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Change of the precision of hand movements in young men after short-term (anaerobic) exercise

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Summary:

Background: Physical exercise causes disturbances of body homoeostasis resulting in fatigue. This affect the quality of motor activity, including precision of hand movement. The objective of the work was to evaluate the effect of a short-term (anaerobic) physical exercise on hand movement in men in static and dynamic conditions.

Materials &methods: The study group comprised of 52 young men aged 20.44±7.87 years old. Heartbeat frequency, systolic and diastolic blood pressure were measured. Precision of hand movement was studied with the use of the MLS module from the Vienna Test System. Tests of precise hand movements were conduced in static and dynamic conditions. A number of errors committed was analysed. Tests were performed with a dominant hand, twice: before and after an anaerobic exercise. The exercise test was to perform a maximum number of arm flexes in frontal support (press-ups), until denied.

Results: Comparison of test results before and after the exercise indicated a statistically significant increase of hand tremor in statics and no changes in dynamics after the exercise. This occurrence was manifested by a number of errors made. Using multiple regression, it was shown that hand tremor in statics is related to body built. Higher values of height and body mass correlated with a greater number of errors. A statistically significant impact of resting heartbeat frequency on a number of errors in statics was also observed. In dynamic conditions, a relationship between hand tremor and a volume of work performed and the resultant heartbeat frequency was detected. The increase in number of flexes by one causes the increase in number of errors by two.

Conclusion: Physical exercise significantly affects hand precision in statics in the students studied. Impact of physical exercise on a greater number of errors committed in a dynamic test was not observed.

Keywords: tremor, hand motor, movement precission, Vienna System Tests, anaerobic effort

Introduction

Physical exercise causes disturbances of body homoeostasis resulting in fatigue, which impacts performance abilities and quality of motor activity (Gremion & Kuntzer 2014). Decreased precision and accuracy of movements, among others, occur in this state (Abd-Elfattah 2015). This phenomenon is particularly prominent in case of hand motor activity.

Motor abilities of the hand have key significance for effective learning and carrying out of motor tasks, not only in sports but also in the process of physical education, sports training and everyday functioning. A human hand is a structure of a complex built. Multiplicity of bones and joints, as well as generously innervated muscles facilitate a wide range of manual capabilities. However, in the conditions of stress, agitation or fatigue, an increase of hand muscle tremor occurs which can measurably lower the quality of performed manual tasks which require a greater precision. Muscles in a resting state are continuously stimulated with impulses of 7-11 Hz intensity (Lakie 1994a), which, among other things, is to maintain a specific body posture. However, under the influence of different stressors (e.g. fatigue after a physical exercise), impulsation becomes altered which results in an increase of muscle tremor and a decrease of movement precision. It is especially prominent in case of hand (Lakie 1994b).

Fatigue is defined as incapability of continuing exertion under a specified load (Edwards 1983). This condition is induced by a range of processes, type of which depends on the type of physical exertion. Fatigue concerns both peripheral tissues (muscles) as well as central tissues (nervous system). In short-term anaerobic exertions, duration of which is up to several dozen seconds, the main energy substrates in the initial seconds are phosphagens (ATP, phosphocreatine). Whereas when the exertion starts to take longer, the main source of energy become anaerobic glycolysis, i.e. the energy sourced from glucose (Zatoń & Jastrzębska 2010). Reasons behind fatigue in this type of exertions lie in the depletion of energy substrates and an insufficient rate of their re-synthesis. The accumulation of metabolites such as hydrogen ions, inorganic phosphate or ammonia creates unfavourable environment for a further muscle work. A temporary disorder of muscle contraction capability occurs under such conditions. On the central level, we observe a disorder of sensory-conductive processes. Coordination of the activity of different muscles is, therefore, worsened, and the amplitude of tremor increases (Górski 2015). As a result of these occurrences, there can be an impaired movement precision which is particularly noticeable in hand motions.

The purpose of the study was to determine the effect of a short-term anaerobic strain on hand tremor in static and dynamic conditions, and the precision of hand movement in young men. Another purpose was to determine which of the analysed morphological parameters, hemodynamic qualities and load parameters in exertion affect tremor in static and dynamic conditions most.

Material and methods

The study group comprised of 1st year students of physical education - sport course at the University of Physical Education in Wrocław. Students studied were selected randomly. The sampling frame was a list of students enrolled in the course. Selection pattern was based on a simple random sample (simple sample without replacement). A confidence interval of 95% and a maximum error of 5% were assumed. Not knowing the distribution of the characteristic in the population, fraction size was set at 0.5. 52 students took part in the study (out of 75 of all participating in classes). Response rate was 83%. The sample responded in a very high level and enables correct analysis. The men studied were aged 20.44 years old. It was a homogeneous group. Studies were conducted in the Laboratory of Bio-kinetic Experiments of the Bio-structure Institute at the University of Physical Education in Wrocław in the late morning hours.

<u>Study Methods</u>

The group studied was subjected to basic measurements of somatic characteristics (body height and mass). A Swiss Anthropometric device and a calibrated electronic scale were used. A body mass index was calculated - BMI.

Hemodynamic parameters were measured: heartbeat frequency and systolic and diastolic blood pressure. Precision of hand movement was studied with the use of the MLS module from the Vienna Test System. A static test was conducted: 30 seconds of holding a peg in a hole - third in terms of size. And a test in dynamic conditions: line tracing (fig. 1). A number of errors committed was analysed. Tests were made with a dominant hand. All subjects declared being right-handed. Tests were performed twice: before and after an anaerobic exercise. The physical exercise test was to flex arms in frontal support (press-ups). A person studied had to perform a maximum number of repetitions until performance of a full flex was too difficult and thus denied. A number of repetitions was counted and the time of performing the test.

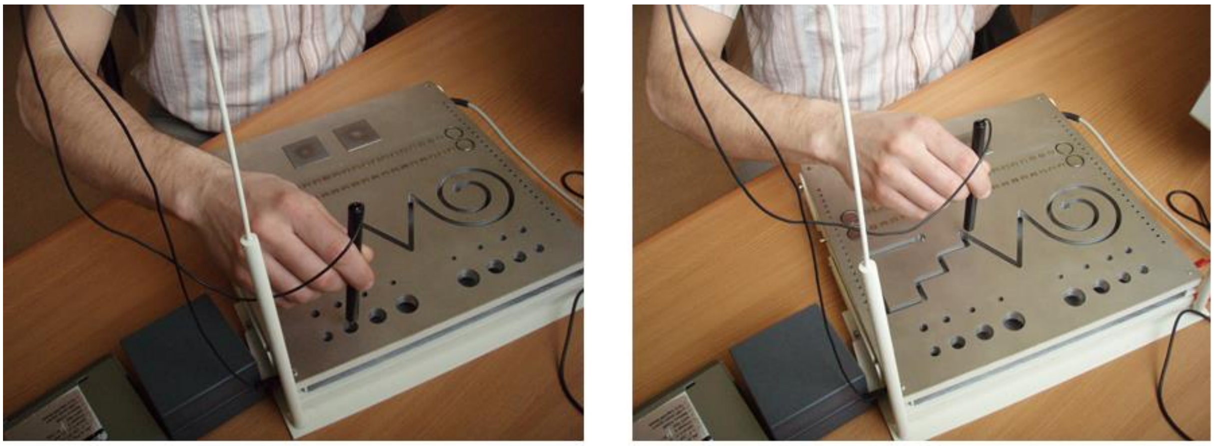

Fig. 1 Tests made with the use of the MLS module from the Vienna Test System. From left: static test - holding a peg, and dynamic test - line tracing

Methods of compiling materials

An assessment of normality of distribution of studied characteristics was conducted with the use of Shapiro-Wilk test. After identifying no reasons for rejecting the hypothesis of normal distributions, basic descriptive statistics were calculated: a difference between measurement results before and after physical activity was calculated, and a statistical significance of differences was evaluated with a t-Student test for dependent groups.

A multiple regression was conducted in order to determine the effects of individual body built parameters, hemodynamic characteristics and parameters of physical strain on the precision of hand movement in statics and dynamics (while resting and after the exercise). The analysis was based predominantly on the interpretation of standardised coefficients β , which enable determination of the hierarchy of impact of individual independent variables on a dependent variable. The analysis assumed the significance level of α=0.05. The calculated p<0.05 was deemed statistically significant and presented in tables in bold.

Results

Table 1 presents the static characteristic of body built parameters, strain load, hemodynamic characteristics and results of static and dynamic tests.

Tab. 1. Static characteristic of measured parameters

parameter	Test before exertion		Test after exertion	
	mean	sd	mean	sd
body height [cm]	180.75	7.87	×	×
body mass [kg]	77.23	6.33	×	×
BMI	23.65	1.33	×	×
Bends in support [number]	45.88	15.13	×	×
Time of bends in support [s]	39.42	14.84	×	×
Heartbeat frequency [number]	73.21	12.31	105.17	16.39
Systolic blood pressure [number]	140.71	12.59	154.92	18.82
Diastolic blood pressure [number]	83.75	7.18	83.79	9.27
Holding a peg - errors [number]	4.12	2.31	19.48	11.28
Line tracing - errors [number]	27.27	9.06	29.10	8.10

The applied anaerobic physical effort proved effective and lead to fatigue of those studied, which is confirmed in the statistically significant increase of heartbeat frequency and systolic blood pressure after the strain (tab. 2). A negligible alteration of diastolic blood pressure was observed. Comparison of the results of coordination tests indicates a statistically significant increase of hand tremor in statics which manifests itself in a greater number of errors, but no effect of exertion on tests in dynamics (tab. 2).

Table 2. Diversification of results after 2 tests (result before the exertion - result after exertion)

Variable	Difference	t	p
Heartbeat frequency [number]	**-31,96**	**-17,72**	**0,00**
Systolic blood pressure [number]	**-14,21**	**-7,08**	**0,00**
Diastolic blood pressure [number]	-0,04	-0,04	0,97
Holding a peg - errors [number]	**-15,95**	**-10,70**	**0,00**
Line tracing - errors [number]	-1,00	-0,85	0,40

In an attempt to determine the hierarchy of independent variables in terms of effect on a dependent variable - the intensity of hand tremor expressed in number of errors - the results of multiple regression were analysed. Taking into consideration hand tremor in resting (before exertion), the variables accepted for the analysis create a model which statistically significantly explains only tremor in statics (tab. 3). This model is, however, moderately adjusted explaining only 33% of variability of the number of errors made in the test of holding a peg in the hole.

Situation is completely different in case of the results of static and dynamic tremor conditioning after the exertion. Both models were statistically significant. These models, in addition to morphological and hemodynamic variables, also include parameters of strain load (number and duration of press-ups). All models were very well adjusted, and the percentages of explained variation of errors made in both static and dynamic tests were respectively 82% and 91% (tab. 3).

Table 3. Determination coefficients of the models built form both before-strain and after-strain tests.

Statistics	Before physical effort		After physical effort	
	Holding a peg	Line tracing	Holding a peg	Line tracing
Adjusted R^2	**0,330**	0,304	**0,824**	**0,908**
F	**2,892**	2,677	**12,083**	**24,574**
p	**0,039**	0,051	**0,000**	**0,000**

Number of errors in the static test in resting position is conditioned predominantly by body built. Both somatic characteristics have an effect in a similar degree (tab. 4). Higher values of body height and mass are accompanied by an increase in number of errors. The weight-height ratio has a slightly lesser effect on test results. A statistically significant effect of the resting heartbeat frequency on the number of errors in the test of holding a peg in the hole was also observed. It could be related to the effect of emotional agitation. Those more agitated (stressed or excited by the test), shook heavier and thus made more errors by touching walls of the opening.

Table 4. Values of standardised coefficients β and regression coefficients (b_0) and levels of their statistical significance for explanatory variables of tremor in statics and dynamics before exertion.

Group	Stat.	Variable					
		Body height	Body mass	BMI	Heartbeat frequency	Systolic blood pressure	Diastolic blood pressure
Holding a peg	β	**18,392**	**17,098**	**11,911**	**0,549**	0,236	-0,110
	b_0	**7,380**	**8,530**	**28,210**	**0,160**	0,080	-0,050
	p	**0,047**	**0,043**	**0,043**	**0,047**	0,317	0,647
Line tracing	β	3,163	3,398	1,897	0,281	0,391	0,203
	b_0	3,391	4,528	11,998	0,224	0,360	0,226
	p	0,723	0,676	0,737	0,298	0,111	0,410

Analysing the hierarchy of impact of individual independent variables on both tests, it can be stated that there are significant differences indicating different relationships between structure zone and function zone of the body showing the control of nervous system on the tremor level. Physical exertion modifies dexterity and control of the nervous system of hand tremor in different ways in statics and dynamics.

In case of hand tremor in statics, it is the morphological parameters which have a statistically significant impact on number of errors (increased tremor). The increasing body dimensions are accompanied by an increase of number of errors made (increased hand tremor) (tab. 5). This observation is consistent with the one made before for tremor in statics before exertion.

In case of hand tremor in dynamics, of greater significance was the parameters of physical strain load (i.e. number of flexes and duration of arm flexes in press-ups) and the consequent heartbeat frequency. As expected, the greater work performed (higher number of flexes) and the longer the duration of exertion test, and thus the higher heartbeat frequency, the higher the tremor. The increase in number of flexes by one causes the increase in number of errors by two (tab. 5).

Table 5. Values of standardised coefficients β and regression coefficients (b_0) and levels of their statistical significance for explanatory variables of hand tremor in statics and dynamics after exertion.

Group	Stat.	Variable							
		Body height	Body mass	BMI	Heartbeat frequency	Systolic blood pressure	Diastolic blood pressure	Bends in support [number]	Time of bends in support
Holding a peg - errors	β	**22,099**	**20,756**	**14,016**	0,032	-0,196	-0,189	0,656	0,047
	b_0	**26,110**	**28,660**	**93,100**	0,020	-0,130	-0,290	0,530	0,040
	p	**0,004**	**0,005**	**0,005**	0,806	0,176	0,334	0,097	0,875
Line tracing - errors	β	11,437	10,813	8,672	**0,431**	-0,055	-0,220	**2,105**	**1,616**
	b_0	16,300	18,010	69,480	**0,390**	-0,040	-0,410	**2,060**	**1,700**
	p	0,197	0,211	0,147	**0,033**	0,777	0,414	**0,001**	**0,002**

Discussion

Human hand is characterised by rich motor activity and mobility. Its complex structure is adjusted to performance of many movement tasks requiring the highest level of precision. However, as a result of homoeostasis disturbance through physical strain, stress or state of psycho-physical agitation there can be an increase of muscle tremor which can affect the precision of hand movement. Getting to know this issue constitutes a significant aspect of physical education, in the period of learning movement activities, in sport training or mastering skills, or sport competition and achieving satisfactory results. Also in daily functioning, or in older people where it is essential to maintain physical capability for as long as possible.

The undertaken subject is not widely dealt with in literature in a way that is presented here. In our experiment we studied the effect of increased muscle tremor caused by physical anaerobic exertion on the precision of hand movement in static and dynamic conditions. We used the MLS module from the Vienna Test System. Changes created as a result of physical exercise caused a significant increase of hand tremor which manifested itself in static conditions. Moreover, body height was also related to the number of errors made. Significant differences in number of errors made were not noted in the dynamic conditions in comparison to the pre-exercise state. However, an increase of workload and the resultant intensified heart work were related to the number of errors made. Our group comprised of healthy, young people.

The issue of muscle tremor is particularly explored in case of the elderly suffering different neurological afflictions, e.g. the Parkinson's disease (Christakos 2008). The elderly, as a result of involution process, face many unfavourable changes in the functioning of motor apparatus (Koster 2010). This to a large extent concerns manual capabilities (Carmeli 2003). However, as shown in the research of Sebastjan et al. (2008) on the group of elderly women, the hand motor capabilities remain on a good level in healthy elderly women. Research conducted by Skrzek et al. (2014), also among elderly women, shows that maintaining physical activity contributes to maintaining the right motor capability of the hand.

The issue of hand movement precision can also be referred to sport, where in shooting disciplines (e.g. biathlon, archery, sport shooting) muscle tremor can seriously impair achieving a good sport result. Gajewski (2006) showed that both physical and endurance exercise contribute to the increase of muscle tremor amplitude. However, a short-term physical exercise contributed to a great amplitude of tremor than the endurance exercise. In case of physical strength exercise there was also a faster recovery noted, than in the endurance exercise. Research conducted by Goonetilleke (2009) showed that the ability to maintain balance (serving as the indicator of maintaining muscles in a certain position with the lowest tremor/vibration amplitude) is essential in shooting sports. People with the lowest tremor amplitude had the highest effectiveness of shooting. Similar observations were noted by Pellegrini et al. (2004, 2005). People noting the lowest number of errors were characterised by the lowest level of muscle tremor. It is also consistent with our observations. The relation between heartbeat and the muscle tremor which the research has noted is reflected in using substances banned in sport by the World Anti-Doping Agency (WADA) - beta-blockers. The substances effectively slow down an accelerated heartbeat in conditions of physical strain allowing to achieve better results in tasks requiring precision (Kruse 1986).

The topic undertaken by ourselves has not been widely discussed in the literature. The available data is scarce and often differs in terms of methodology. The issue of hand movement precision should be particularly interesting for teachers working with children and youth in learning new manual activities, with athletes and trainers of disciplines requiring precision (e.g. shooting sports), or people working with the elderly who are loosing their capabilities as a result of involution. In our research we found an increase of muscle tremor under the influence of physical strain, which manifested itself in a larger number of errors made in static conditions. We have also noted a relation between body height and an increased number of errors made. This information can prove useful also in selection for certain sports disciplines where movement precision is essential. Interestingly, exertion has not significantly affected tests made in dynamic conditions. Further research should focus on mechanisms explaining this phenomenon.

Conclusions

1. Short-term anaerobic exertion affects the precision of hand movements. However, it causes increase of tremor only in statics. It does not affect hand tremor in motion. Tremor is controlled more in dynamic activities which can have significance and be used in physical education and in sport. This knowledge should be particularly interesting for trainers and representatives of sports requiring precision.
2. From both types of hand precision tests in static and dynamic conditions, in terms of resting state a greater impact of conditionings by the analysed variables was found to be hand tremor in statics. Morphological parameters had an effect on this type of tremor. The greater body dimensions, the greater resting tremor.

In the situation of introducing physical effort, both tremor in statics as well as in dynamics showed dependency on the analysed independent variables. At the same time, however, tremor in static conditions was affected by morphological parameters (and the dependence was the same as before the exercise). Whereas the tremor in dynamics was affected by the amount of work performed (determined both by the load - number of repetitions, as well duration of the effort) and the resultant heartbeat frequency.

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