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Myotonometry as a tool for determination of fatigue in the upper extremities of garment industry workers

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Abstract. The myotonometric measurements of upper limb muscles of garment workers working in a static posture are presented. The workers' pain intensity was followed on the pain Visual Analogue Scale. The results show that *M trapezius* and other spine muscles differ at the beginning and the end of the workweek. In hand muscles, the difference is not so significant. The load accumulates in the hands over the years, and the spine and neck get tired more quickly; therefore, there are more complaints of pain in the neck and back. The values of measured stiffness of the muscles was between 156–278 N/m and for the own frequency of muscles 11.2–16.5 Hz.

Keywords: myotonometry, fatigue, musculoskeletal disorders, garment workers.

Introduction

The majority of occupational diseases (OD) in Estonia and in the world [1, 2] pertain to musculoskeletal disorders (MSDs) caused by long-term monotonous work or a static working posture. This is a great problem in the garment industry [3]. The ODs in Estonia are diagnosed in a late stage when the worker is already disabled. In this last stage, it is difficult to find proper rehabilitation methods for total recovery [4]. Therefore, rehabilitation has to begin sooner. The present investigation is dedicated to determination of fatigue of the hand, shoulder and higher-back muscles after work in a static posture, using the advanced measuring method – "myotonometry" [5]. The parameters that show changes in the muscles are as follows: (a) Frequency which characterizes muscle tension. The own frequency of muscle describes the muscle tone in the relaxed state of the muscle. The value of the parameter is usually 11–16 Hz, depending on the muscle. In a normal state, the muscle tension at rest is insignificant, but the frequency increases when the muscle is energized. Increased muscle tone at rest may reduce blood flow to the muscles; (b) Decrement characterizes muscle elasticity i.e. a muscle's ability to recover its original shape after contraction. Values of the decrement are normally less than 1.0–1.2, depending on the type of the muscle. The changed elasticity may affect blood flow in muscles when working movements are performed. There may be greater wear, and the speed of movement may be limited [5]; (c) Stiffness characterizes a muscle's ability to resist its shape-shifting power. The values of stiffness are in the range of 150 N/m to 300 N/m, depending on the type of the muscle. The results of "myotonometric" measurement of workers in different occupations can be found in [6–8]. The aim of the study is to determine the fatigue of muscles during the work process in the garment industry.

Methods and Contingent

The MYOTON-3 myotonometer was used to evaluate the functional state of the skeletal muscles of garment industry workers (N = 32, all female). The workers of gore machine (N = 4) and universal sewing machines (N = 28) were the most ergonomically not well-designed workstations. Completing and ironing workers were excluded from the study group. The myotonometer is a handheld device (Fig. 1, 2) developed at the University of Tartu, Estonia, by Dr. Arved Vain. The myotonometer exerts a local impact on the biological tissue by means of a brief mechanical impulse. The impact force is small enough so that it causes no changes in the neurological reaction of the biological tissue. The tissue responds to the mechanical impact with damping or oscillation, which is registered by an acceleration sensor located on the measuring tip of the device. The workers' musculoskeletal pain intensity was assessed by using the pain Visual Analogue Scale (VAS, a scale from one to ten). The workers filled in the questionnaire forms. The arithmetic mean and standard deviation (SD) were calculated. To ascertain the relationships between the characteristics, *Spearman's rank correlation coefficient* (Spearman's Rho) was applied, the differences between the groups were tested by means of *Student's t-test*. The difference $p<0.05$ was considered to be statistically significant.

Fig. 1. Myotonometer "MYOTON-3"

Fig. 2. Measurement of muscles stiffness

Results

The following muscles were measured myotonometrically: *M abductor pollicis brevis, M adductor pollicis brevis* (hand muscles), *M trapezius med and M erector spinae* (spine muscles). The results show that various *M trapezius* and other spine muscles differ at the beginning and at the end of a workweek. In the hand muscles, the difference is not so significant. The load is accumulated in the hands over the years, and the spine and the neck get tired more quickly, therefore there are more complaints of pain in the neck and in the spine. The stiffness (S), decrement (D) and frequency (F) of various muscles at the beginning (BEGIN) and at the end (END) of the workweek are presented in Table 1.

Table 1. The myotonometric measurements of hand and spine muscles at the beginning and at the end of the workweek

Adductor poll left BEGIN			*Adductor poll left* END			*Adductor poll right* BEGIN			*Adductor poll right* END		
F	S	D	F	S	D	F	S	D	F	S	D
16.5	**278.9**	2.35	15.8	**277.4**	2.33	15.9	**268.7**	2.6	15.8	**277.2**	2.3
*3.0	31.5	0.3	2.01	29.77	0.44	2.38	31.29	0.3	2.2	33.44	0.4
Trapezius med left BEGIN			*Trapezius med left* END			*Trapezius med left* BEGIN			*Trapezius med right* END		
F	S	D	F	S	D	F	S	D	F	S	D
11.8	**156.0**	1.24	11.2	**175.5**	1.43	12.0	**161.3**	1.3	11.5	**186.5**	1,6
*2.7	37.78	0.46	3.13	72.1	0.33	2.6	42.8	0.5	3.51	81.2	0.5
Er spinae left BEGIN			*Er spinae left* END			*Er spinae right* RIGHT			*Er spinae right* END		
F	S	D	F	S	D	F	S	D	F	S	D
15.0	**265.0**	2.0	15.0	**272.2**	1.9	14.9	**242.6**	2.0	15.4	**259.7**	2.1
*2.3	57.85	0.37	2.9	58.50	0.33	2.52	49.9	0.4	3.0	51.2	0.4

Note: * – SD

The correlation between the myotonometric measurement values (F, S, D) of garment workers at the beginning and at the end of the workweek were calculated (R^2 = 0.92–0.97) and the p-value (Anova) was between 0.01 and 0.03.

The stiffness of muscles is higher (except of M *add poll left*) at the end of the workweek. The stiffness of different muscles is marked in bold in Table 1. Muscle tiredness increases during the workweek; the left hand is less loaded than the right hand, therefore the stiffness values are more constant.

Discussion

The results of the present study of garment workers correspond to the previous data regarding back pain (59.1%). The frequency of pain occurrence in the neck area (71.4% of all GW), in the shoulders (67.3% of all GW), the wrist/hand region (53.1% of all GW) is higher when compared to the study of Reinhold et al. [9]. In the study of Friedrich et al. [3], the proportion of garment industry workers suffering from neck, upper back and lower back pain was much higher: 52.4%, 54.8% and 72.8% respectively of all the workers studied, which is in better conformity with the results of the present study. Comparing the results of the myotonometry (stiffness) acquired in the current study with the data on office workers and sportsmen of other researchers [6, 8], it could be concluded, that the values are comparable (stiffness *M erector spinae* right Pille (present study) = 242.6–259.7 N m^{-1}; Oha et al. [6] = 325.1–332.1 N m^{-1}; left Pille (present study) = 265.0–272.2 N m^{-1}, Oha et al. [6] = 330.6–320.5 N m^{-1}; stiffness of lower limbs acquired by Pruyn et al. [8]: = 293.8–393.2 N m^{-1}.

Conclusion

There are persistent muscle tone changes in garment workers' muscles. Increased decrement results indicate a slight muscle overload rather than a persistent condition. The stiffness of the investigated muscles increased and the frequency decreased during the workday as a rule; the decrement changes depend on the side of the body. The patented myotonometrical technology [5] – non-invasive, quick and easy measurement of superficial skeletal muscles – can be used in occupational health for diagnostics of work-related musculoskeletal disorders.

References

[1] *Annual Report of Work Environment 2014* [online]. 2015. Labour Inspectorate [cited 29 March 2016]. Available from Internet: http://www.ti.ee/fileadmin/user_upload/failid/dokumendid/Meedia_ja_statistika/Toeoekeskkonna_uelevaated/2014/TKY_2014_ik.pdf

[2] Hoy, D. G., *et al.* 2015. Reflecting on the global burden of musculoskeletal conditions: lessons learnt from the Global Burden of Disease 2010 Study and the next steps forward, *Annals of the Rheumatic Diseases Journal* 74(1): 4–7. http://dx.doi.org/10.1136/annrheumdis-2014-205393

[3] Friedrich, M.; Cermak, T.; Heller, I. 2000. Spinal troubles in sewage workers: epidemiological data and work disability due to low back pain, *International Archives of Environmental Health* 73(4): 245–254. http://dx.doi.org/10.1007/s004200050424

[4] Pille, V., *et al.* 2015. Work-related musculoskeletal symptoms in industrial workers and the effect of balneotherapy, *Agronomy Research* 13(3): 820–828.

[5] Vain, A. 2002. *Myotonometry*. Tartu.

[6] Oha, K.; Viljasoo, V.; Merisalu, E. 2010. Prevalence of musculoskeletal disorders, assessment of parameters of muscle tone and health status among office workers, *Agronomy Research* 8(special issue): 192–200.

[7] Roja, Z., *et al.* 2006. Assessment of skeletal fatigue of skeletal fatigue of road maintenance workers based on heart rate monitoring and myotonometry, *Journal of Occupational Medicine and Toxicology* July: 1–9. http://dx.doi.org/10.1186/1745-6673-1-20

[8] Pruyn, E. C.; Watsford, M. L.; Murphy, A. J. 2015. Validity and reliability of three methods of stiffness assessment, *Journal of Sports and Health Science* 1–8. http://dx.doi.org/10.1016/j.jshs.2015.12.001
[9] Reinhold, K., *et al.* 2008. Innovations at workplace: improvement of ergonomics, *Engineering Economics* 60(1): 85–94.