Duration of Effect of the Approximation Technique on the Dynamic Control Structure

MOTOHARU ITOH, RPT1,2), SATOSHI MIYASHITA, PhD, RPT3), SHUJI GOTO, PhD4), DONALD P. LAUDA, PhD5)

2)Itoh Scientific Institution
3)Acupuncture & Integrative Medicine College, Berkeley
4)Educational Foundation Goto Gakuen
5)California State University, Long Beach

Abstract. [Purpose] The purpose of this study was to investigate the durability of the effect on the dynamic control structure after performance of the Approximation technique (ApT) administered to the lower extremity. Body sway was measured on a stabilometer under two conditions: one without a stimulus, and the other with a disturbance stimulus. [Subjects] The subjects were 38 healthy males, 19 to 27 years of age. [Methods] Participants in the experimental group stood on two scales, and we performed ApT from the iliac crests toward the long axes direction of lower extremities on each leg for one minute in turn and confirmed the approximation with a 10 kg load. Experimental group performed the stabilometer in an unstable environment and we measured the center of gravity sway after the intervention. The control group was measured without performing the maneuver. [Results] Significant differences in Area of Ellipse (AoE) and locus length per unit area (L/A) after ApT for lasted for 70 minutes. [Conclusion] We conclude ApT is a useful improved stability of center of gravity for 70 minutes.

Key words: PNF, Dynamic control, Approximation

INTRODUCTION

In order to resist gravity and to maintain a standing position, a cooperative function is led by suitable muscle contraction and a suitable balanced function1). The high central neurons to the lower motor neurons are intricately involved in the control of the standing position through each joint, with many deep sensory receptors scattered in articular capsules, muscles, ligaments, synovial membranes, etc., aligned in an anti-gravity direction. However, it is considered that the reaction of muscles is delayed in losing balance when in a standing position causing decreased susceptibility of the receptors of the muscle spindle and tendon spindle, and weakening the transmitter function to the central nervous system2). In coping with the situation, stability of the articular surface is maintained by approximation stimulus to each joint. This causes contraction in both muscle and tendon spindles, or adds stretch stimulation through which α motor neurons become excited through Ia afferent nervous fibers, and γ motor neurons excited through Ib nervous fibers. As a result, simultaneous contraction is induced. We maintain the standing position through bathyesthesia receptors of the skin and muscle on the plantar surface which perceive the slight sway of the body’s center of gravity by plantapedis contact on the ground. Most activities in our daily life tend to be dynamic, and if we can
elucidate the effect of body control under dynamic conditions, we can create any suggestions for improving balance function. Physical therapists use proprioceptive neuromuscular facilitation (PNF), in various clinical settings and sports. The approximation technique (ApT), a special technique, is used in many cases in order to improve the stability of the body. However, there are few studies which have investigated ApT compared with studies that have used the techniques of hold relax, slow reversal hold, and rhythmic stabilization. We reported in preliminary research that ApT led to immediate stability in a dynamic environment. Continuing that research, the purpose of this study was to review the duration of the effect given to the dynamic control structure by performing ApT to the lower extremity from the viewpoint of center of gravity sway body.

SUBJECTS AND METHODS

The subjects of the study were 38 healthy males from 19 to 27 years of age, with an average age of 20.6. Each participant was provided detailed information concerning the study and all provided their informed consent.

We used a Gravicorder GS-11 (Anima Co., Ltd.) in this study. This device detects the foot pressure on a force plate in the standing position and converts the foot pressure change and sway of center of gravity to electrical signal. The study of the sway of the body using the stabilometer conducted under two conditions: (1) one without a stimulus, and (2) the other with a disturbance to measure the sway induced. The ApT procedure was performed by having the subjects stand on a scale and periodically measured with compression loads of 10 kg each. This was applied from the pelvis to one of the lower limbs for one minute, alternating between the right and left leg. The group receiving out this procedure was named the “ApT group”. Measurements of the sway of the body were taken every 10 minutes for 90 minutes after the ApT procedure was performed. We later measured the same subjects for 90 minutes without performing the ApT procedure on same time schedule (control group). All the subjects were asked to rest quietly in the sitting position when not being measured. Silence was maintained during the experiment to eliminate any disturbance which could create instability. This was facilitated by setting air stabilizers (Nordisk Co., Ltd.) on the three corners of the stabilimeter, and having a Bella fitting mat (Lei Dell and Clutch Co., Ltd.) and the Gravicorder above each of them. In order to remove control by vision, we got the subjects to take the most symmetrical possible posture with their eyes closed, in a standing position posture on the force plate. Measurement items were the changes in the area (Area of Ellipse, AoE), the length of the Y-axis (Height of Ellipse, HoE) the maximum migration length in the direction of the X-axis (Width of Ellipse, WoE) and the total locus length (Sway Path Length, SPL) of the center of gravity locus. We calculated the locus length per unit area (L/A) and the locus length per unit time (L/T) from the items. We reviewed the durability of the effect on the dynamic control structure in changes between the ApT group and the control group. One-way ANOVA was used to compare the time-dependent changes of the data over 90 minutes and repeated ANOVA was used to compare the changes of the data between subjects with a significance level of p<0.05 using the Tukey Kramer test.

RESULTS

AoE before the performance of the ApT was 7.8 ± 1.6 cm². AoE after the performance was 3.4 ± 0.6 cm². Reduction of the area was significantly recognized in AoE for 70 minutes, as compared with the data before the performance of ApT (F(9, 370) = 301.2, p<0.05) (Table 1).

L/A before the performance of the ApT was 20.4 ± 33.8 cm⁻¹. L/A after the performance of ApT was 43.0 ± 32.0 cm⁻¹. Increase of the length was significantly recognized in L/A for 70 minutes, as compared with the data before the performance of ApT (F(9, 370) = 343.2, p<0.05) (Table 1).

HoE before the performance of the ApT group was 1.6 ± 1.6 cm, and was 0.3 ± 0.7 cm immediately after the performance of ApT. The maximum displacement width of the center of gravity in the back and forth direction showed a shortening tendency, and a significant difference was recognized immediately after performance of ApT group (F(9, 370) = 4.3, p<0.05) (Table 1).

AoE was significantly reduced for 70 minutes, as compared with the data before the performance of ApT (F(9, 370) = 301.2, p<0.05) (Table 1).

L/A before the performance of the ApT was
Table 1. Compared changes of durable stability between pre-technique and post-technique

<table>
<thead>
<tr>
<th></th>
<th>Pre-ApT 0 (min.)</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th>70</th>
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<tbody>
<tr>
<td><strong>AoE (cm²)</strong></td>
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<tr>
<td>Exp.</td>
<td>7.8 ± 1.6</td>
<td>3.4 ± 0.6*</td>
<td>1.6 ± 0.7*</td>
<td>1.5 ± 0.5*</td>
<td>1.5 ± 0.5*</td>
<td>2.0 ± 0.5*</td>
<td>2.3 ± 0.4*</td>
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<tr>
<td>Con.</td>
<td>3.7 ± 0.9</td>
<td>3.8 ± 0.8</td>
<td>2.0 ± 1.0</td>
<td>2.4 ± 0.7</td>
<td>2.6 ± 0.9</td>
<td>2.6 ± 0.9</td>
<td>2.3 ± 0.9</td>
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<tr>
<td><strong>L/A (cm⁻¹)</strong></td>
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<tr>
<td>Exp.</td>
<td>20.4 ± 33.8</td>
<td>43.0 ± 32.0*</td>
<td>62.5 ± 59.3*</td>
<td>67.3 ± 35.0*</td>
<td>67.0 ± 31.9*</td>
<td>50.0 ± 30.8*</td>
<td>43.0 ± 36.1*</td>
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<tr>
<td>Con.</td>
<td>22.1 ± 44.0</td>
<td>62.2 ± 51.0</td>
<td>41.0 ± 40.9</td>
<td>54.4 ± 64.9</td>
<td>55.2 ± 51.6</td>
<td>58.6 ± 54.0</td>
<td>73.3 ± 52.8</td>
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<td><strong>HoE (cm)</strong></td>
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<td>Exp.</td>
<td>1.6 ± 1.6</td>
<td>0.3 ± 0.7*</td>
<td>1.7 ± 1.5</td>
<td>1.8 ± 1.8</td>
<td>1.9 ± 1.7</td>
<td>2.0 ± 2.0</td>
<td>1.9 ± 1.8</td>
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<tr>
<td>Con.</td>
<td>1.8 ± 1.7</td>
<td>1.6 ± 1.9</td>
<td>1.7 ± 1.9</td>
<td>1.8 ± 1.7</td>
<td>2.0 ± 1.7</td>
<td>2.0 ± 1.8</td>
<td>1.9 ± 1.7</td>
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<td><strong>WoE (cm)</strong></td>
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<tr>
<td>Exp.</td>
<td>-0.4 ± 1.1</td>
<td>0.6 ± 1.0</td>
<td>0.5 ± 0.9</td>
<td>1.0 ± 1.2</td>
<td>1.0 ± 0.7</td>
<td>0.9 ± 1.0</td>
<td>0.8 ± 1.0</td>
</tr>
<tr>
<td>Con.</td>
<td>0.4 ± 0.9</td>
<td>0.6 ± 0.6</td>
<td>1.1 ± 3.0</td>
<td>1.0 ± 3.6</td>
<td>0.5 ± 3.9</td>
<td>0.6 ± 4.4</td>
<td>0.4 ± 4.8</td>
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<td><strong>SPL (cm)</strong></td>
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<td>Exp.</td>
<td>159.0 ± 35.3</td>
<td>146.4 ± 37.3</td>
<td>100.0 ± 28.7</td>
<td>101.0 ± 27.2</td>
<td>100.5 ± 27.6</td>
<td>100.0 ± 29.3</td>
<td>98.9 ± 29.3</td>
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<tr>
<td>Con.</td>
<td>125.0 ± 39.6</td>
<td>121.9 ± 40.8</td>
<td>118.5 ± 40.9</td>
<td>84.0 ± 45.4</td>
<td>83.0 ± 46.4</td>
<td>80.0 ± 48.6</td>
<td>83.0 ± 47.5</td>
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<td><strong>L/T (cm)</strong></td>
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<tr>
<td>Exp.</td>
<td>2.7 ± 2.1</td>
<td>2.4 ± 2.0</td>
<td>1.7 ± 2.0</td>
<td>1.7 ± 1.4</td>
<td>1.7 ± 1.4</td>
<td>1.7 ± 1.3</td>
<td>1.7 ± 1.4</td>
</tr>
<tr>
<td>Con.</td>
<td>0.6 ± 0.7</td>
<td>0.6 ± 0.7</td>
<td>0.5 ± 0.9</td>
<td>0.5 ± 0.8</td>
<td>0.5 ± 0.8</td>
<td>0.5 ± 0.8</td>
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The asterisk denotes statistically significant differences between Pre-ApT and each time of the Experimental group (p<0.05). Exp. is Experimental group and Con. is Control group.

20.4 ± 33.8 cm⁻¹. At 70 minutes after the performance of ApT, L/A was 41.7 ± 36.3 cm⁻¹. L/A was significantly increased for 70 minutes (F(9, 370) = 355.4, p<0.05) (Table 1). No significant differences in HoE, WoE, SPL and L/T between the ApT group and control group were found (Table 1).

**DISCUSSION**

Significant shortening of HoE was found just after ApT performance. Imai⁶) reported mechanoreceptors in the gastrocnemius are greatly activated in the fascias posterior of the joint capsule and the deep part fascia. Yanagisawa and others⁷) also reported as a result in comparison of each approximation case among 5 kg, 10 kg, 15 kg, and non-approximation case, ApT increased excitability of calf muscles and an enlarged H wave amplitude. Therefore, we thought to decrease the sway of the body to forth controlling.

L/A showed significant shortening after ApT performance. Ookawa and others⁸) reported that L/A correlates well with frequency of X and Y axis directions and is a parameter correlates well with holding standing posture. Tokita⁹) and Yamada¹⁰) reported that imperceptible control depends on the deep sensory system. Therefore, we concluded that ApT is a valid maneuver for immediate effect on control of the sway of the body under a dynamic control structure. Patricia¹¹,¹²) reported nerve endings are distributed over all synovial joint organizations such as joint capsules or ligaments. Kennedy¹³) and Schultz¹⁴) histologically proved the presence of mechanoreceptors in a study of the anterior crucial ligament in the knee¹⁵). Thereafter Kennedy and Schultz concretely reported there are significant numbers of mechanoreceptors in the knee anterior crucial ligament, posterior crucial ligament, collateral ligament, meniscus and synovial membrane. We assumed mechanoreceptors and muscle spindles were stimulated following synovial tissues stimulation by adding passive approximation stimulus to the joints of the lower extremities stimulating ventral horn cells through afferent fibers and raising the excitability of α
motor neurons. Consequently, activity of the ventral horn cells was raised by successive approximation handling.

In ApT group, as compared with the numerical values before ApT performance, significant changes in AoE and L/A were shown for 70 minutes with the area reduced and the locus length shortened.

Patricia12) reported muscle activity is facilitated by the load of body weight and that muscle activity during continuous joint approximation was investigated as well as muscle activity of the gluteus medius muscle being a posture-holding muscles and the sway of center of gravity on the hip joints after ApT performance was controlled. Ihara16) also reported excitement of the impulse is maintained by simultaneous stimulus of γ and α motor neurons.

In this study, we think ApT using a spatial facilitation phenomenon induced useful effect for 70 minutes by stimulation to γ loops after ApT performance.

On the other hand, we think that the sensitivity of the muscle spindles was gradually inhibited by γ motor neurons and this shortened the durability of the effect because of adaptation to the stimulation17). Therefore, AoE was enlarged and L/A was shortened. We were not able to analyze how there was a decrease of the impulse. On the durability of the effect, we concluded that ApT is a valid maneuver because it produced significant changes in AoE and L/A.

In conclusion, we were able to confirm that the sway of the body was controlled by adding approximation stimulation to the joints of the lower extremities. We thought further study needed about relations between the inhibition and excitation mechanisms of the motor neurons. On this study, it became apparently ApT was useful for immediate effect and duration of effect for improvement of response in the dynamic environment.

REFERENCES