

Predictors and prevalence of musculoskeletal disorders among sewing machine operators

E. Merisalu^{1,*}, M. Männaste¹, K. Hiir¹ and A. Traumann²

¹Estonian University of Life Sciences, Institute of Technology, Kreutzwaldi 56, EE51014 Tartu, Estonia

²TTK University of Applied Sciences, Pärnu mnt. 62, EE10134 Tallinn, Estonia

*Correspondence: eda.merisalu@emu.ee

Abstract. Musculoskeletal disorders (MSD) are a common and most often disabling problem among sewing machine operators and associated to work related factors. The aim of study was to determine work related and individual risk factors and the prevalence of MSDs among sewing machine operators and describe relationships between risk factors and MSDs. The data were collected in random sample method, using parts of a standardized CUPID (Cultural and Psychosocial Influences on Disability) questionnaire. The questions were focused on occurrence of MSDs in different body regions, in the past year and past month. The respondents assessed pain in the neck, lower back, and both on the right and left side of shoulders, elbows, wrists/hands and knees. The questions about individual, physiological and psychological risk factors and health behaviour were included.

The response rate was 43.9%, from 130 sewing machine operators fifty seven of them responded to the questionnaire. They all were women, in mean age 44.4 ± 8.6 years and with average body mass index (BMI) 26.8 ± 6.6 kg m⁻². The majority had work experience more than 5 years. Sewing work is monotonous, in steady sitting position, with repetitive movements in elbow, wrist and fingers during a whole workday. The most of respondents (93%) have reported poor autonomy to decide over the working schedule and 75.4% had low decision latitude over what and how to do work. The majority of sewing machine operators get support from the colleagues and management.

Musculoskeletal pain at least in one body site was measured in 91.2% of cases in the past 12 months and among 82.5% of respondents in the past month. More than half of participants reported pain in three or more body sites. The most often pain regions were lower back (66.7%), neck (61.4%), wrist/hand (50.9%) and shoulders (42.1%) in the past year, and neck (45.6%) in the past month. Pearson correlation analysis showed positive relationships between lower back pain and poor autonomy ($p = 0.02$) and BMI ($p = 0.05$) and repetitive elbow bending was related to neck and wrist/hand pain ($p = 0.05$, in both). Regular smoking was related to wrist/hand pain ($p = 0.003$). In conclusion, high prevalence of MSDs among the sewing machine operators has observed, whereas lower back, neck, wrist and shoulders were the most often reported pain regions. Lower back pain correlated positively with BMI and autonomy, smoking with wrist/hand pain and repeated upper limb movements with neck and elbow pain.

Key words: sewing machine operator, musculoskeletal disorders, risk factors.

INTRODUCTION

The prevalence of musculoskeletal disorders (MSD) as work related diseases is high in Estonia and Europe. According to Estonian Health Board statistics (2014), there are 74% of MSDs are recorded with the diagnosis of occupational diseases and as the most common reason for receiving medical absence benefits in Estonia (Buckle & Devereux, 2002; EU-OHSA, 2007a; Health Board, 2014; HSE, 2015). In the Great Britain (2014–2015) the study of working conditions showed, that MSDs constituted 44% from all work related diseases (HSE, 2015). Musculoskeletal disorders are the main cause of sick leave in United States. In 2012, 29% of cases of the lost workdays have recorded because of MSDs (Summers et al., 2015).

Sewing machine operator's work is monotonous, usually with high work pace and whole day repetitive movements of elbow, wrist and fingers. Often the workers are placed on the delimited rooms, sitting closely behind the working tables not always ergonomically designed. Work on the riveting machine demands an awkward position and forced upper limb movements with up-lifted shoulders, causing strain in the neck and upper back. During the most of day the bending of elbow and wrist/hands, with inclined neck and head and upper body has caused high risk of MSDs (Buckle & Devereux, 2002; EU-OSHA, 2007a). A number of cross-sectional studies have demonstrated that sewing machine operators include into the risk group with high probability for pain in the neck and shoulder, upper and lower back and wrist/hand regions (Schibye et al., 1995). Structural damages in the skeletal muscles, tendons, joints and nerves are the main causes of MSDs and often influenced on character of work and working conditions (EU-OSHA, 2007b). The epidemiological studies have shown work related MSDs describing a wide range of inflammatory and degenerative diseases and disorders, resulting in pain and functional impairment, affecting the neck, shoulders, elbows, forearms, wrists and hands (Buckle & Devereux, 2002). Physiological, psychological, physical and individual risk factors could be directly related to MSDs (Buckle & Devereux, 2002; Lu et al., 2015). High work demands, low support by colleagues and managers and poor satisfaction with work can cause strain in musculoskeletal system (EU-OSHA, 2007a).

Earlier studies have shown, that there is a link between individual factors and MSDs. In 2013, it was carried out the study among the Portuguese production workers, with the aim to describe the correlations between BMI and MSDs. The participants were divided into two groups: normal weight ($BMI \leq 24.9 \text{ kg m}^{-2}$) and overweight/obesity group ($BMI \geq 25 \text{ kg m}^{-2}$). The results have demonstrated, that there was a higher risk for shoulder pain among the participants with overweight (Wang et al., 2007). Positive correlation between work experience and pain in shoulders, elbow and wrist was observed also in Turkey and Denmark, whereas high prevalence of neck (57%), shoulder (51%), and lower back pain (47%) was recorded in Danish population (Deyyas & Tafese, 2014).

The results of the previous study have demonstrated that when to increase the task variety and adopt rotations between different types of workstations, by increasing rest periods and improving the control over psychosocial stressors helps to prevent MSDs among sewing operators (Wang et al., 2007).

The aim of study was to analyse work related and individual risk factors and prevalence of MSDs among sewing machine operators and describe relationships risk factors and MSDs.

MATERIAL AND METHODS

The cross-sectional study was carried out in the largest sewing company in Estonia. The total number of the sewing machine operators in the official record was 130. In random sample method the anonymous electronic questionnaire was used to clear out the main risk factors and prevalence of MSDs. The questionnaire study was performed in Estonian and Russian languages from December 2015 to January 2016. The participation in the study was voluntary.

The questionnaire was based on the international survey '*Cultural and Psychosocial Influences on Disability*' (CUPID) (Coggon et al., 2012), *Baecke Physical Activity Questionnaire* (BQ) (Baecke et al., 1982) and *The Nordic Musculoskeletal Questionnaire* (NMQ) (Kuorinka et al., 1987). The questions about socio-demographic data, sport activities and occupation were included in the Part-A, in total 33 questions. The questions about pain occurrence in different body sites and duration of sick leave in the past 12 months and the past month were used in the Part-B, in total 18 questions. Five questions about general health formed the Part-C. In total 57 questions were included in the questionnaire. The respondents answered to the questions about the incidence of work related risk factors on the Likert scale 1–4, where 1 – never, 2 – seldom, 3 – sometimes, 4 – often. To the questions about the nature of work and prevalence of musculoskeletal pain were answered on the scale 'yes'/'no', regarding to right or left side of body or both. The duration of pain was assessed on the scale 1–3, where: 1 – 1–6 days, 2 – 1–4 weeks, 3 – 1–12 months. How many days did pain prevent them from going work, was measured on the scale 0–3, where: 0 – 0 days, 1 – 1–5 days, 2 – 6–30 days and 3 – more than 30 days. The main activities at work were assessed on the scale 0–4, where: 0 – never, 1 – seldom, 2 – sometimes, 3 – often, 4 – very often. For calculating of Body Mass Index (BMI) the formula $[\text{body mass (kg)} (\text{height (m)}^2)^{-1}]$ was used. Four BMI categories have taken into consideration: underweight (BMI < 18.5 kg m⁻²), normal weight (BMI 18.5...24.9 kg m⁻²), overweight (BMI 25...29.9 kg m⁻²), obesity of the 1st grade (BMI 30...34.9 kg m⁻²) obesity of the 2nd grade (BMI 35...39.9 kg m⁻²) and obesity of 3rd grade (BMI 40...44.9 kg m⁻²) (WHO, 2016).

Statistical analysis. The data of e-questionnaire have saved automatically into the statistical program MS Excel and then transmitted into the program SPSS.23.0 (*Statistical Package of Social Sciences*). Descriptive statistics (%), χ^2 -test for groups' comparison and dispersion analysis ANOVA (*Analysis of Variance*) for comparison of averages have used. Pearson and Spearman correlation analyses for measurement of relationships between work related risk factors and MSDs have used, and based on the statistical significance ($p \leq 0.05$). The study was affirmed by the Research Ethics Committee of the University of Tartu (protocol no 253/T-9, 16.11.2015).

RESULTS

The e-questionnaire was sent to 130 sewing machine operators and 57 of them answered to the questionnaire, the response rate was 43.8%. All the respondents were women, in mean age 44.4 ± 8.6 years and 93% had work load 40 hours per week and 7% worked 43–45 h in week. The most of them (82.5%) had work experience in this job more than five years. The main work tasks were: sewing (86%), co-ordination of 10.5% and work on riveting machine 3.5%. About half of the participants (44.6%) had normal BMI ($18.5\text{--}24.9 \text{ kg m}^{-2}$), 25% were in overweight ($25\text{--}29.9 \text{ kg m}^{-2}$), and 28.5% were obese ($\geq 30 \text{ kg m}^{-2}$) (WHO, 2016). About 37.5% of the respondents were physically active and 29.8% were regular smokers (Table 1).

Table 1. Descriptive characteristics of the study group (n – number of respondents; % – proportion of respondents)

Parameter	Category	n	%
Main occupation	Sewing machine operator	49	86.0
	Co-ordinator	6	10.5
	Riveting machine operator	2	3.5
Work experience (years)	< 5	47	82.5
	1–5	7	12.3
	< 1	3	5.3
Workload (hours per week) average $40,3 \pm 1,2$	40	53	93.0
	43	1	1.8
	45	3	5.3
BMI (kg m^{-2}) average $26,8 \pm 6,5$	Underweight	1	1.8
	Normal weight	25	44.6
	Overweight	14	25.0
	Obesity I–III grade	16	28.5

The results showed, that very often 73.7% of sewing machine operators are working in sitting position and about two third of them are standing and walking seldom. A half of them lifted loads more than 25 kg seldom and 42.1% were exposed to lifting of loads sometimes (Fig. 1).

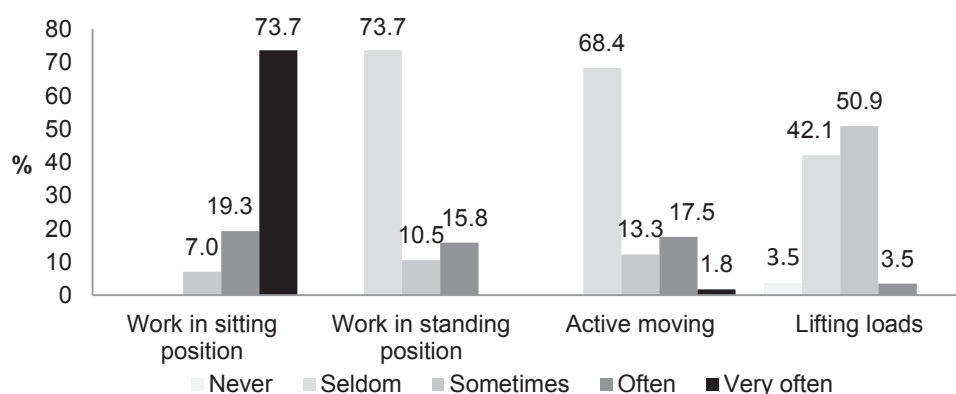


Figure 1. Evaluation of activities at work among sewing machine operators (% , proportion of respondents).

Almost all the workers affirmed that they are working under the pressure to complete tasks by a fixed time or complete a target number of articles that the team are expected to finish in the day. Most of them have reported continuous repetitive movements of wrist/hands and bending and straightening of elbows. Ninety two percent of respondents didn't use regular breaks during the work day (Fig. 2).

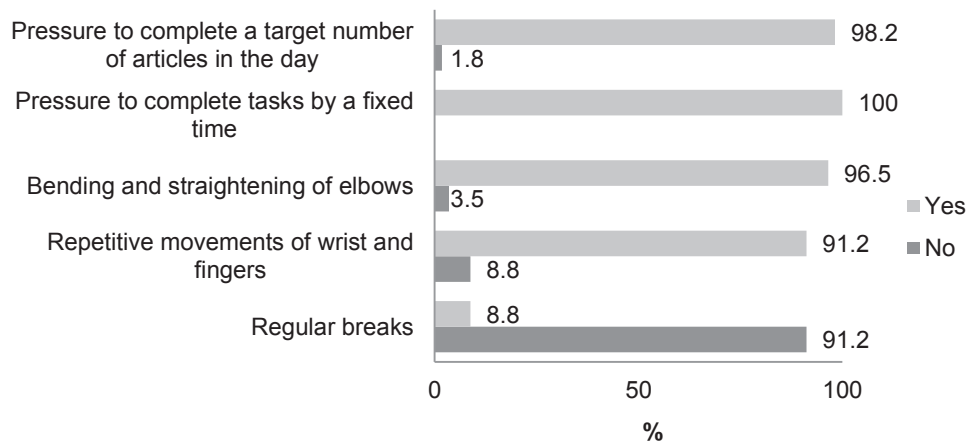


Figure 2. Evaluation of mental strain at work, repetitive movements and regular breaks among sewing machine operators (% , proportion of respondents).

In almost all of the cases (93%) poor autonomy over working schedule and breaks were reported. Also, 75.4% have reported that they have no chance to decide over work content and work activities and about half of them (47.4%) hadn't any choice in deciding what and how to do the work. More than half of the respondents have mentioned that sometimes support is available from the managers and less than half (40.4%) get advises from the supervisors quite often. About half of workers mentioned support sometimes from the colleagues (Table 2).

Table 2. Autonomy at work and support of colleagues and managers (% , proportion of respondents; (n), number of respondents)

Risk factor	Often	Sometimes	Seldom	Never
No choice in deciding how and when to do the work	24.6 (14)	14.0 (8)	14.0 (8)	47.4 (27)
Poor autonomy over work content and activities	12.3 (7)	8.8 (5)	3.5 (2)	75.4 (43)
Poor autonomy over working schedule and breaks	-	3.5 (2)	3.5 (2)	93.0 (53)
Help and support from the colleagues	33.3 (19)	49.1 (28)	8.8 (5)	8.8 (5)
Help and support from the managers	40.4 (23)	54.4 (31)	3.5 (2)	1.8 (1)

High prevalence of lower back pain (66.7%), neck (61.4%) and wrist/hand pain (50.9%) in the past 12 months and neck pain (45.6%) in the past month have observed. The right side was more painful, compared to the left one (Table 3).

Table 3. The prevalence of MSDs in the past 12 months and the past month on the right or left side of body or both (% , proportion of respondents)

Pain region	In the past 12 months				In the past month			
	Total	Right	Left	Both	Total	Right	Left	Both
Shoulders	42.1	14.0	17.5	8.8	26.3	10.5	10.5	3.5
Elbow	22.8	14.0	5.3	3.5	15.8	7.0	5.3	3.5
Wrist/hand	50.9	19.3	17.5	14.0	33.3	14.0	10.5	8.8
Knees	14.0	7.0	1.8	5.3	8.8	5.3	3.5	-
Neck	61.4				45.6			
Lower back	66.7				33.3			

Pain in more than three body sites was reported by 52.6% of respondents in the past 12 months and by 24.5% in the past month. Few pain-free respondents have seen in this study. No any pain was reported by 8.8% in the past 12 months and by 17.5% in the past month (Table 4).

Table 4. The number of body sites of musculoskeletal pain among sewing machine operators in the past 12 months and the past month (% , proportion of respondents; (n), number of respondents)

The number of pain sites	In the past 12 months	In the past month
0	8.8 (5)	17.5 (10)
1	14.0 (8)	38.6 (22)
2	22.8 (13)	19.3 (11)
3	29.8 (17)	14.0 (8)
4	14.0 (8)	10.5 (6)
5	7.0 (4)	-
6	3.5 (2)	-

The duration of pain from one to six days was reported more often in the lower back (42.1%), neck (31.6%) and wrist/hand (28.1%). The duration of pain from one to four weeks was measured more often in the neck (19.3%) longer than one month in the lower back (14.0%) (Table 5).

Table 5. Duration of pain and sick leave by the body regions among sewing machine operators (% , proportion of respondents; (n), number of respondents)

Pain region	Duration of pain			Sick leave			
	1–6 days	1–4 weeks	1–12 months	0 days	1–5 days	6–30 days	> 30 days
Lower back	42.1 (24)	10.5 (6)	14.0 (8)	84.2 (48)	5.3 (3)	8.8 (5)	
Neck	31.6 (18)	19.3 (11)	10.5 (6)	38.6 (22)	31.6 (18)	19.3 (11)	10.5 (6)
Shoulder	24.6 (14)	10.5 (6)	7.0 (4)	86.0 (49)	1.8 (1)	7.0 (4)	-
Elbow	12.3 (7)	5.3 (3)	3.5 (2)	87.7 (50)	1.8 (1)	1.8 (1)	-
Wrist/hand	28.1 (16)	14.0 (8)	8.8 (5)	93.0 (53)	-	1.8 (1)	1.8 (1)
Knee	7.0 (4)	1.8 (1)	5.3 (3)	-	-	-	-

In the most cases the workers didn't take the days off because of MSDs. Because of neck pain about one third of the respondents missed workdays from one to five days and 19.3% 6–30 days and 10.5% had sick leave more than 30 days. Surprisingly, a few respondents missed workdays because of lower back pain.

The correlation analysis showed direct relationship between BMI and lower back pain ($p = 0.05$). Positive correlation was detected also between smoking and wrist/hand pain ($p = 0.003$). Significant relationships between bending and straightening of elbow and pain in the neck ($p = 0.05$) and wrist/hand ($p = 0.05$) were observed. Positive correlations between autonomy on work content, tasks schedule, and rest breaks and pain in the lower back ($p = 0.02$) and elbow ($p = 0.01$). Lack of regular breaks didn't correlate to MSDs.

DISCUSSION

The sewing machine operators include into the risk group, with high probability for MSDs in neck/shoulder, upper and lower back and wrist/hand regions (Schibye et al., 1995). This study of work related risk factors and prevalence of MSDs among sewing machine operators was ordered by the enterprise management who were very interested in improvement of working conditions to prevent MSDs among the workers. Often the sewing machine operators are sitting closely behind the tables not always ergonomically designed and using technology that compel an awkward position (for example riveting). During the most of workday the bending and straightening of hands, wrists and fingers cause inflammatory and degenerative changes in the tendons, joints and muscles, resulting in pain and functional impairment (Schibye et al., 1995; EU-OSHA, 2007a; EU-OSHA, 2007b; Sealetsa & Thatcher, 2011; Männaste & Merisalu, 2016). A number of studies have shown that work related MSDs mainly affecting the neck, shoulders, elbows, forearms, wrists and hands of sewing machine operators (Schibye et al., 1995; Buckle & Devereux, 2002; EU-OSHA, 2007a; Deyyas & Tafese, 2014; Lu et al., 2015). In our study, there is additional information about the prevalence of MSDs among the sewing machine operators that the lower back pain was on the first place (Männaste & Merisalu, 2016). The direct relation between physiological, psychological, physical and individual risk factors and MSDs has been found in the earlier studies (Buckle & Devereux, 2002; Lu et al., 2015). In the present study the most of respondents had pain at least in one body region and more than half in three and more body sites in the past 12 months. Some of the authors have found the relationship between MSDs, physical overstrain and job satisfaction (Wang et al., 2007).

Although the majority reported poor autonomy at work, surprisingly the higher autonomy in work content, tasks schedule and resting breaks was positively correlated with lower back and elbow pain. Contrary, the earlier studies have shown negative association between poor autonomy and MSDs (Melzer & Iguti, 2010). Apparently the higher choice in deciding what and how to do the work is strongly forcing the workers, causing overstrain and more often MSDs. At the same time few of the sewing machine operators misses workdays because of illness and short duration of sick leave about one week was reported. The earlier research on garment workers has demonstrated, that when the breaks were too short, the higher prevalence of pain in the neck and shoulders was observed (Afonso et al., 2014). The Chinese researchers are detected, that the optimal number of breaks and diverse work tasks enable to prevent MSDs among sewing machine operators (Lu et al., 2015).

The present study clearly demonstrate the need for better job control, because even when a higher autonomy the sewing machine operators are working too hard to complete the tasks by a fixed time to achieve the better results. High work pace plays here an important role.

In the present study positive correlation between BMI and lower back pain confirmed that there is a higher risk for MSDs among the workers with overweight (Lu et al., 2015; WHO, 2016; Männaste & Merisalu, 2016). It has been shown that steady work in sitting position during a whole workday is related to high risk on overweight (Buckle & Devereux, 2002; EU-OSHA, 2007a). So, the variation of work tasks in different positions and work rotation could be diminish risk of overweight and prevent MSDs among sewing machine operators (Wang et al., 2007; Lu et al., 2015).

Also, the smoking conceives a risk on musculoskeletal problems. Additionally to toxic effect of smoking on a whole body, the higher prevalence of MSDs has seen in our study – the more often wrist/hand pain was detected among the regular smokers. It has been recommended to stop smoking that to prevent MSDs (Abate et al., 2013). Different ergonomic intervention activities and physio- and psychotherapy procedures could be useful to prevent MSDs and sick leave among sewing machine operators (Buckle & Devereux, 2002).

CONCLUSIONS

The results of study showed, that sewing machine operators include in the risk group with high prevalence of MSDs. Almost all the respondents (91.2%) reported pain at least in one body region in the past 12 months and most often in lower back, neck and wrist/hand. A relatively short duration of lower back pain (1–6 days) was reported by 42.1% of respondents and sick leave from one to five days was mentioned by 31.6% because of neck pain.

Monotonous work in constraint sitting position with repetitive movements and poor autonomy were observed as work specific risk factors for all the sewing machine operators. Most of the participants reported few breaks and work under pressure to complete tasks by a fixed time.

Statistically significant relationships between work related and individual risk factors have seen. Positive correlations between bending and straightening of elbow and pain in the neck and wrist/hand were observed. The regular smokers had higher prevalence of wrist/hand pain. Overweight and autonomy correlated positively with lower back pain. But support by colleagues and supervisors could be give positive effect on teamwork to better manage work overload.

In conclusion, it is very important to pay more attention on workplace ergonomics to correct a sitting posture and adapt the movements of elbow and wrist/hand among sewing machine operators. The best physical exercise programs, and optimal breaks and effective rehabilitation activities could be included into the work schedule of sewing machine operators. Further longitudinal studies are needful to investigate the effect of intervention programs on MSD prevalence among sewing machine operators.

ACKNOWLEDGEMENTS. The research team is much obliged to the sewing company management for help and guidelines in carrying out the study among the sewing machine operators.

REFERENCES

- Abate, M., Vanni, D., Pantalone, A. & Salini, V. 2013. Cigarette smoking and musculoskeletal disorders. *Muscles, Ligaments and Tendons Journal* **3**(2), 63–69.
- Afonso, L., Pinho, M.E. & Arezes, P.M. 2014. Risk factors associated with musculoskeletal symptoms in footwear sewing workers. *Occupational Safety and Hygiene II* pp. 597–602.
- Baecke, J.A.H., Burema, J. & Frijters, J.E.R. 1982. A short questionnaire for the measurement of habitual physical activity in epidemiological studies. *The American Journal of Clinical Nutrition* **36**, 936–942.
- Buckle, P.W. & Devereux, J.J. 2002. The nature of work-related neck and upper limb musculoskeletal disorders. *Applied Ergonomics* **33**(3), 207–217.
- Coggon, D., Ntani, G., Palmer, K.T. et al. 2012. The CUPID (Cultural and Psychosocial Influences on Disability) study: methods of data collection and characteristics of study sample. *PLoS One* **7**(10), 1–22.
- Deyyas, W.K. & Tafese, A. 2014. Environmental and organizational factors associated with elbow/forearm and hand/wrist disorder among sewing machine operators of garment industry in Ethiopia. *Journal of Environmental and Public Health* 2014:732731, pp 1–8.
- EU-OSHA. 71/ET. Facts. European Agency for Safety and Health at Work. 2007a. Work related musculoskeletal disorders (in Estonian). <https://osha.europa.eu/et/tools-and-publications/publications/factsheets/71>. Accessed 24.3.2016.
- EU-OSHA. 3/EN. European Agency for Safety and Health at Work. 2007b. Work-related musculoskeletal disorders: Back to work report. Luxembourg, pp. 1–100.
- Han, T.S., Schouten, J.S., Lean, M.E. & J.C. Seidell, M.E. 1997. The prevalence of low back pain and associations with body fatness, fat distribution and height. *International Journal of Obesity and Related Metabolic Disorders* **21**, 600–607.
- HSE. Health and Safety Executive. 2015. *Work-related musculoskeletal disorder (WRMSDs) statistics*. Great Britain, 20 pp.
<http://www.hse.gov.uk/statistics/causdis/musculoskeletal/msd.pdf>
- Kuorinka, I., Jonsson, B., Kilbom, A., Vinterberg, H., Biering-Sorensen, F., Andersson, G. & Jorgensen, K. 1987. Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms. *Applied Ergonomics* **18**(3), 233–237.
- Lu, L., Chen, S.G., Tang, S.C., Wang, S., He, L.H., Guo, Z.H., Li, J.Y., Yu, S.F. & Wang, Z.X. 2015. How work organization affects the prevalence of WMSDs. A case-control study. *Biomed Environ Sci.* **28**(9), 627–633.
- Männaste, M. & Merisalu, E. 2016. Nature of work and incidence of musculoskeletal pain among sewing machine operators. *The 10th Master students conference & 1st International Master students conference "Human and Engineering"* (in Estonian). Tartu, pp. 129–135.
- Melzer, A.C.S. & Iguti, A.M. 2010. Working conditions and musculoskeletal pain among Brazilian pottery workers. *Cad Saúde Pública* **26**(3), 492–502.
- Sealetsa, O.J. & Thatcher, A. 2011. Ergonomics issues among sewing machine operators in the textile manufacturing industry in Botswana. *Work* **38**, 279–289.
- Summers, K., Jinnat, K. & Bevan, S. 2015. Musculoskeletal disorders, workforce health and productivity in the United States. *The Work Foundation*. London, pp 40.
- Schibye, B., Skov, T., Ekner, D., Christiansen, J.U. & Sjøgaard, G. 1995. Musculoskeletal symptoms among sewing machine operators. *Scandinavian Journal of Work, Environment & Health* **21**(6), 427–434.
- Health Board. Incidence of occupational diseases and work related diseases in 2014 (in Estonian). Tallinn, 2014. <http://terviseamet.ee/tervishoid/toeoetervishoid/aruated.html> Accessed 24.3.2016.

- Wang, P.C., Rempel, D.M., Harrison, R.J., Chan J. & Ritz, B.R. 2007. Work-organizational and personal factors associated with upper body musculoskeletal disorders among sewing machine operators. *Occupational and Environmental Medicine* **6**(4), 806–813.
- WHO. World Health Organization Europe. 2016. *Body Mass Index – BMI*. <http://www.euro.who.int/en/health-topics/disease-prevention/nutrition/a-healthy-lifestyle/body-mass-index-bmi>