurses is high, especially in the neck and lower back. The reported prevalence of neck pain by nurses varies between 40% according to a study among Australian nurses[6] and 60% in a study in the Netherlands[7].

The development of neck pain is closely linked to the activity of the trapezius muscle[8, 9]. The most accepted method of measuring this activity is surface electromyography (EMG)[10]. The periods without measurable EMG activity, so-called rest time, seem to be an important factor in preventing neck pain[11]. The long periods of continuous

Table 1. Characterization of the Swiss and the two Japanese datasets: For the Swiss and the both Japanese datasets the period of data collection, the number of subjects, the age of subjects (mean SD), the ward the subjects worked on, the time frame of the day and the night shift and the order of the measured shifts are shown

Dataset	Swiss data	Japanese data 1	Japanese data 2
Data collection	6.2011–11.2011	10.2010–2.2011	11.2011–2.2012
N	17	10	12
Age	33.5 ± 10.1	30.8 ± 8.9	31.5 ± 8.7
Ward	Orthopedic ward (n=8) Intensive care (n=6) Emergency department (n=2) Post anesthesia care unit (n=1)	Cardiology ward	Orthopedic ward (n=7) Circulation and lung (n=3) Surgery (n=2)
Day shift	7.00–16.00	08.00–16.30	08.30–17.00
Night shift	21.30–7.00 (n=8)/23.00–7.30 (n=6)/ 22.00–6.00 (n=2)/20.00–6.30 (n=1)	00.00–8.30	00.30–09.00
Order of the measured shifts	Randomly; only one shift per day	Day shift and later on the same day night shift	Day shift and later on the same day night shift

muscle activity, on the other hand, have been shown to lead to neck pain[12]. As an explanation, the Cinderella Hypothesis[13] proposes that long-lasting, low-level contractions always activate the same muscle fibers. When these fibers become overexerted, muscle pain develops.

One burden of the nursing profession is the rotating shift work[14] that is associated with health problems such as burnout[15], cancer[16] and MSDs[17]. Working in a rotating shift system often leads to work-family conflicts[18], which in turn are associated with neck pain[19]. In addition, physiological and organizational parameters and psychological loads such as time pressure can also lead to a reduced rest time of the trapezius muscle[20, 21] and are therefore risk factors for neck pain.

Currently there are many studies about the workload of nurses in different countries[22, 23]. Some of them found correlations of work schedules and self-reported physical workload to MSDs, others just reported the workloads of nurses in many different countries[3, 22–26]. Caruso and Waters[1] noticed, physiological data are still missing. Therefore, in the present study we analyzed the activity of the trapezius muscle, the heart rate and the time pressure during day and night shifts in Swiss and Japanese nurses. Related literature described similar levels of self-reported workloads in different countries, hence we hypothesized that the country the nurses work in had little influence on the results. We also hypothesized that the workload is higher during day shift than during night shift. Therefore, we expected trapezius muscle activity, heart rate and time pressure to be higher during the day shift in comparison with the night shift.

Subjects and Methods

Subjects

Seventeen Swiss and 22 Japanese nurses (10 of one dataset and 12 of another) participated in this study (Table 1). The educational level of all participating nurses was equivalent to a registered nurse. All nurses were female with at least one year of work experience in the same job. Swiss subjects worked either part-time (≥ 80%) or full-time while Japanese subjects worked only full-time. The following exclusion criteria were defined: clinical findings of MSDs, skin disease, and intake of muscle relaxants. In the Swiss dataset, subjects with cardiovascular, psychological or neurological diseases or medication use were excluded. In both Japanese datasets, subjects with shoulder and neck pain due to injury or systemic disease, BMI>30 and subjects using tranquilizing medication were excluded. The Swiss part of the study was approved by the ethical committee of the canton of Zurich (Switzerland) and all Swiss subjects gave their written informed consent. The Japanese part of the study was approved by the ethical committee of the Japan Health and Welfare Organization (580–1 Horikawacho, Saiwaiku, Kawasakishi, Kanagawa 212-0003). Furthermore, the ethical committee of the Graduate School of Health Sciences, Jikei Institute (Osaka, Japan) approved the work of the master students on this project and the ethical committee of the participating hospitals accepted the completion of the study in their hospital. All Japanese subjects gave their written informed consent. Subjects were instructed according to the Helsinki declaration, participated voluntarily and were free to discontinue their participation at any time without explanation.

Apparatus

Surface EMG and heart rate of Swiss subjects were collected with the PS11-UD (THUMEDI GmbH & Co. KG, Thum-Jahnsbach, Germany) with a sampling rate of 2,048 Hz. Data were filtered in the device with an analog 3rd-order highpass filter with a cutoff frequency of 4 Hz (−3 dB) and a 10th-order anti-aliasing filter adjusted to 650 Hz (−3 dB). Additionally, a digital highpass filter at 12 Hz, a digital band replacement filter at 50 Hz, 100 Hz, 150 Hz, 200 Hz, 250 Hz, 300 Hz and 350 Hz, and two algorithms, which used low and very low frequencies (7–13 Hz and 0.5–1.7 Hz) were applied. The flatness (ripple) of the device's transfer function is ± 0.1 dB from 20–500 Hz. With Matlab R2011b, a root-mean-square procedure was conducted with a window width of 250 ms, downsampling the processed data to 4 Hz. For more information, see Nicoletti *et al*[27]. The electrodes used were pre-gelled Ag/AgCl electrodes (Kendall Arbo, England).

Bioplar EMG of the Japanese data 1 was collected with the Muscle Tester Me3000P (Mega Electronics Ltd, Koupio, Finland). Data with a sampling rate of 2,000 Hz were band pass filtered with a frequency band from 20 to 500 Hz and preprocessed with a root-mean-square procedure with a window width of 100 ms. The electrodes used were pre-gelled Ag/AgCl electrodes (Ambu Neuroline, Denmark).

Bipolar EMG of the Japanese data 2 was collected with the YS_BioMeas (RMS4, Yuui-Koubou Ltd., Japan). The effective frequency range went from 8 to 1,000 Hz. The raw EMG signals were amplified (×1,000), notch-filtered (central frequency 55 Hz) and a root-mean-square procedure was conducted with a window width of 50 ms. EMGs were recorded at a resolution of 16 bits with a sampling rate of 50 Hz. The electrodes used were pre-gelled Ag/AgCl electrodes (Ambu Neuroline, Denmark).

In the Swiss dataset, heart rate was measured using a two-electrode electrocardiogram (ECG) that was also part of the PS11-UD. After internal processing (moving average mean of 7 R-R intervals) the heart rate was given. Values smaller than 30 bpm or higher than 200 bpm and areas with a standard deviation larger than 40 bpm over 7 values were excluded. In both Japanese datasets, heart rate was measured with a heart rate watch (Polar CS600, Polar, Finland).

Procedure

Each subject was measured during a day and a night shift on the same ward (Table 1; Swiss subjects were measured during two day shifts, but only data of the first day shift were used for this publication). In Swiss nurses, only one shift per day was measured. The order of day and night shift was selected randomly. In Japanese nurses, the night shift was measured later on the same day than the day shift. The measurement device was applied before the start of the shift. The position of the EMG electrodes was the same in all three datasets, based on the recommendation of SENIAM[28]. The electrodes were placed on the line from the acromion to the cervical vertebra 7 (C7) with the midpoint of the two electrodes 2 cm medial of the midpoint of this line. The distance between the two electrodes was 2 cm. A reference electrode was placed on C7, except in the Japanese data 2 which was placed on the thoracic vertebra 3 or 4 (TH3/TH4). The measuring device was worn around the waist and the cables were fixed on the skin to reduce movement artifacts.

In Swiss data, heart rate was collected with a two-electrode ECG. One electrode was placed on the left side of the chest wall below the breast while the other was placed below the clavicle. For the Japanese data, the belt of the heart monitoring watch was worn around the chest and the watch was worn around the wrist.

Subjects performed submaximal reference contractions at the beginning of every shift, slightly modified from the description of Mathiassen *et al*[10]. Subjects held their arms in a horizontal position, laterally extended in 90° abduction. In Swiss data, subjects held this position for three 20 s periods, with a 40 s break between periods. In both Japanese datasets, the break between the three contractions was 30 s.

At the beginning and at the end of every shift, subjects answered a question about time pressure on a scale from 1 to 5, whereby "1" meant "great time pressure" and "5" meant "far too little work".

Analysis

All data were processed with Matlab R2011b. Japanese data 1 was downsampled from 10 Hz to 5 Hz while Japanese data 2 was downsampled from 50 Hz to 5 Hz. EMG data were normalized using the mean value of the three submaximal reference contractions, called the reference voluntary electrical activation (RVE). After this normalization, values were expressed as % RVE. Data points above 1,000% RVE were removed. Afterwards, the rest time (defined as % of shift duration with EMG below 5% RVE) and the 10th, 50th and 90th percentiles of EMG activity were calculated.

In heart rate data of Swiss nurses, heart rate was filtered with an internal procedure of the PS11-UD (see "Apparatus"). In both Japanese datasets, heart rate was filtered with a peak detection procedure and face validity. The scale of the question about time pressure was inverted, so that a higher value indicated more time pressure. After inverting "1" meant "far too little work" and "5" meant "great time pressure".

Statistics

Mixed model analysis was used for statistical analyses (SAS 9.2). The dependent variables used were the rest time of trapezius muscle, the 10th and the 50th percentile of EMG activity and the heart rate. The shift (night or day) and the nation (Switzerland or Japan) as well as the interaction shift*nation were part of the model. The subject was a random factor. For comparing the two Japanese datasets, the same model, only including the two Japanese datasets as two different samples ("nation"), was calculated. In order to compare the time pressure values at the beginning and at the end of the shift, a mixed model including the shift (night or day), the nation (Switzerland or Japan), the time of the diary value (beginning or end of the shift) as well the interactions time*nation, time*shift and time*shift*nation was calculated.

Furthermore, an exploratory analysis was undertaken to elucidate eventual relationships between perceived time pressure and trapezius rest time or heart rate. To test if trapezius muscle rest time or heart rate were influenced by the level of time pressure before work, mixed models (separately for the factors trapezius muscle rest time and heart rate) including the covariates nation and shift were calculated. To test if the level of time pressure after work is influenced by trapezius muscle rest time or heart rate during work, the parameters heart rate and rest time were simultaneously included in the mixed model analysis with the covariates shift, nation and shift*nation.

Results

Recordings of trapezius EMG were analyzed for all 37 nurses. Heart rate data of 12 shifts and diary data of 3 shifts were missing.

Pooling of the data of the Japanese datasets

The two Japanese datasets were joined for analysis. The parameters trapezius muscle rest time (p=0.20; n=22), 10th percentile (p=0.33; n=22) and 50th percentile (p=0.69; n=22) of EMG activity, heart rate (p=0.70; n=16) and time pressure (difference between the beginning and the end of the shift; p=0.13; n=20) showed no difference between the datasets. The 90th percentile was significantly different (p=0.01; n=22) between the two Japanese datasets. As apparent in Fig. 1d, this difference originated from three subjects with extremely high values during night shift. As these values could not be clearly explained or classified as physiologically impossible, the 90th percentile of trapezius muscle activity was not further analyzed.

Trapezius muscle activity

Table 2 shows the mean values of the EMG parameters during day and night shift in Swiss and Japanese nurses. Using mixed model analysis, rest time of the trapezius muscle was found to be longer in Swiss nurses than in Japanese nurses (Table 3). Although rest time of trapezius muscle tended to be longer during the day shift than during the night shift in Japanese nurses and to be longer during the night shift than the day shift in Swiss nurses (Table 2), no significant shift effect or interaction effect (shift*nation) was found. The longer rest time in Swiss nurses compared to Japanese nurses was also evident in Fig. 1A that compared the individual trapezius rest time levels of the day and the night shifts of all the subjects and showed the regression lines. The regression lines were nearly parallel, which means that the ratio of rest time of the day compared to the night shift was the same in both countries. Although, the average level in the Swiss nurses was higher.

The 10th and the 50th percentile of EMG activity showed a significant different shift effect in the two nations (Table 2). The percentiles were higher during the night shift in Japanese nurses and slightly higher during the day shift in Swiss nurses (Table 1). This effect was also visible in the different slopes of the regression lines in Fig. 1B and C.

Heart rate

Heart rate was higher during the day shift than during the night shift in both countries (Table 2). As shown in Table 3, this shift effect is statistically significant. No effect of the nation and no interaction effect (shift*nation) was seen. It is notable that heart rate is rather high on average, indicating a high workload.

Time pressure

The level of time pressure was significantly different between Swiss and Japanese nurses (Table 3). At the beginning of the shifts, the indicated levels of time pressure appeared to be similar (Table 2), being independent of nationality or shift type. At the end of the shifts, Japanese

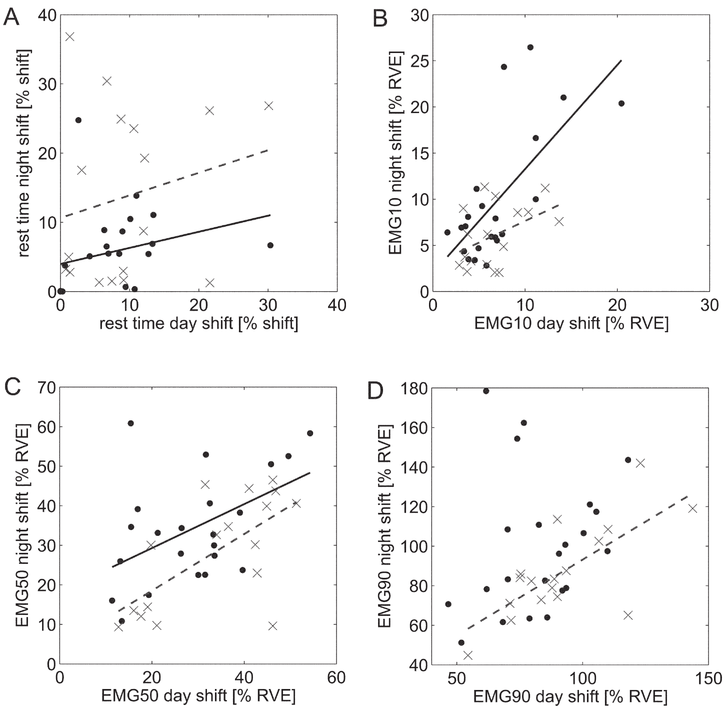

Fig. 1. A) Trapezius muscle rest time (rest time), B) 10th percentile (EMG10), C) 50th percentile (EMG50) and D) 90th percentile (EMG90) of trapezius muscle activity during day and night shift in Swiss and Japanese nurses. These electromyography (EMG) parameters are plotted as day shift vs. night shift. Percentiles of EMG were expressed relative to reference voluntary electrical activation (RVE). Single data points of Swiss nurses are marked with a cross (×) and the regression line of Swiss nurses is shown as a dashed line. Single data points of Japanese nurses are marked with a dot (•) and the regression line of Japanese nurses is shown as a solid line. n_{Japan}=22, $n_{Switzerland}$=17.

Table 2. For the day and the night shift of Swiss and Japanese nurses the mean values and SD of electromyography (EMG) parameters, heart rate and time pressure at the beginning and at the end of the shifts are shown. The percentiles of EMG activity were expressed relative to the reference voluntary electrical activation (RVE). n_{Japan}=22, $n_{Switzerland}$=17 for EMG parameters, n_{Japan}=16, $n_{Switzerland}$=17 for heart rate and n_{Japan}=20, $n_{Switzerland}$=17 for the diary

	Japan		Switzerland	
	Day shift	Night shift	Day shift	Night shift
Rest time (% of shift)	7.1 ± 7.1	5.6 ± 6.0	9.6 ± 8.2	13.8 ± 12.4
10th percentile (% RVE)	7.0 ± 4.3	9.9 ± 7.1	6.6 ± 3.2	6.1 ± 3.3
50th percentile (% RVE)	28.8 ± 12.2	34.2 ± 13.9	33.5 ± 13.0	28.2 ± 14.2
90th percentile (% RVE)	82.7 ± 18.8[a] (84.6 ± 19.4)[b]	100.4 ± 34.7[a] (90.2 ± 24.1)[b]	91.9 ± 22.3	86.9 ± 23.8
Heart rate (bpm)	91.2 ± 9.5	83.4 ± 7.7	89.7 ± 9.2	82.2 ± 10.0
Time pressure beginning[c]	2.8 ± 1.1	2.8 ± 0.9	3.2 ± 0.7	2.9 ± 1.0
Time pressure end[c]	3.5 ± 0.8	3.5 ± 1.0	2.9 ± 0.8	2.9 ± 0.7

[a] all data. [b] data without the 3 subjects mentioned in Results. [c] reported time pressure at the beginning/at the end of the shift.

nurses indicated significantly more time pressure compared to the beginning of the shift and compared to the Swiss nurses.

Time pressure at the beginning of the shifts tended to predict a shorter trapezius muscle rest time (F=2.2, p=0.14) and a higher heart rate (F=2.7, p=0.11) during

Table 3. Degrees of freedom (DoF), F and *p* values of mixed model analysis for Swiss versus Japanese nation, day versus night shift and shift*nation interaction are shown for rest time of trapezius muscle, 10th and 50th percentile of trapezius muscle activity, heart rate and time pressure (value at the end of the shift − value at the beginning of the shift). n_{Japan}=22, $n_{Switzerland}$=17 for EMG parameters, n_{Japan}=16, $n_{Switzerland}$=17 for heart rate and n_{Japan}=20, $n_{Switzerland}$=17 for the diary

Parameter	Effect	DoF numerator	DoF denominator	F	*p*
Rest time	nation	1	37	6.05	0.019
	shift	1	37	0.62	0.435
	shift*nation	1	37	2.74	0.107
10th percentile	nation	1	37	2.26	0.141
	shift	1	37	2.54	0.120
	shift*nation	1	37	5.60	0.023
50th percentile	nation	1	37	0.03	0.871
	shift	1	37	0.00	0.991
	shift*nation	1	37	7.08	0.012
Heart rate	nation	1	29	0.15	0.699
	shift	1	29	38.42	<0.001
	shift*nation	1	29	0.44	0.515
Time pressure	nation	1	109	6.35	0.013
	shift	1	109	0.40	0.528
	time	1	109	3.92	0.050
	time*nation	1	109	9.79	0.002
	time*shift	1	109	0.21	0.650
	time*nation*shift	1	109	0.18	0.676

Table 4. Recorded rest time of trapezius muscle in literature in different professions

profession	country	n	Recording time	Rest time (%)	Reference
Health care	Norway	44	Full workday	19.3	Westgaard *et al.*[32]
Seller	Norway	22	Full workday	11.7	Westgaard *et al.*[32]
Dental hygienist	Sweden	12	5 h 54 min	8.2	Akesson *et al.*[33]

work. The level of time pressure at the end of the shifts was not significantly correlated with trapezius rest time (F=0.04) or heart rate (F=0.6) during the preceding work period.

Discussion

The rest time of the trapezius muscle was longer in Swiss nurses than in Japanese nurses. The 10th and 50th percentiles of EMG activity were the highest during night shifts of Japanese nurses. The heart rate was higher during the day shift in Swiss and in Japanese nurses. The level of time pressure at the beginning of the shifts was similar in Swiss and Japanese nurses but only significantly increased towards the end of the shift in Japanese nurses.

Trapezius muscle activity

The rest time of the trapezius muscle was longer in Swiss nurses than in Japanese nurses during the day and night shifts. The literature suggests that sufficient rest time of the trapezius muscle is the most important factor detectable by surface EMG for preventing neck pain[11, 29] and therefore, work should allow for enough muscle rest time. It is not currently clear which amount of trapezius muscle rest time is "enough", but the 5.3% and 7.1% of the shifts of the Japanese nurses seems to be extremely short. Even the 10% and the 13.8% of Swiss nurses may be too short.

Rest time data was compared with data from other studies. We used the threshold value of 5% RVE to define rest time of the trapezius muscle. The studies in Table 4 used the maximal voluntary electrical activation (MVE) for normalization. All values below 0.5% MVE were defined as rest time. Both RVE and MVE are widely used and accepted in literature[30]. A small study of ten subjects[31] reported that 100% RVE corresponds to 17% MVE if the RVE is conducted without additional weight on the arms (we were not able to compare our data with data from studies using RVE with additional weight). Therefore, 0.5% MVE corresponds to approximately 3% RVE. As this is a bit smaller than the 5% RVE that we used in this study, the percentages of rest time in literature should be slightly smaller than the ones in our study. However, the published rest times[32] for health care workers are slightly longer than in our Swiss nurses and markedly longer than in our Japanese nurses. The health care workers recorded in Westgaard *et al.*[32] were nurses (45%), nurses in home care (24%) and supervisory and support personnel (31%). The rest time of sellers also was higher than the ones recorded in our study[33]. Only the rest time of dental hygienists lay in the area of the Swiss nurses, but these values were still higher than in Japanese nurses. Based on the comparison with data from these two studies (Table 4), we conclude that the nursing profession is one of the professions with the shortest rest time values. Especially among Japanese nurses, trapezius muscle rest time was very short.

The 10th and the 50th percentiles of trapezius muscle activity showed opposite shift effects in Swiss and Japanese nurses. The values were higher during day shifts for Swiss nurses and higher during night shifts for Japanese nurses. Such a trend of increased trapezius muscle activity during night shifts in Japanese nurses was also evident for trapezius muscle rest time, but was not significant. Both measures, the 10th percentile of trapezius muscle activity and rest time, represent the continuous activity of the trapezius muscle. This continuous strain was the biggest in the night shift of Japanese nurses. Therefore, we propose to give the nurses in this shift more chances to take a break, especially in Japan. The 50th percentile characterizes the median load of the shift. Interestingly, this median load was nearly the same in the day shift of the Japanese nurses and in the night shift of the Swiss nurses as well as in the night shift of the Japanese nurses and in the day shift of the Swiss nurses. This implies that the mean overall workload seemed to be similar in Swiss and in Japanese nurses but its temporal distribution is different. The 90th percentile or the peak activity was the highest in the night shift in the Japanese nurses.

Different reasons for this higher trapezius muscle activity and the smaller rest time of the trapezius muscle in the night shift of Japanese nurses are possible. It seems that the workload during night shifts is higher in Japanese nurses than in Swiss ones. This could be caused by less staff during night shifts. As a higher activity of the trapezius muscle could be caused by physical or psychological strain[34, 35], another possible cause could be a high psychological strain during night shifts. The same arguments can be given for the larger workload in Swiss nurses during day shifts. Another reason could be the different shift systems in the two countries. In Switzerland, after working a day shift, nurses were free at least until the next morning. If a night shift followed the day shift, nurses were free until the evening of the next day. The Japanese nurses, on the other hand, started their first night shift seven hours after finishing the previous day shift. Therefore, the time for regeneration before the night shift was short. Trinkoff *et al.*[26] showed more MSDs in nurses having less than 10 h off work between two shifts. In Japanese nurses, it is possible that trapezius muscle was not fully recovered before starting the night shift and therefore, more trapezius muscle activity was found.

As shown by Tanaka *et al.*[36] and Arakawa *et al.*[37] the shift system as well as the recovering periods are extremely important to avoid medical errors. Since medical errors could have severe consequences for patients, the shift system should allow the nurses to work as focused as possible. Another factor augmenting the probability of medical errors is if the nurses suffer from pain[37]. Considering the possible development of neck pain[12], the activity of trapezius muscle should be reduced and the rest time increased. As mentioned in the introduction section of this paper, trapezius muscle rest time can be augmented by changing physiological loads[25], psychological loads[20] or organizational factors[14].

Heart rate

The heart rate was significantly higher during the day shift than the night shift in both Swiss and Japanese nurses. The main reason for that is the circadian rhythm. As the human body is meant to have an approximately 24 h rhythm, the heart rate is lower in the phase that is meant for recovery[38] (more details are reported in Nicoletti *et al.*[27]).

Time pressure

The average reported levels were similar between the two countries, but we believe it is inappropriate to draw conclusions based on these absolute values. It was highly demanding to develop a questionnaire scale in Japanese and German that has a similar meaning among Swiss and Japanese nurses. The final wording was decided on after intense discussions in Switzerland, in Japan as well as among the authors. It is less difficult to compare relative changes within the two groups. In Japanese nurses we observed a significant increase between the start and the end of day and night shifts, while reported stress levels tended to decrease among Swiss nurses.

An exploratory analysis tested if higher levels of stress at the beginning of work would predict shorter trapezius muscle rest periods and a higher mean heart rate. Considering the nationality and type of shift (day or night shift), such a tendency was evident but not significant. Thus, the hypothesis that stress may increase trapezius muscle tension[21] was tentatively supported. This concerned the combined effect of stress and working with a high workload. It was not tested if perceived stress without any work demands would have a similar effect. On the other hand, we tested if short trapezius rest periods and/or a higher heart rate during work would predict stress levels at the end of the shift; this was not the case. This lack of a relationship leads to the question of whether the high workload visible in EMG and heart rate is appropriately sensed by the nurses. It is likely that further stressors such as unavailability of physicians, unsupportive management, interpersonal issues, and patient mental health are directly correlated with perceived stress levels[39] and have a more direct impact on the perception of time pressure than the measured trapezius muscle activity.

A possible limitation of this study was that EMG data of the three datasets was measured with three different devices. It is generally accepted that results from different studies may lead to slightly different results but these effects are known to be small if proper standardization procedures are used[10]. The Japanese and Swiss research team held several joint laboratory sessions to ensure identical procedures for all measures taken, including the standardization procedure. Additionally, researchers from both countries were involved in the measurements of both countries. We are thus sure that the reported difference in trapezius rest time is induced through the work situation and not the measuring device. Furthermore, we did not record the exact break times in the different shifts. But we are convinced that they are not very different and we know that in all the recorded shifts nurses were not allowed to take a nap.

Conclusion

Japanese nurses had a shorter trapezius muscle rest time compared to Swiss nurses as well as compared to published values. Especially during night shifts, their trapezius muscle rest time was short. On average, it was below 6% of the working time, indicating that opportunities to relax the trapezius muscle were limited. In Swiss nurses, night shifts seemed to allow for significantly more rest periods. The same relative load pattern was seen for the parameters describing static and average muscle activity. Heart rate was higher during day shifts and average levels above 80 beats per minute indicated a rather high workload among both Japanese and Swiss nurses.

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