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Job specific risk factors, demographic parameters and musculoskeletal disorders among military personnel depending on type of service

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Abstract. Current study aimed to analyse the prevalence of job specific risk factors (JSRF) and musculoskeletal disorders (MSDs) among military personnel depending on demographic factors and type of service. An anonymous questionnaire study was carried out in five departments of Estonian Defence Forces (EDF) among local service personnel (LSP) and the Peace Corp personnel (PCP) arrived back from mission. The average response rate was 38.7% (LSP 31.9% and PCP 77.6%). In LSP group there were 44.7% male participants, with mean age 39.2 ± 11 years, length of service in present position 5.8 ± 4.9 years and work load of 37.9 ± 8.4 hours per week. In PCP group 97.4% were males, with mean age 27.5 ± 5.7 years, service length on present position 3.1 ± 2.6 years and work load of 84.3 ± 60.9 hours per week. The dominant JSRF in LSP was 'demand for constant concentration' (76.5%) and night work (57%) in PCP (group difference $p < 0.0001$). 'Fast movements' and 'lifting loads >40 kg' were the specific tasks most often reported in mission. 'Job insecurity' was more often reported by the female; 'night work' and 'work-rest disbalance' by the male military personnel ($p < 0.001$).The prevalence of MSDs was higher among women and LSP than in men and PCP group ($p < 0.05$). In LSP mild to moderate discomfort reported by 2/3 because of neck-shoulder strain and by ½ because of lower back pain. In conclusion, MSDs seems to depend more on demographic parameters and type of service than JSRFs. Further studies are needed to focus on predictive factors of MSDs among military personnel.

Key words: job specific risk factors, demographic parameters, musculoskeletal disorders, military personnel.

INTRODUCTION

Musculoskeletal injuries are recognized as a leading health problem in the military, but the size of the problem is underestimated. Injury rates during military training are high, ranging from 6 to 12 per 100 male recruits per month during basic training and up to as high 30 per cent per month for Naval Special Warfare training (Kaufman et al., 2000). More than 7,000 MSDs were identified in 2006 among nondeployed, active duty service members from military medical surveillance in USA. Most of MSDs (82%) were classified as inflammation and pain caused by overuse, followed by joint derangements (15%) and stress fractures (2%). The knee or lower leg (22%), lumbar spine (20%), and ankle/foot (13%) were leading body regions. When these injuries are combined with acute traumatic injuries, there could be 1.6 million injury-related medical encounters each year in total in US army alone (Hauret et al., 2010). Injury-related musculoskeletal conditions are common in young and active population: about 2/3 involve lower back pain, followed by cervical and midback pain syndromes. Some predictive factors associated with spine-area pain are similar to those observed in civilian cohorts, such as psychosocial distress, heavy physical activity or lifestyle. Risk factors specific to military personnel include concomitant psychological trauma, extreme noise and vibration exposure, heavy combat load requirements, and urban dismounted ground operations (Cohen et al., 2012). A study of the Danish army showed similar musculoskeletal problems in different service types (infantry, signal, combat service support, engineers, and artillery). Working as a gunner for less than 2 years increased the risk of reporting neck pain ($p = 0.011$) and working as a loader increased the risk of shoulder pain ($p = 0.017$) (Nissen et al., 2009). Health statistics of Estonian military personnel (2008) demonstrated that MSDs ranked 2nd and occupational injuries 3rd among total cases of health problems according to primary health checks in the units of Medical Centres, EDF. Duties in service when injuries took place were: a) in service ($n = 217$): direct external causes, e.g. hot war (n = 13), vehicle traumas ($n = 21$) and military training ($n = 145$); b) sport ($n = 152$) and c) leisure activities ($n = 74$). A total of 500 injuries were recorded in Estonia in 2007, where half of all cases were lower limb traumas, including bone fractures and the same prevalent – microtraumas as cutaneous blisters and frictions (Merisalu et al., 2009). Similar results have been shown in previous studies about training and combat environment, where the loads have been associated with an increased risk of lower limb overuse injuries (foot blisters, metatarsalgia, stress fractures, knee pain ets) (Birrell et al., 2007). A study of health of Finnish male military personnel showed that the group with the longest sickness absences (> 7 days) exhibited lower muscle fitness in three of four tests and shorter running distance compared to the groups with shorter sickness absence ($p < 0.001$). In addition, high Body Mass Index (BMI), poor muscle fitness and poor aerobic endurance were associated with increased sickness absence (Kyröläinen et al., 2008). Risk factors of neck pain were analysed in 629 office workers of Belgium military personnel. More than ¾ of respondents reported neck pain as life-long problem and more than half of them reported neck pain once per week at least (De Loose et al., 2008).

The study of US Army personnel indicated the need to consider the interaction between workplace factors and gender on disability in the military personnel and to pay more attention on back-related disorders and prevent musculoskeletal disability risk in women (Feuerstein et al., 1997). The study among British Army recruits demonstrated that gender was not an independent risk factor for injury, suggesting that lower levels of aerobic fitness are the primary cause of the greater incidence of injury among female recruits during initial training (Blacker et al., 2008). In US Military Academy stress fracture incidence was much higher in women than in men, indicating increased stress fracture risk for smaller tibial and femur sizes (Cosman et al., 2013).

Musculoskeletal injuries are the leading healthcare problem for military members in missions. Since 2003 the start of operations in Iraq musculoskeletal complaints continued to be a primary cause of disability and have been reported to cost up to $500 million annually (George et al., 2007). Mortality rate among US military subjects in Bosnia-Hertsegovina (1996) was 1 case per 100 soldiers in week (Sanchez et al, 2001). There are many factors that lead to musculoskeletal complaints, but the extended periods of walking and marching under heavy loads was the major problem. Wearing of combat boots and walking long distances with univorm and loads of 20 to 60 kg impact on plantar pressure distributions during gait (Goffar et al., 2013). One infantry unit that collected data during deployment to Afghanistan in 2003 reported an average fighting load of 29 kg, an approach march load (for more prolonged operations) of 46 kg, and an emergency approach march load (in which certain transportation resources were unavailable) of 60 kg across several missions (Birrellet al., 2007). Musculoskeletal pain was common during peacekeeping mission in Swedish military personnel on 6 months duty in Afghanistan. About 70% of 344 respondents to a questionnaire reported any MSD, where 17% of respondents had pain both in lumbar spine and shoulders and 14% in lower extremities. Low pain and low disability were reported by 57% (grade I), high pain with low disability reported by 36% (grade II) and any pain with high disability 5% (grade III) (Glad et al., 2012).

So, as shown in the number of studies, the influence of job specific factors and gender on mortality are clearly demonstrated among military personnel. The purpose of the present study was to describe work related risk factors and prevalence of MSDs among Estonian military personnel depending on demographic parameters in local (domestic) service and in missions.

MATERIAL AND METHODS

Subjects

Based on the statistics of EDF (2008) there were in total 3,199 subjects in the EDF register. The study group was selected by random sample method and consisted of 841 subjects from five departments of EDF and named as local service personnel (LSP). The Peace Corp personnel (PCP) was time selected, *i.e.* completed by the subjects (n = 147) who arrived from the missions after 6 months duty in Afganistan and Iraq. The total sample size was 988 subjects.

Questionnaire

The questionnaire was compiled following the validated questionnaires used among service occupations in the national and international studies (Mykletun, 1997; Põlluste & Merisalu, 2007). The questionnaire consisted of nine parts, where demographic and general data (age, gender, rank, unit and length of service, working hours), questions about working environment (unbalanced work-rest conditions, need for constant concentration, job insecurity, monotonous and night work; tasks in active operations: work in constraint posture, fast repetitive movements, lifting loads, creeping with loads, computer work) (n = 11) and musculoskeletal problems of different body parts (n = 13) were included. The exposure to risk factors was measured on a 3-point scale, where: 1 – never, 2 – sometimes, 3 – often. Musculoskeletal disorders (MSDs) in different body parts were measured on a 4-point scale; where: 1 – no discomfort, 2 – mild discomfort but not disturbing, 3 – moderate discomfort that makes working difficult, 4 – discomfort leading to sick leave.

The data was analysed using Statistical Package *SPSS*.22.0. Frequency tables were used to describe the sample by gender, age, work load, service length and risk factors. The χ^2-test and Fisher's exact test was used to compare differences by gender, JSRFs and MSDs between the service groups (LSP/PCP). Spearman and Pearson correlation analyses were used to describe relationships between demographic factors (age, service length, working hours), JSRFs and MSDs.

Procedure

The anonymous guestionnaire study was carried out in five departments of EDF, from October 2008 to March 2009. The participation was voluntary and anonymous. Voluntary participation was promoted with the help of an individual informed consent letter, where the purpose of study, possible outcomes and practical benefits were explained. The signed informed consent letter in closed envelope and filled questionnaire in a separate closed envelope was put into a sealed box. The contract between the Estonian Ministry of Defence and the research structure (University of Tartu) was signed (25.07.2008 no 9.2.-10./5450). The agreement with the departments of the EDF and the permission of the Research Ethics Committee, University of Tartu were pursued before the study (173/T-16, 21.08.2008).

RESULTS

The study group consisted of 841 subjects from 5 departments. The sample size of LSP was 268 subjects (response rate 31.9%) and of PCP 114 subjects (rensponse rate 77.4%). In total 382 responded, with an overall response rate 38.7% (Table 1).

Table 1. Composition of the study group by the type of service (LSP and PCP) (n, %)

Name of group	Target group (n)	Study group (n)	Response rate (%)
LSP	841	268	31.9
PCP	147	114	77.6
Total	988	382	38.7

Demographic and general data of the sample by the service groups are shown in Table 2. In the LSP group there were 55.3% (n = 149) female and 44.7% (n = 119) male respondents with mean age of 39.2 ± 11.0 years. There was a gender difference in mean age – the men were younger than women (p = 0.0001). In the LSP group the mean total length in service was 9.5 ± 5.8 years and in the present position 5.8 ± 4.9 years. The mean working time in the LSP group was 37.9±8.4 hours per week. The women had longer service length and worked longer hours than men (p = 0.0001). By rank they were military servants (46.3%), non-commissioned officers (31.7%), officers (20.8%) and not defined (1.2%).

In the PCP group the majority was male (97.4%), with mean age of 27.5 ± 5.7 years, with mean service length of 5.9 ± 3.9 years and having worked in the present position for 3.1 ± 2.6 years. PCP group worked long hours (on average 84.3 ± 60.9 hours in a given week), and female personnel even more (132.0 ± 62.4 hours). The distinct differences were observed between gender groups by service length and work load ($p < 0.0001$). By rank there were 57.0% ($n = 65$) non-commissioned officers, 36.8% ($n = 42$) soldiers and 6.2% ($n = 7$) officers.

Table 2. Demographic and general data by the type of service and gender (mean, SD, max, min and *p* – difference between the groups)

Parameter	Mean	SD	Min	Max	Group difference, *p*
Age (years)					
Total LSP	39.2	11.0	20.0	70.0	LSP>PCP 0.0001
Male	35.5	9.9	21.0	70.0	
Female	42.2	11.0	20.0	67.0	M<F 0.007
Total PCP	27.5	5.7	20.0	49.0	
Male	27.5	5.8	20.0	49.0	
Female	27.0	4.6	23.0	32.0	-
Total service length (years)					
Total LSP	9.5	5.8	0.1	40.0	LSP>PCP 0.0001
Male	10.9	6.0	0.1	40.0	
Female	8.2	5.3	0.2	35.0	M>F 0.005
Total PCP	5.9	3.9	1.0	18.0	
Male	5.9	3.9	1.0	18.0	
Female	6.8	2.0	4.5	8.0	M<F 0.001
Years in present position					
Total LSP	5.8	4.9	0.1	40.0	LSP>PCP 0.0001
Male	5.5	5.6	0.1	40.0	
Female	6.0	4.3	0.2	16.0	-
Total PCP	3.1	2.6	0.5	13.0	
Male	3.0	2.6	0.5	13.0	
Female	8.0	0	8.0	8.0	F>M 0.0001
Work load (hours per week)					
Total LSP	38.0	8.2	5.0	50.0	LSP<PCP 0.0001
Male	37.6	9.4	5.0	50.0	
Female	38.4	6.9	8.0	48.0	M<F 0.007
Total PCP	84.4	61.0	5.0	178.0	
Male	82.8	60.7	5.0	178.0	
Female	132.0	62.4	60.0	168.0	-

The exposure to the JSRFs in LSP and PCP is shown in the Table 3. The highest mean score on the 3-point scale was measured in ‘demand for constant concentration’ (2.7) for LSP group and ‘night work’ (2.6) for PCP group. At the same time, ‘demand for constant concentration’ was a risk factor for ¾ of LSP and ½ of PCP group. Job insecurity because of organisational changes was a more disturbing factor for LSP, compared to PCP group ($p < 0.0001$). ‘Night work’ and ‘disbalanced work-rest ratio’ were the most frequent risk factors for PCP, compared to LSP group ($p < 0.0001$).

Table 3. Exposure to job related risk factors (%) by the type of service (LSP and PCP)

Job specific factor	Mean, on 3-p scale LSP/PCP	Never		Sometimes		Often		Group differnce, *p*
		LSP	PCP	LSP	PCP	LSP	PCP	
Routine work	2.0/2.0	23.4	23.2	53.3	51.8	23.4	25.0	–
Night work	1.6/2.6	46.1	1.8	41.4	41.2	12.5	57.0	0.0001
Work & rest disbalance	1.7/2.0	45.7	28.1	41.1	43.0	13.2	28.9	0.0001
Job insecurity because of organisational changes	1.9/1.6	26.3	53.0	56.9	38.1	16.9	8.8	0.0001
Constant concentration	2.7/2.4	6.2	14.9	17.4	34.2	76.5	50.9	0.0001

Results for exposure to JSRFs on active operations are presented in Table 4. Less than half of respondents worked with fast precised movements 'sometimes' or 'often'. About 1/3 of PCP lifted loads above 40 kg 'sometimes in month'.

Table 4. Exposure to the job related risk factors specific to PCP active operations

Job tasks in mission	Mean, 3-p scale	Never		Sometimes		Often	
		n	%	n	%	n	%
Lifting loads 20–40 kg	1.1	98	88.3	12	10.8	1	0.9
Lifting loads >40 kg	1.4	67	60.4	40	35.1	4	3.6
Constraint position	1.1	98	88.3	12	10.8	1	0.9
Fast precised movements	1.5	60	54.1	44	39.6	7	6.3
Creeping with loads	1.2	92	82.9	14	12.6	5	4.5
Computer work	1.2	86	77.5	24	21.6	1	0.9

The comparison of musculoskeletal complaints by body region and severity in LSP and PCP groups are shown in the Table 5. MSDs were registered more often among the LSP group ($p < 0.05$). In the latter, 'mild to moderate discomfort' was reported because of neck-shoulder strain (69.2%), the lower back (54.8%) and feet pain (41.4%). Fingers', wrist, neck-shoulder, upper-back and foot pain were the symptoms causing more discomfort for LSP group, compared to PCP ($p < 0.05$). 'Mild to moderate discomfort' because of knee pain was reported by 45% and neck shoulder strain by 38.7% of PCP group. The most frequent cause of sick leave for LSP was lower back pain (1.9%) and for PCP – heel pain (2.7%).

Gender differences of JSRFs are shown in Fig. 1. The men were more often exposured to 'night work' and 'work-rest disbalance', and the women to 'job insecurity because of changes in the organisation' ($p < 0.001$).

'Night work' correlated negatively with age (r= -0.45, p< 0.001) *i.e.* younger military members and male had higher exposure to 'night work'. Long working hours and 'work-rest disbalance' correlated positively with 'night work' (r = 0.32 and r = 0.29, respectively).

Table 5. Musculoskeletal complaints by body region and severity (%) among LSP and PCP (p –group difference)

MSD/ body region	Mean, 4-p scale	No discomfort		Mild discomfort		Moderate discomfort		Caused sick leave		
	LSP/PCP	LSP	PCP	LSP	PCP	LSP	PCP	LSP	PCP	p^*
Fingers' numbness	1.3/1.2	71.9	85.6	25.9	13.5	1.9	0.9	0.4	-	0.022
Hands'weakness	1.2/1.1	79.8	86.5	16.4	12.6	3.8	0.9	-	-	-
Wrist pain	1.4/1.1	71.2	86.5	23.1	13.5	5.8	-	-	-	0.001
Elbow pain	1.3/1.1	78.9	88.3	16.5	10.8	4.6	0.9	-	-	-
Neck-should strain	1.9/1.4	30.8	60.4	53.6	36.0	15.6	2.7	-	0.9	0.0001
Hips' pain	1.2/1.1	81.5	88.3	13.9	10.8	4.2	0.9	0.4	-	-
Knee pain	1.5/1.5	56.4	54.1	37.5	39.6	5.8	5.4	0.4	0.9	-
Heel pain	1.3/1.2	77.3	82.9	18.5	12.6	3.9	1.8	0.4	2.7	-
Foot pain	1.5/1.2	57.9	77.5	35.3	21.6	6.1	-	0.8	0.9	0.0001
Tiredness in feet	1.4/1.2	70.4	80.2	24.9	18.9	4.3	0.9	0.4	-	-
Numbness in feet	1.2/1.1	78.5	85.6	19.2	14.4	2.3	-	-	-	-
Upper back pain	1.4/1.3	62.8	75.7	32.6	21.6	4.7	2.7	-	-	-
Lower back pain	1.7/1.5	43.3	55.0	44.8	39.6	10.0	4.5	1.9	0.9	-

*Fisher's exact test

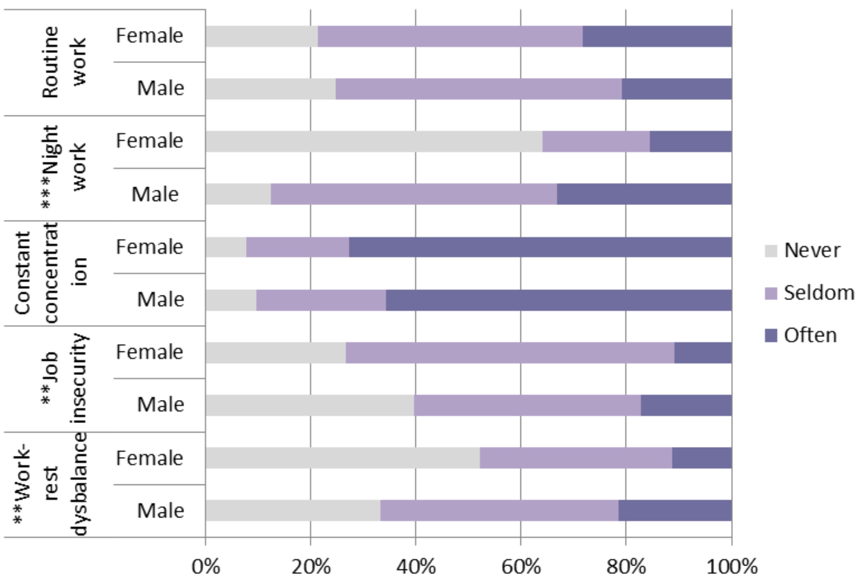

Figure 1. Gender differences of job related risk factors (**$p < 0.001$, ***$p < 0.0001$).

Gender differences in prevalence of MSDs are shown in the Fig. 2. Neck-shoulder strain, pain in lower and upper back, feet, wrist and hands caused more discomfort for female service personnel, compared to the men ($p < 0.05$).

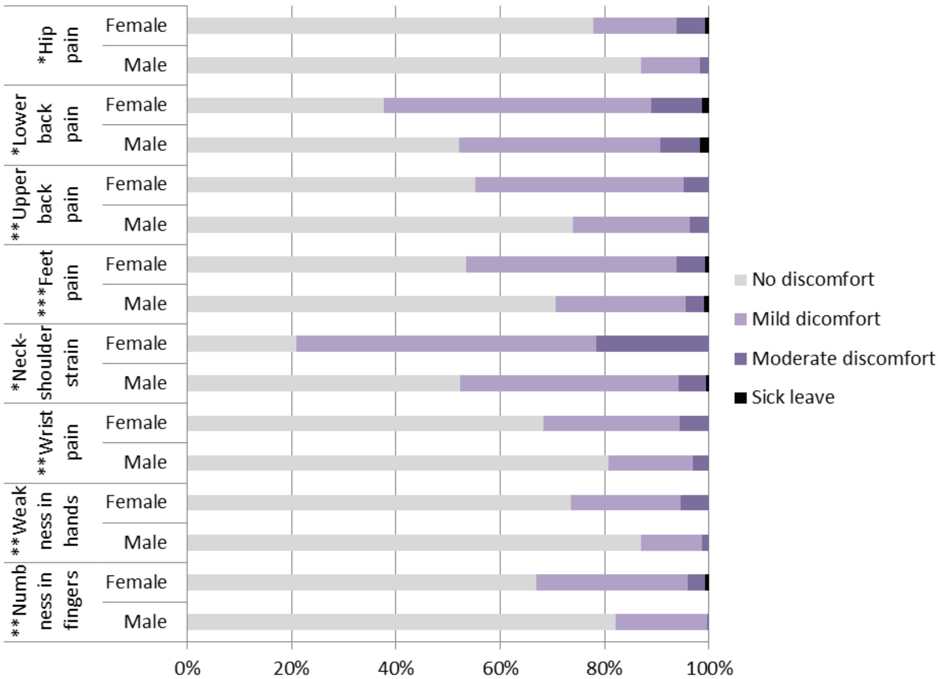

Figure 2. Gender differences in prevalence of MSDs among military personnel (*$p < 0.05$, **$p < 0.001$, *$p < 0.0001$).

Correlation analysis of demographic parameters and MSDs showed that prevalence of neck-shoulder strain was higher in female ($r = 0.34$) and older military personnel ($r= 0.31$, $p < 0.001$). Distinct intercorrelations were observed between the MSDs in different body regions ($p < 0.001$). Direct intercorrelations were seen between numbness in fingers and weakness in hands ($r = 0.53$), between wrist and elbow pain and numbness in feet and fingers ($r = 0.48$ both), between foot and elbow pain, and wrist and neck pain ($r = 0.40$ in both), knee and heel pain ($r = 0.41$).

DISCUSSION

In the present study the demographic data, JSRFs and MSDs were taken under the analysis. The results were compared between two groups depending on type of service – the group of local military service and missions. The women in the local military service had higher mean age and longer years in present position and worked longer hours than the male counterparts. The women and older personnel were more often confronted with 'job insecurity because of organisational changes' and they reported more neck-shoulder strain. The male and younger personnel reported more often 'night work' and 'disbalanced work-rest conditions'. Long working hours correlated positively with 'work-rest disbalance' and 'night work'.

A number of preliminary studies have analysed the causes and prevalence of MSDs among military personnel (Feuerstein et al., 1997; Birrell et al., 2007; George et al., 2007; Blacker et al., 2008; De Loose et al, 2008; Hauret et al., 2010; Cohen et al., 2012; Cosman et al., 2013). Our study results showed some similarities with earlier research. In LSP group 'mild to moderate discomfort' was reported by 2/3 of respondents because of neck-shoulder strain and among half because of lower back pain. De Loose et al. (2008) showed that more than ¾ of respondents in military service had neck pain as life-long problem. Nissen and co-authors (2009) demonstrated that higher risk of neck pain was seen in gunners working in military service less than 2 years and an increased risk of shoulder pain was observed among loaders. Few systematic analyses about demographic parameters, JSRFs and MSDs have been published (Feuerstein et al., 1997; Blacker et al., 2008; Cosman et al., 2013; Cubata et al., 2014).

Up to now few research has been done in comparing health risks and MSDs between Peace Corp and local military service groups. Hotopf et al. (2006) compared the symptoms of regular personnel in UK and peacekeeping corp in Iraq and in latter they didn't see worse health outcomes, apart from a modest effect on multiple physical symptoms. In our study the distinct difference in prevalence of JSRF and MSDs in LSP and PCP was observed. High work load, 'work-rest disbalance', work in night shifts, 'lifting loads' and doing 'fast precised movements' were characteristic JSRFs in mission. Relatively few health complaints were reported by PCP group. Less than half of them assessed 'mild to moderate discomfort' because of knee pain or neck-shoulder strain and few of them (2.7%) took sick leave because of heel pain. Contrary to our results high morbidity rate among US military subjects in Bosnia-Hertsegovina was observed, where walking and marching under heavy loads was the major problem leading to MSDs in US army (Sanchez et al., 2001; Goffar et al., 2013). Musculoskeletal complaints among US Peace Corp in Iraq since 2003 continued to be a primary cause of disability and have been reported to cost up to $500 million annually (George et al., 2007). Till now no calculations about EDF costs have published in Estonia.

Low prevalence of MSDs among our PCP can be explained by their younger age, excellent physical preparedness for missions and relatively short length of military service. They were healthy young men able to work long hours in night time. They managed well with their health conditions during 6 months' mission. However, according to primary health checks in the units of Medical Centres of EDF, in total 500 injuries were recorded among local service people in 2007 (Merisalu et al., 2009). Thereon, more serious outcomes with musculsoskeletal disabilities and lost lives in missions have been registered. Based on the statistics of EDF (2015) since 2004 there are 130 peacekeepers injured and 11 death cases registered in Estonia.

Indeed, we must preserve lives of young military people and decrease high prevalence of MSDs, increasing military readiness and decreasing the costs associated with poor outcomes and treatment (Gates & Huard, 2005). The human factors engineering purpose is to enhance mission effectiveness with enhanced combat systems. New technologies enable warfighters to work more effective manner with fewer personnel. While the tradeoffs between new technologies and numbers of operators needed are complex, strong evidence suggests that these manpower savings can be significant and have the potential to accelerate military transformation (Osga & Galdorisi, 2007).

CONCLUSIONS

The results of the present study demonstrate quite stressful milieu in the local military service with demand for constant concentration and high job insecurity because of structural changes. These factors were more characteristic to less experienced, female and older personnel. The job related risk factors and MSDs significantly differed by type of service. Because of military service is ever popular among young women more attention could be payed to gender differences in the nearest future. Globalisation of military structures, continuing technological modernisation and increasing pressure on widening defence ability in Eastern Europe predict higher mental and physical pressure and morbidity among military personnel in Estonia. Further studies are needed for analysing relationship between JSRFs and MSDs and disability among military personnel. Preventing risks in military service enables better management of health conditions and guarantees higher work ability of military personnel, depending on age and gender.

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