KOKUSHIKAN SOCIETY OF
SPORT SCIENCE
No.20, 47-54, 2020

Study

Muscle activity and hemodynamics during twisting action of the wrist

Akiharu SUDO*, Kenji YAMADA**, Hiroo YAMAKAWA*** and Masamichi ANDO***

Abstract

Diastolic blood pressure is typically considered to indicate arterial stiffness. Atherosclerosis develops as the functioning of vascular endothelial cells diminishes. When blood flows rapidly through those endothelial cells, they release a vasodilator called nitric oxide (NO). NO relaxes smooth muscle in the tunica media and it dilates blood vessels. In other words, blood vessels stiffen and lose their elasticity depending on the level of NO. Research over the past few years has suggested that performing an exercise with a grip strength of about 30% may decrease blood pressure. However, no studies thus far have examined the decrease in blood pressure as a result twisting an object. Moreover, the relationship between twisting motion and grip strength has yet to be determined. The current authors hypothesized that gripping and twisting action might have similar effects. Accordingly, the aims of the current study were to observe muscle activity and hemodynamics during repeated twisting action and to ascertain the relationship between grip strength and twisting action. Thus, left and right grip strength was measured in a standing position, and maximum twisting strength was measured in a seated position while twisting a twist bar in the opposite direction with the right and left hands. In addition, grip strength of the right hand was measured in a seated position, and maximum twisting strength was measured with a twist bar. Muscle activity of the brachioradialis and flexor carpi ulnaris was measured during that action, and the relationship between muscle activity and twisting action was examined. Results indicated that twisting action was correlated with grip strength. Grip strength was correlated with the level of muscle activity of the flexor carpi ulnaris and the brachioradialis during twisting action. The appropriate pace for twisting motion was not evident, so the pace of twisting was examined. Subjects performed 40, 50, or 60 twists for 1 min continuously, rested for 1 min, and then performed the twisting action for another min. Before and afterwards, blood flow volume around the flexor carpi ulnaris and the brachioradialis was measured, and blood pressure was also measured. Results indicated that blood flow volume tended to increase after twisting action at all 3 paces. Blood flow volume around the brachioradialis in particular was significantly greater at a pace of 60 twists per min. Moreover, blood flow volume in the vicinity of the flexor carpi ulnaris

* Graduate School of Sport System, Kokushikan University
** Lecturer Faculty of Physical Education, Kokushikan University
*** Murata Manufacturing Co.,Ltd. New Business Incubation Department Business Incubation Center

increased significantly at all 3 paces. Systolic blood pressure increased after twisting action at all 3 paces. In contrast, diastolic blood pressure tended to decrease at all 3 paces, and it was significantly lower particularly at a pace of 40 twists per min. Based on these findings, repeatedly performing continuous twisting action alternately activates the brachioradialis and the flexor carpi ulnaris. As a result, blood flow volume increases and the stretchability of the vascular wall increases, presumably causing diastolic blood pressure to decrease.

Key words; twisting action of the wrist, blood flow, blood pressure

Introduction

Research over the past few years has suggested that performing an isometric exercise with a grip strength of about 30% for 3 months continuously should increase blood flow and decrease blood pressure[2]. However, no studies thus far have examined the decrease in blood pressure as a result twisting an object. Diastolic blood pressure is typically considered to indicate arterial stiffness. Atherosclerosis develops as the functioning of vascular endothelial cells diminishes. When blood flows rapidly through those endothelial cells, they release a vasodilator called nitric oxide (NO). NO relaxes smooth muscle in the tunica media and it dilates blood vessels. In other words, blood vessels stiffen and lose their elasticity depending on the level of NO[1) 3)]. Thus, alternately activating muscles will result in better blood flow and presumably improve arterial stretchability. Accordingly, the first step would be to ascertain the relationship between twisting motion and grip strength and to determine whether gripping and twisting action have similar effects. The next step would be to observe muscle activity and hemodynamics during repeated twisting action and to ascertain the relationship between the two.

Methods

The current study examined the relationship between twisting motion and grip strength in Experiment 1, and it examined changes in blood pressure and blood flow volume during twisting motion at different paces in Experiment 2. During examination of the relationship between grip strength and twisting strength in Experiment 1, subjects were 17 typical adult males. During examination of the level of muscle activity during gripping and twisting motion, subjects were 25 typical adult males. In Experiment 2, subjects were 9 typical adult males. Subjects did not have a condition in the wrist in the previous 6 months. At the start of the experiments, the purpose of the study, its methodology, and safety concerns associated with the experiments were fully explained verbally, and then subjects consented to participation in these experiments. This study was conducted in accordance with the Helsinki Declaration, and this study was reviewed and approved by the ethics committee of the Faculty of Physical Education, Kokushikan University. Physical characteristics of the 17 subjects are shown in Table 1, physical characteristics of the 25 subjects are shown in Table 2, and physical characteristics of the 9 subjects are shown in Table 3.

Left and right grip strength of the 17 subjects was measured in a standing position, and the average of the left and right was used. Grip strength of the right hand of the 25 subjects was measured in a seated position, and that measurement was used. Twisting strength was measured using the Picolium® (Murata Manufacturing) [4]. The Picolium is a special film that can assess twisting force and that is wrapped around a bar. This apparatus allows measurement of twisting strength when a subject twists in the opposite direction with his right and left hands. Twisting strength with maximum effort was measured in a seated position, and that force was calculated with a PC. The maximum value was used.

Electromyography was used to examine the relationship between seated grip strength and twisting strength. Surface electromyography was performed using wireless probes (BTS FREEEMG1000, BTS Bioengineering). The recorded muscles were 2 muscles in the forearm, the brachioradialis and the flexor carpi ulnaris. Probes were attached to the belly of each muscle. EMG signals were detected with a bipolar electrode arrangement, and electrodes were attached parallel to the direction of each muscle. EMG signals were digitized using a sampling frequency of 1 kHz, imported to a PC for analysis, and analyzed using electromyography analytical software (EMGanalyser). Signals were filtered with a band-pass filter of 20-500 Hz. Raw waveforms were full-wave rectified, and the integrated electromyogram (iEMG) was determined. An attempt at seated grip strength and twisting action at full strength was measured for 3 s. iEMGs for 1 s

Table 1. Physical characteristics of subjects (n=17).

n	Age (yrs)	Body height (cm)	Body weight (kg)	BMI (kg/m^2)
17	21.3±0.9	170.1±5.0	68.8±9.0	23.7±2.8

Values are mean ± S.D..
BMI: Body mass index.

Table 2. Physical characteristics of subjects (n=25).

n	Age (yrs)	Body height (cm)	Body weight (kg)	BMI (kg/m^2)
25	19.4±1.2	171.3±4.9	68.7±7.9	23.4±2.5

Values are mean ± S.D..
BMI: Body mass index.

Table 3. Physical characteristics of subjects (n=9).

n	Age (yrs)	Body height (cm)	Body weight (kg)	BMI (kg/m^2)
9	21.6±0.7	170.9±4.6	69.3±10.3	23.7±3.6

Values are mean ± S.D..
BMI: Body mass index.

(excluding 1 s before and 1 s after) were analyzed.

Blood pressure was measured in the subject's right hand using an automated sphygmomanometer (Omron). Blood flow was measured using a laser blood flow meter with a fiber optic probe (Omegaflow, Omegawave). Marks were made in the vicinity of the belly of the brachioradialis and the flexor carpi ulnaris, and efforts were made to use the same measurement position. Blood pressure and blood flow were measured twice, once at rest and once after twisting motion.

Twisting motion was calculated as 30% of maximum effort using the Picolium, and the exercise was performed while the subject watched a PC monitor. A metronome was used to examine twisting motion at 3 different paces : 40, 50, or 60 twists in 1 min. After exercise at a given pace for 1 min, the subject rested for 1 min and then performed twisting motion for another min. The pace was randomly determined depending on the subject, with an interval of 1 week between attempts.

Each measurement is expressed as the mean±standard deviation. Statistical processing was performed with the statistical analytical software Excel Statistics 2010. The relationship between grip strength and twisting strength was determined using Pearson›s product moment correlation analysis, and the closeness of a correlation was determined using a test of no correlation. Changes in blood pressure and blood flow before and after twisting motion were determined using a paired t-test. The level of significance was 0.05.

Results

Standing grip strength was 47.3±5.0 kg and twisting strength was 289.9±29.9. A significant correlation between the two was noted (r=0.7400, p<0.001) (Fig.1). Seated grip strength was 43.5±

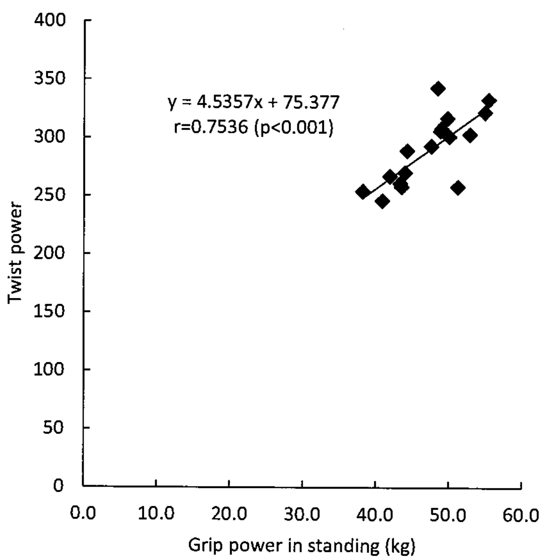

Fig. 1. Relationship between twisting strength and grip strength while standing (n=17).

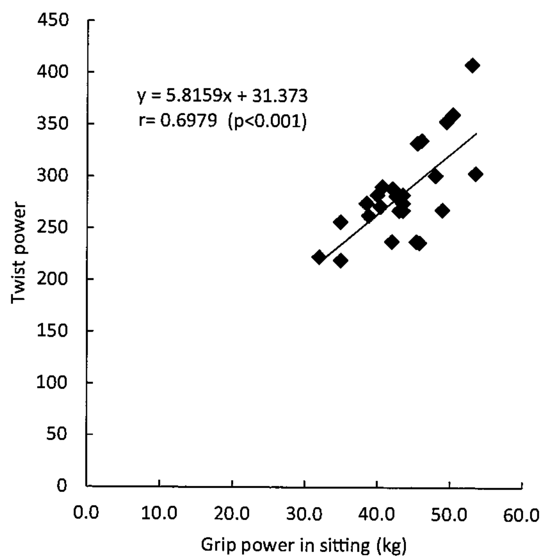

Fig. 2. Relationship between twisting strength and grip strength while sitting (n=25).

5.4 kg and twisting strength was 284.2±45.1. A significant correlation between the two was noted ($r=0.6979$, $p<0.001$) (Fig.2). The level of muscle activity of the brachioradialis was 0.280±0.127 mV during gripping and 0.424±0.160 mV during twisting action. A significant correlation between the two was noted ($r=0.4189$, $p<0.05$) (Fig.3). The level of muscle activity of the flexor carpi ulnaris was 0.264±0.168 mV during gripping and 0.337±0.129 mV during twisting action. A significant correlation between the two was noted ($r=0.54542$, $p<0.01$) (Fig.4).

Changes in blood flow volume were examined before and after twisting motion with 30% effort. Blood flow volume around the brachioradialis remained the same at 2.2 mL/min/100 g (units omitted hereafter) at a pace of 40 twists/min. At a pace of 50 twists/min, blood flow volume increased 23.5% from 1.7 to 2.1. At a pace of 60 twists/min, blood flow volume increased significantly (40.0%) from 1.5 to 2.1 (Fig.5). Blood flow volume around the flexor carpi ulnaris increased significantly (35.0%) from 2.0 to 2.7 at a pace of 40 twists/min. At a pace of 50 twists/min, blood flow volume increased significantly (36.4%) from 2.2 to 3.0. At a pace of 60 twists/min, blood flow volume increased significantly (56.3%) from 1.6 to 2.5 (Fig.6).

Changes in blood pressure were examined before and after twisting motion with 30% effort. Systolic blood pressure increased 2.0% from 125.9 mmHg (units omitted hereafter) to 128.3 at a pace of 40 twists/min. At a pace of 50 twists/min, systolic blood pressure increased 3.6% from 123.9 to 128.3. At a pace of 60 twists/min, systolic blood pressure increased 3.0% from 118.1 to 121.7 (Fig.7). In contrast, diastolic blood pressure decreased significantly (4.0%) from 72.9 to 70.0 at a pace of 40 twists/min ($p<0.05$). At a pace of 50 twists/min, diastolic blood pressure decreased 0.1% from 70.4 to 70.1. At a pace of 60 twists/min, diastolic blood pressure decreased 1.5% from 69.6 to 68.6 (Fig. 8).

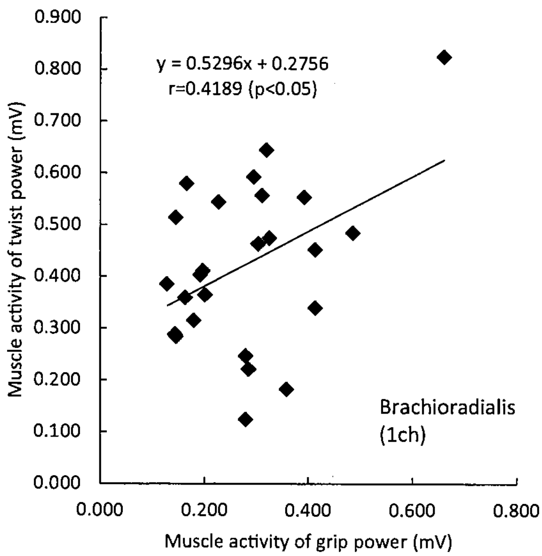

Fig. 3. Relationship between the muscle activity of the brachioradialis while twisting and while gripping.

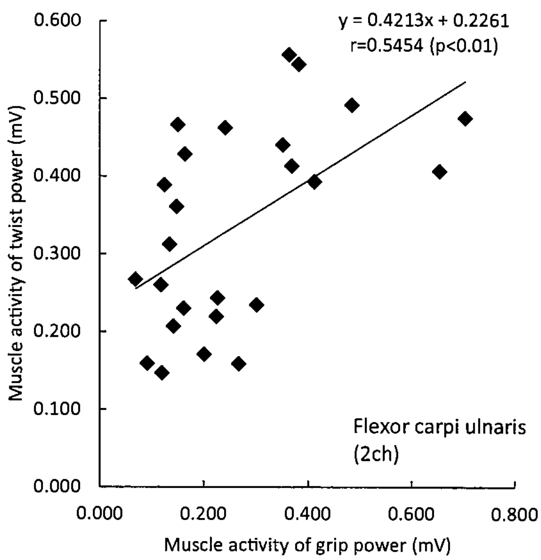

Fig. 4. Relationship between the muscle activity of the flexor carpi ulnaris while twisting and while gripping.

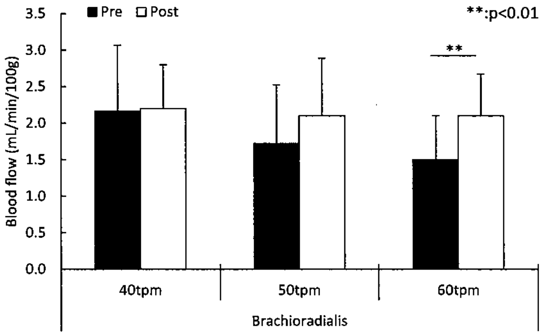

Fig. 5. Comparison of systolic blood pressure and diastolic blood pressure in the brachioradialis pre- and post-exercise.
tpm : twists per minute.

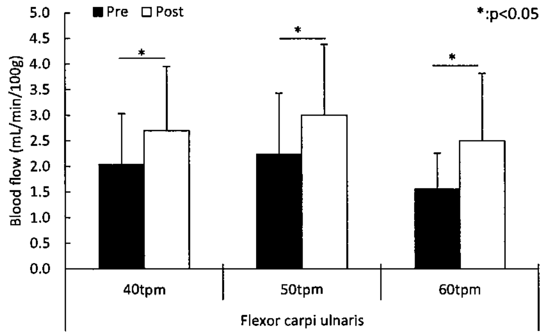

Fig. 6. Comparison of systolic blood pressure and diastolic blood pressure in the flexor carpi ulnaris pre- and post-exercise.
tpm : twists per minute.

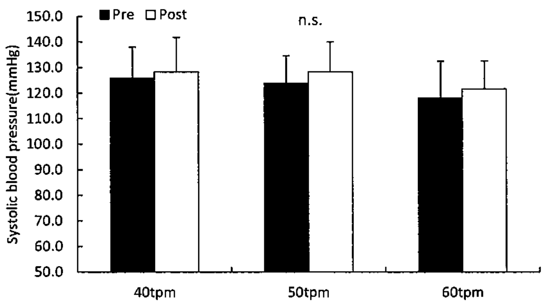

Fig. 7. Comparison of systolic blood pressure pre- and post-exercise.
tpm : twists per minute.

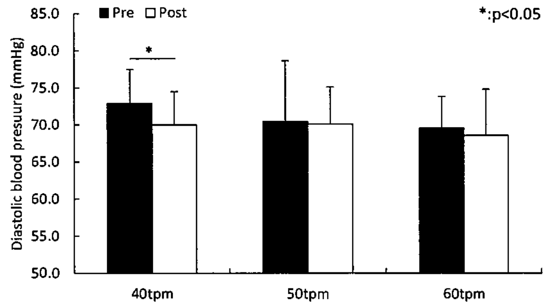

Fig. 8. Comparison of diastolic blood pressure pre- and post-exercise.
tpm : twists per minute.

[Discussion]

Standing grip strength and twisting strength were closely correlated, and seated grip strength was also correlated with twisting strength. This indicates that twisting action is an exercise involving the forearm. Moreover, the level of muscle activity during gripping was correlated with that during twisting action at 2 locations, the brachioradialis and the flexor carpi ulnaris. This suggested that gripping and twisting action can activate similar muscles in the forearm.

Twisting motion with a load performed at 30% effort was based on a previous study. In the current study, that twisting motion was performed for a total of 2 min, with a rest period after each min. Blood flow volume increased at all 3 paces. Blood flow volume around the brachioradialis increased significantly at a pace of 60 twists/min compared to that at the other 2 paces. In addition, blood flow volume in the vicinity of the flexor carpi ulnaris increased significantly at all of the paces. In this study, a pace of 60 twists/min may have simultaneously caused an increase in blood flow in the vicinity of the brachioradialis and the flexor carpi ulnaris. Systolic blood pressure tended to increase at all of the paces. In contrast, tended to decrease at all of the paces. Moreover, diastolic blood pressure decreased significantly at a pace of 40 twists/min. Diastolic blood pressure presumably decreased because peripheral vascular resistance decreased. A study has reported that diastolic blood pressure is affected by peripheral vascular resistance. Blood flow volume increased as a result of twisting motion, and the circulation presumably attempted to increase blood flow volume in the periphery of the body. An immediate effect, diastolic blood pressure decreased. This suggests that a continuous twisting exercise may be an exercise that leads to a decrease in blood pressure. Blood pressure decreased significantly at a pace of 40 twists/min, so that pace might be effective at reducing blood pressure. Results revealed that blood flow volume was satisfactory at a pace of 60 twists/min and that blood pressure was satisfactory at a pace of 40 twists/min, but subjects were healthy college students, so the effectiveness of training involving continuous twisting action for individuals with hypertension needs to be studied further.

Conclusion

Diastolic blood pressure is typically considered to indicate arterial stiffness. Atherosclerosis develops was the functioning of vascular endothelial cells diminishes. When blood flows rapidly through those endothelial cells, they release a vasodilator called NO. NO relaxes smooth muscle in the tunica media and it dilates blood vessels. In other words, blood vessels stiffen and lose their elasticity depending on the level of NO. Research over the past few years has suggested that performing an exercise with a grip strength of about 30% may decrease blood pressure[5]. However, no studies thus far have examined the decrease in blood pressure as a result twisting an object. Moreover, the relationship between twisting motion and grip strength has yet to be determined. The current authors hypothesized that gripping and twisting action might have similar effects. Accordingly, the aims of the current study were to observe muscle activity and hemodynamics during repeated twisting action and to ascertain the relationship between grip strength and twisting action. Thus, left and right grip strength was measured in a standing position, and maximum twisting strength was measured in a seated position while twisting a twist bar in the opposite direction with the right and left hands. In addition, grip strength of the right hand was measured in a seated position, and maximum twisting strength was measured with a twist bar. Muscle activity of the brachioradialis and flexor carpi ulnaris was measured during that action, and the relationship between muscle activity and twisting action was examined. Results indicated that twisting action was correlated with grip strength. Grip strength was correlated with the level of muscle activity of the flexor carpi ulnaris and the brachioradialis during twisting action. The appropriate pace for twisting motion was not evident, so the pace of twisting was examined. Subjects performed 40, 50, or 60 twists for 1 min continuously, rested for 1 min, and then performed the twisting action for another min. Before and afterwards, blood flow volume around the flexor carpi ulnaris and the brachioradialis was measured, and blood pressure was also measured. Results indicated that blood flow volume tended to increase after twisting action at all 3 paces. Blood flow volume around the brachioradialis in particular was significantly greater at a pace of 60 twists per min. Moreover, blood flow volume in the vicinity of the flexor carpi ulnaris increased significantly at all 3 paces. Systolic blood pressure increased after twisting action at all 3 paces. In contrast, diastolic blood pressure tended to decrease at all 3 paces, and it was significantly lower particularly at a pace of 40 twists per min. Based on these findings, repeatedly performing continuous twisting action alternately activates the brachioradialis and the flexor carpi ulnaris. As a result, blood flow volume increases and the stretchability of the vascular wall increases, presumably causing diastolic blood pressure to decrease.

References

1) Furchgott RF, Zawadzki JV : The obligatory role of endothelial cells in the relaxation of inertial smooth muscle by acetylcholine. Nature 288 : 373-376, 1980.
2) Inoue T, Matsuoka H, Higashi Y, Ueda, S, Sata M, Shimada KE, Ishibashi Y, Node K ; Vascular Failure Workshop Group : Flow-mediated vasodilation as a diagnostic modality for vascular failure. Hypertens Res 81 : 2105-2113, 2008.
3) Green DJ, Dawson EA, Groenewoud HM, Jones H, Thijssen DH : Is flow-mediated dilation nitric oxide mediated? A meta-analysis. Hypertension 63 : 376-382, 2014.
4) M. Ando, H. Kawamura, K. Kageyama, and Y. Tajitsu, Jpn. J. Appl. Phys.51 (2012) 09LD14.
5) Robent. D. Brook, MD. Chair etc. ; Beyond Medications and Diet : Alternative Approaches to Lowering Blood Pressure. AHA Sientific Statement.