Effect of prolonged Stretch Exercise of upper Extremity Muscles on both Arm and Hand of Cooperative Motion

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Summary

Stretching of muscles before and after sports and/or for rehabilitation increases some physical effects and the recovery from fatigue. Many of the movement of hands and fingers in occupational therapy are harmoniously practiced. It is not clear weather stretching of skeletal muscle is effective for organized fine motion of fingers and arms. This study was carried out to examine the hypothesis that cooperative movement of bilateral arms would improve by a stretching. The speed of cooperative movement was increased and tension of the forearm muscles were decreased by stretching of the skeletal muscle. An increase effect of movement within a period in cooperative motion was recognized by stretching. It is conceivable that the effect of physical movement by relaxation of muscles was stimulated the cooperative motion. On the other, the increased quantity of cooperative motion increases the number of errors and mistakes, and stretching did not increases the accuracy of work. We can expect the development of an intervention using stretching in occupation therapy employing fine motion of human hands and forearm movements.

Introduction

Continuous muscle stretching before and after sports and/ or rehabilitation increases the effect of exercise and recovery from it[1,2]. Purpose of stretching is 1) prevention of injuries of muscles, tendon and ligament[3], 2) increase of flexibility[4] 3) reduce of distress by relaxation of body and mind, 4) recovery from muscle fatigue[5,6], 5) improvement of muscle coordination[7,8], and 6) improvement of performance[9,10].

One of methods of stretching is to extend muscles without counteraction and a calm breathing and maintain the state for a certain period. Another one is a dynamic stretching by using counteraction[1]. According to the previous studies, a static stretching shows effects on reduction of the muscle tension evaluated by electromyogram[1,11], delay of time of reduction of contraction and increase of endurance[12,13], and recovery from fatigue[14].

The dynamic stretching is effective for instant increase of physical capability[1], and Shellock et al. reported that dynamic stretching is effective for warming up and static stretching is effective for cooling down[9]. There are many reports on effects of macro and rough exercise like a whole body movement but few studies are available on the effect of stretching of cooperative exercise like of finger and arm movement.

A fine motion training using fingers and arms are presented for functional disability patients of their upper extremity in occupational therapy. A cooperative movement of fingers and arms, feed

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Fig. 1. Resonance test in general aptitude test for profession to measure the amount of cooperative motion.
Cooperative motion was measured by tracing line on the tracing board using bilateral hand operation of pantograph and by the length of line and the errors produced within a fixed time. Pantograph was operated by both hands after the setting a pencil in the position and the tip of the pole was inserted in the round hole.

back from perception and visual system, and a fixed posture of parts of body like arms and trunk are interact to fine movement of hands and such fine movement have a relationship with higher brain function, concentrative and psychological status[18,19].

One of factors to stimulate the accuracy of work using bilateral hands under harmonious cooperation may be relaxation of skeletal muscle by stretching[10,15,16]. Increase accuracy of cooperative motion can be obtained by relaxation from the stretching, it may be conceivable to propose an intervention for disability of fine work using fingers and arms.

Here, we would like to propose a hypothesis, that performing statistic stretching prior to cooperative motion 1) gives a relaxation of skeletal muscles by continuously forced stretching of upper extremity muscles and by reduction of action potential during action and 2) forced and continued extension of upper extremity muscle stimulates the accuracy of cooperative motion by bilateral arms and hands.

Methods

The subjects consisted of 20 healthy adult volunteers (10 males and 10 females, separated to a group intervened by stretching and the control group without intervention). Experiments were carried out in the laboratories for general use, for analysis of the brain function and for mind and body functions in Niigata University of Health and welfare. Every subject was informed orally and in written form about the objects, content and reliability of this experiment, and one can freely quit being experiment at any time, one wishes. This study was approved by the ethics committee of Niigata University of Health and Welfare.

Effective arm was determined according to Edinburgh Handedness Inventory[17]. Physical function and surface electromyogram during cooperative action were measured by a general vocational aptitude test (response test, response pantogragh), electromyogram, using analog and digital signal converter (Power Lab/ sp. AD Instruments).

Stretching was performed for the subject sitting on a chair and the fingers and arms were moved by two therapists for 2 minutes consisted of 20 seconds of each motion, flexion and extension of finger and arm joints, spination and pronation of forearm, horizontal filexion and extension of shoulder joints of both side simultaneously. Horizontal flexion of shoulder joint was performed onside at a time. The subjects were calmly sited on the chair during resting as the control group.

For cooperative motion, response test of general vocational test was used. The response test included a line drawing on a tracing paper set on a tracing board by bilateral hands using pantograph and then judge the ability of cooperative motion from the time required and tracing errors. A pencil was fixed at the position

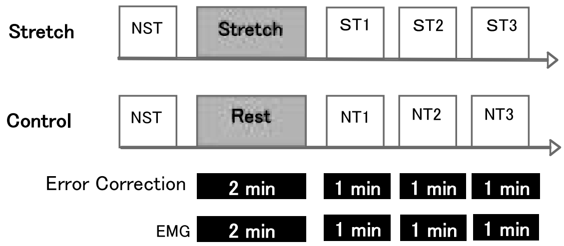

Fig. 2. Protocol.
Both group practiced line tracing with pantograph for 1 minutes and 20 seconds rest before stretching. The stretch group carried out 2 minutes passive prolonged stretching, while the control group takes a rest for 1 minute. Then, 20 seconds rest and 1 minute resonance called 1 task were repeated for 3 times. During the rest period and the control group the subject was sit on chair in calm. NST: non-stretch trial, ST: stretch trial, NT: non stretch trial.

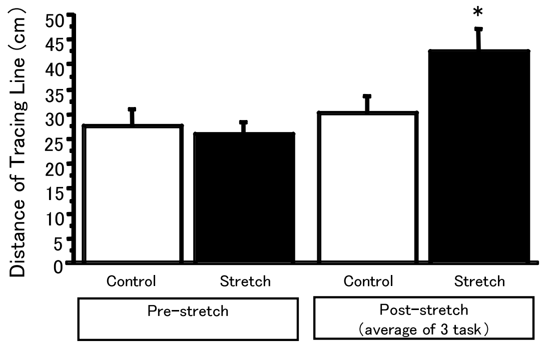

Fig. 3. Comparison of the distance of tracing line before and after stretching.
The tracing distance (amount of cooperative motion) were 25.7±8.3cm and 22.5±7.5cm prior to stretching for the stretch group and the control respectively, no difference was found (non paired t-test, t=0.940, p=0.370). The average length of tracing after 3 tasks were 41.7±15.9cm and 30.4±10.3cm for the stretching group and the control respectively, and significantly interaction was found between the groups. (2 way ANOVA, F[3.36]=4.276, p=0.011, n=20). In the stretching group significantly increased of cooperative motion after stretching relative to a prior stretching (post-hoc, Bonferroni, p<0.001).

and tip of the pole was inserted at the round hole on the board, and subject moved pencil to trace the line by moving handle (Fig.1).

Subjects were sit-on-chair position with 43 cm high and a table with 72 cm high was used. The order of tests were following: 1 minutes of response test before stretching, 20 seconds of rest, 2 minutes of passive continuous stretch of muscles for the stretching group and 1 minute rest for the control group, followed by 20 seconds of rest period and 1 minutes of response test. This was one task. Three tasks were repeated with 20 second intermission. Calm chair-sitting position was kept during the rest for experimental group and at all the period for the control group (Fig.2).

The cooperative motion (required for tracing of line) and errors by off from the line were measured. The average length of tracing distance was considered as a cooperative motion and total number of errors from three trials was presented.

Surface muscle electric potentials at the terminus on right arm were recorded by the probe placed on the surface of radius, signal amplification through electromyogram amplifier, detected by A/D transformation by Power Lab and finally to the personal computer.

Two way analysis of variance (ANOVA) and correlation analysis were performed by Stat View Vr.5.0 for windows for the statistic analysis. The Post-hoc test was used to test after ANOVA. Statistical setting was least at 5 %. Following Edinburgh Handedness Inventory, Laterality Quatient: LQ=[(+ number of right hand) − (+number of left hand] +[(+number of right hand) + (+number of left hand)] was calculated and LQ<0 and LQ>0 were designated as left handed and right handed[17].

Results

1. Comparison of line tracing (cooperative motion)

Line tracing rate (cooperative motion) did not show any difference between stretch group 25.7±

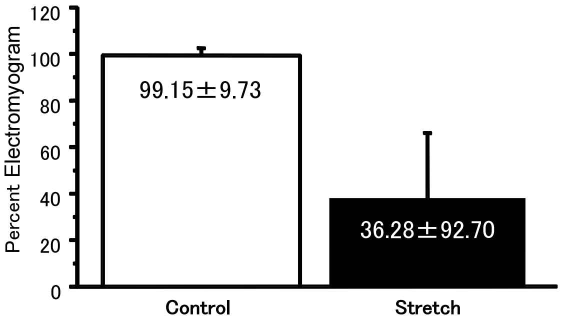

Fig. 4. Comparison of muscle potentials between stretch group and the control.
Muscle potential during cooperative motion were 36.28±92.70% and 99.15±9.73% for stretch group and the control respectively, and thus the control group had significantly higher value (non paired t-test, t=2.133, p=0.047, n=20).

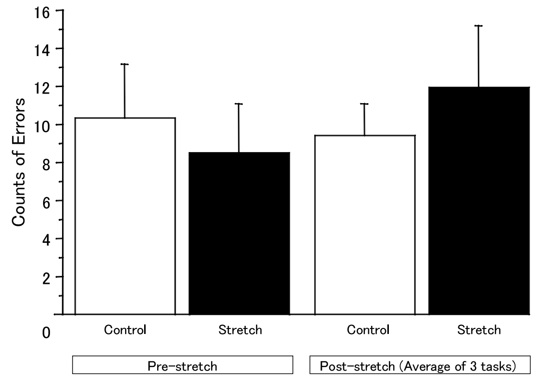

Fig. 5. Comparison of number of errors before and after stretching.
The number of errors were 8.5±8.2 and 9.4±8.2 for stretch group and the control respectively, and there was no difference. An average number of errors from 3 tasks were 11.7±10.1 and 9.3±5.6 for stretch group and the control respectively, and there was no difference (non paired t-test, t=0.663, p=0.515). An alteration was not detected between stretch group and the control (2 way ANOVA, F[3.36]=0.292, p=0.829, n=20).

8.3 cm/min., and the control group 22.5±7.5 cm/min. prior to skeletal muscle stretching (non paired t-test, t=0.940 p=0.370). Average 3 task tracing distance post stretching were 41.7± 15.9 cm, and 30.4 ±10.3 cm for the stretching group and the control, respectively, and thus there were significantly difference was found after ANOVA (F[3.36]=4.276, p=0.011, Fig.3). In stretching group, the cooperative motion significantly increased after stretching in comparison with the prior result (post-hoc, Bonferroni, p=0.001).

2. Comparison of discharge from muscle during cooperative motion.

Electric potential of muscles after stretching was calculated based on accumulative value of muscle potential during cooperative motion as 100%. Alternative action was not observed in muscle potential (n=20, F[3,36]=1.161, p=0.338). Muscle potential during cooperative motion was significantly higher in the control group 99.15± 9.73% than the stretch group 36.28±92.70% (non-paired t-test, t=2.133, p=0.047, Fig. 4).

3. Comparison of the number of errors during cooperative motion.

Number of errors before stretching were 8.5± 8.2 and 9.4±8.2 by the stretching and the control, respectively and thus there was no difference (non paired t-test, t=0.431, p=0.671). The 3-task average number of error were 11.7±10.1 and 9.3± 5.6 for stretch group and the control group, respectively and there was no difference (non paired t-test, t=0.663, p=0.515). An interaction of error numbers between stretch group and the control group was not found after ANOVA (F[3.36]=0.292, P=0.829, Fig.5).

The results of correlation analysis between tracing distance and number of errors showed a positive correlation among stretch group (r=0.772, p=0.008, Fig. 6). On the other, the control group showed a tendency of positive correlation between tracing distance and the number of errors (r=0.614, p=0.061).

Discussion

This study examined the hypothesis that upper

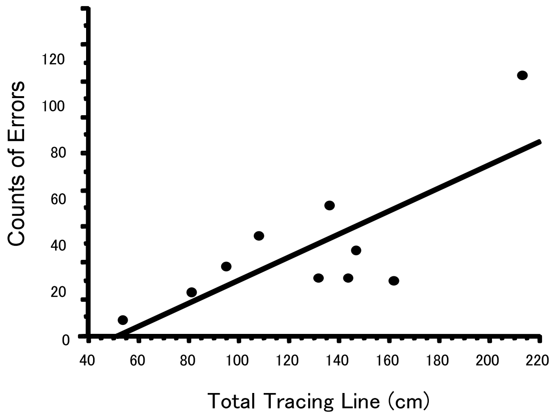

Fig. 6. Correlation between amount of cooperative motion and the number of errors in line tracing.
There were significantly positive correlation between total line tracing distance and total error of 3 tasks in stretch group (r=0.772, p=0.008, n= 10).

extremity stretching prior to cooperative motion gave a relaxation of skeletal muscle, reduction of muscle electric discharge and an increased amount of cooperative motion. This study showed both an increase of cooperative motion of upper extremity and a reduction of electric potential of muscle for a period of time. This supports the hypothesis that stretching reduces muscle tension and causes an effective increase of cooperative motion.

It has been reported that a static stretching is effective on muscles and endurance of muscle power in constant bending and stretching of elbow joint of arm[18-20]. Stretching prior to and following fatigue by contractive equidistance movement of knee joint shows a delay of onset of reduction of mid frequency by mid frequency analysis of rectus femoris, and it has been reported that stretching increase a durability of muscle against work load[21-22]. Electrophysiological experiments demonstrated the effect of muscle extension to the transmission ability between neuron and muscle[23]. An increase of active frequency of micro terminal potential by chronic muscle extension and a magnitude increase of micro terminal potential after repeated stimulation in acute muscle extension[24]. Namely, it is speculated that muscle extension has a stimulation effect of activity of neurotransmitter release from the termini of motor neurons. And static stretching prior to motion increases a cooperative motion towards muscle activity in a short period and thus shows an uplift of speed of cooperative motion[25,26].

Stretching of lower leg for case with contractive spasm induces lowering of muscle discharge[27]. Lipophilic cations, rhodamine 6G and tetraphenylphosphonium suppress the movement of ions in membrane, locally and dose dependent fashion in skeletal muscle cells and inhibit release of Ca^{2+} and contraction of muscle[27]. Stretching prior to exercise possibly acts physically to polarization of skeletal muscle cells, in conjunction with alteration of peripheral blood flow, and inhibits contraction. It is conceivable that static stretching prior to cooperative motion reduced an excess contraction relative to the work before stretching.

In this experiment, muscle potential was measured on right forearm radius and a reduction of muscle potential during the work was observed. Stretching continuously extends all part of upper extremity and can be considered to increase the amount of work within a period. However, holding of the pantograph to carry out the cooperative motion made us to measure the forearm muscle potential in right arm movements. Because the possibility that the action of competitive muscle may affect cooperative motion, more detailed analysis of these activity of stretching effect for cooperative motion is required.

A cooperative motion depends on the ability of precise motion and generally used to express a functional condition as a case of “skill of hand”. A cooperative motion is a combination of complex and collaborative motion, requires an accuracy of space and timing[28]. The amount of cooperative motion within a certain time presents a speed of accomplishment of complex, and cooperative movement and the number of errors can be considered as an expression of accuracy of movement. Quantity of cooperative motion after stretching was significantly increased, but the number of errors correlated with the amount of work. Stretching had increased the amount of work within a period but did not increase the accuracy of work. To reduce the error, not only relaxation of skeletal muscles but psychological stress like a concentration of mind and carefulness may be indispensable[29].

Jahnke et al. reported that statistic stretch which suppresses the extending reflex is not effective for improving of skeletal muscles but dynamic stretch which easily induces extension reflex is effective[30]. It has been suggested that practice of dynamic stretch prior to exercise and static stretching after exercise are effective for macro scale exercise[9]. In general, static stretching is applied before and after exercise in many cases. This study has not determined which are more effective for cooperative motion, dynamic or static stretching. Thus, comparison of stretching methods for better exercise is needed for future study.

Conclusion

This study examined the effectiveness of fine motion in cooperative motion after static stretching. Stretching of upper extremity muscles increased the speed of cooperative motion and reduced the discharge of muscle potential. Stretching of upper extremity effectively increase amount of fine works within a period. As amount of cooperative motion increases, the number of error also increased. Thus, a stretching of upper extremity does not increase an accuracy of fine works. In occupational therapy using cooperative motion, an intervention employing upper extremity stretching may be worth while to expect.

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