

The effect of a physiotherapy intervention on intestinal motility

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Abstract. [Purpose] It is important to facilitate intestinal motility in patients with reduced bowel movement through physiotherapy. The purpose of the present study was to compare the effects of passive exercise of the lower limbs and trunk (PELT) and combination therapies (COM) with those of conventional thermotherapy (TT) on bowel sounds (BSs) in healthy adult subjects. Since autonomic activity (AA) significantly influences intestinal motility, we also investigated the relation between intestinal motility and AA by measurement of BSs. [Subjects] The subjects were 16 healthy adult males. [Methods] The subjects were randomly assigned to 3 different physiotherapies, and BSs and sympathetic nerve activity were measured before and after the physiotherapies. [Results] While BSs significantly increased following all physiotherapies, the temporal changes in BSs were different among the physiotherapies. AA measurement showed that PELT and TT significantly decreased the heart rate. While the high-frequency (HF) component was increased in all physiotherapy groups, the increases in HF did not reach statistical significance. There were no significant correlations between BSs and AA. [Conclusion] We found that all of the tested physiotherapies increased BSs, suggesting that they are clinically useful for treatment of patients with reduced intestinal motility due to limited spontaneous movement or inability to rise up from bed.

Key words: Intestinal motility, Passive exercise, Thermotherapy

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INTRODUCTION

Patients treated in an intensive care unit (ICU) tend to have reduced intestinal motility due to various drug treatments (opioid and sedative agents, etc.), inflammation, metabolism, pain, anxiety, and bed rest, resulting in a higher risk for postoperative bowel obstruction¹⁾. Reduced intestinal motility delays enteral or oral alimentation, resulting in malnutrition and digestive symptoms, such as abdominal distension and abdominal pain, which often affects early physiotherapy. Reduced intestinal motility in ICU patients sometimes affects their prognosis, and thus, it is important to facilitate intestinal motility in these patients.

Previous studies showed that early postoperative ambulation in the ICU is effective for facilitating intestinal motility, and “early ambulation” is recommended for prevention and treatment postoperative bowel obstruction²⁾. In contrast, Waldhasen et al. reported that early ambulation (starting from postoperative day 1) had no significant effect on intestinal motility compared with their control group (am-

bulation from postoperative day 4)³⁾. Thus, “the beneficial effect of early ambulation on postoperative bowel obstruction remains unclear”²⁾.

We previously reported that passive exercise of the lower limbs and trunk (PELT) facilitates intestinal motility in patients who have to stay in bed due to various reasons⁴⁾. It is speculated that PELT stretches the intestinal tract and enhances parasympathetic nerve activity, resulting in physiological facilitation of intestinal smooth muscle activity.

In Japan, a form of thermotherapy (TT) that warms the abdomen or back of patients with reduced intestinal motility has been widely used in clinical practice. There are many Japanese reports in which TT was found to be effective for treatment of patients with cardiovascular diseases⁵⁾, patients after orthopedic⁶⁾, patients with prolonged immobility⁷⁾, patients with psychiatric⁸⁾, etc., and for increasing the local intestinal tract blood flow and parasympathetic nerve activity.

Thus, the purpose of the present study was to compare the effect of PELT on bowel sounds with that of conventional TT. We also investigated the effect of a combination therapy (COM) of TT and PELT on bowel sounds. Since autonomic activation is significantly involved in intestinal motility, both bowel sounds and autonomic activation were measured before and after physiotherapy. We then investigated the relation between intestinal motility and autonomic activation. This was a pilot study to determine whether these physiotherapies have beneficial effects on facilitation

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of intestinal motility in patients with physical immobility due to various therapeutic reasons.

SUBJECTS AND METHODS

Sixteen healthy adult males without a history of digestive, bone, and joint diseases were recruited for this study (mean age [SD], 21.2 [1.4] years old; mean body height [SD], 172.1 [5.9] cm; mean body weight [SD], 65.1 [19.8] kg; mean BMI [SD], 21.9 [5.5]). We excluded female subjects in the current study, since female intestinal motility is influenced by the menstrual cycle (changes in progesterone levels), which may have affected the results. We also excluded subjects who smoked and those with daily ingestion of alcohol or caffeinated foods or drinks, as these things may affect autonomic activity.

This study was approved by the Hyogo University of Health Sciences Institutional Research Ethics Committee (Approval #12014). All subjects received an explanation of the research purpose, methods, and data management, and written informed consent was obtained from each subject who agreed to participate in the study.

All study participants were asked not to exercise or eat excessively a day before the study. They were also asked not to consume caffeinated foods/drinks or alcohol within 24 hours before the study to avoid any influence on autonomic activity. We confirmed that all participants followed the instructions before the study. We examined the participants to ensure that they had no digestive symptoms, such as abdominal pain, loose stool, and diarrhea, and if the participants showed digestive symptoms, we postponed the study. In normal subjects, bowel sounds are usually recorded 5 to 35 times/minute in the resting spine position. Thus, when bowel sounds were recorded less than 5 times/minute or 35 times or more/minute, we also postponed the study. All participant ate the same meal (100g steamed rice [instant cooked rice, Nishin Co, Kobe, Japan] and 230 mL mineral water), and the measurements of bowel sounds and autonomic activation were carried out 1 hour later in a room in which the temperature was maintained at 25 °C and excessive noise from outside was blocked. Since body posture influences bowel motility, and patients in ICUs are often treated in a semirecumbent position to prevent ventilator-associated pneumonia, we carried out the study 15 minutes after the subjects were set in a semirecumbent position. The physiotherapy, PELT, TT, or COM, was randomly assigned to each subject by a blind technique, and the assigned physiotherapy was performed for 10 minutes.

In PELT, one leg was passively flexed, and the full flexion position was maintained for five seconds. Each subject was administered this passive exercise ten times for each leg. In addition to leg flexion, right and left trunk rotations were also alternately performed.

In TT, a hot pack (35 × 45 cm) was warmed in a hydrocollator (Sakai Co, Tokyo, Japan) at 80 °C. The warmed hot pack was wrapped in a cotton towel and placed on the abdomen. The hot pack was composed of a cotton canvas bag filled with bentonite.

In COM, PELT was performed while a hot pack was

placed on the abdomen.

Measurements were performed for 5 minutes before and right after the physiotherapy. Both bowel sounds and autonomic activation measurements were carried out at the same time. We set an interval of more than 24 hours between physiotherapies and carried out the measurements.

Bowel sounds are generated by contractions of the alimentary tract, and the mixing of gaseous and liquid contents⁹⁾. Recording bowel sounds with a stethoscope and then analyzing them is simple, easy, and minimally invasive, so this procedure has often been used to assess intestinal motility^{10–12)}. This procedure was used in the current study.

An electronic stethoscope with recording capability (Fuji Medical Co., Memory Stethoscope F-812) was used to record bowel sounds at the midpoint of the line connecting the umbilical region and the right anterior superior iliac spine. Anatomically, the recording site roughly corresponds to the area of the ileocecal valve, and this is the area normally listened to for postprandial peristaltic sounds. Recorded peristaltic sounds were passed through an amplifier and fed to a data acquisition and analysis system (ADInstruments, PowerLab2/26). Waveforms of the peristaltic sounds were converted from analog to digital signals using the PowerLab system and uploaded to a PC. Frequency analysis was performed at 100–500 Hz, the primary frequency range of peristaltic sounds¹⁰⁾, and the integral was calculated every 10 sec.

Intestinal motility is influenced by autonomic activation. When the parasympathetic nerve system is activated, intestinal smooth muscle activity is increased, and the activity is suppressed by sympathetic nerve activation¹³⁾. In order to clarify the relation between autonomic activation and changes in intestinal motility induced by physiotherapy, we measured autonomic activation. The autonomic activity was measured using a MemCalc/Bonaly Light system (GMS Co., Ltd., Tokyo, Japan), and the high-frequency (HF) component representing parasympathetic nerve activity, low-frequency (LF) component representing sympathetic nerve activity, and LF/HF ratio were measured. The measurements were made by placing an autonomic nerve sensor at the electrocardiogram V5 lead position, and the HF, LF, and LF/HF ratio were recorded every 2 seconds. We carried out measurement for 5 minutes in a resting state before physiotherapy and after physiotherapy, as in the case of measurement of bowel sounds.

Data were expressed as means (SD) where available. The Student's *t*-test was used to compare the bowel sounds between before and after physiotherapy. The temporal changes in bowel sounds were analyzed by multiple comparisons with Dunnett's post hoc test. The regression coefficient between changes in bowel sounds and autonomic activities was also calculated. All statistical analyses were performed using a SPSS version 21.0 (IBM, Armonk, NY, USA) and *p* < 0.05 was defined as indicating statistical significance.

RESULTS

Table 1 shows the mean levels of bowel sounds for before and after treatment in each physiotherapy. PELT re-

Table 1. Changes in bowel sounds following physiotherapy

	Mean BS (SD) before PT	Mean BS (SD) after PT
PELT (mV·sec)	7.87 (1.31)	9.45 (3.93) *
TT (mV·sec)	6.75 (2.11)	8.98 (3.75) **
COM (mV·sec)	7.71 (1.63)	10.47 (4.10) **

*Significantly different between before and after PT (p<0.05)

**Significantly different between before and after PT (p<0.01)

PELT, passive exercise of the lower limbs and trunk; TT, thermotherapy; COM, combination; PT, physiotherapy; BS, bowel sound; SD, standard deviation

Table 4. Relations between the changes in bowel sounds and changes in autonomic activation following physiotherapy

	PELT ΔBS	TT ΔBS	COM ΔBS
ΔHR	-0.31	0.16	-0.27
ΔHF	-0.27	-0.42	-0.36
ΔLF/HF	-0.55	-0.29	-0.42

PELT, passive exercise of the lower limbs and trunk; TT, thermotherapy; COM, combination; BS, bowel sounds; HR, heart rate; LF/HF, low frequency/high frequency; HF, high frequency

Table 2. Temporal changes in bowel sounds following physiotherapy

	Mean BS (SD) before PT	Mean BS (SD) after PT				
		1 min	2 min	3 min	4 min	5 min
PELT (mV·sec)	7.87 (1.31)	11.98 (9.30)	8.75 (3.97)	9.17 (4.86)	9.88 (5.91)	7.55 (1.45)
TT (mV·sec)	6.75 (2.11)	7.34 (2.58)	8.84 (4.49)	9.25 (5.72)	8.57 (8.03)	7.41 (3.28)
COM (mV·sec)	7.71 (1.63)	10.71 (4.68)	9.78 (6.77)	10.79 (5.82)	9.60 (3.67)	11.45 (8.37)

PELT, passive exercise of the lower limbs and trunk; TT, thermotherapy; COM, combination; PT, physiotherapy; BS, bowel sound; SD, standard deviation. *p<0.05

Table 3. Changes in H, LF/HF, and HF

	HR (bpm)			LF/HF		HF (msec ²)	
	Before	After		Before	After	Before	After
PELT	65.9 (2.5)	62.6 (2.6) *		1.4 (0.9)	1.4 (0.9)	621.3 (206.7)	1,093.2 (404.3)
TT	67.1 (3.1)	63.2 (2.6) **		1.0 (0.6)	1.2 (0.9)	1,042.0 (326.5)	1,477.2 (424.5)
COM	66.2 (3.0)	62.9 (2.3)		1.9 (1.4)	1.7 (1.3)	1,023.9 (318.2)	1,192.5 (405.2)

Mean (SD)

PELT, passive exercise of the lower limbs and trunk; TT, thermotherapy; COM, combination; PT, physiotherapy; HR, heart rate; LF/HF, low frequency/high Frequency; HF, high frequency

*p<0.05; **p<0.01

sulted in a significant increase in bowel sounds after treatment (9.45±3.93 mV·sec) compared with before treatment (7.87±1.31 mV·sec) (p<0.05). TT resulted in a significant increase in bowel sounds after treatment (8.98±3.75 mV·sec) compared with before treatment (6.75±2.21 mV·sec) (p<0.01). COM also resulted in a significant increase in bowel sounds after treatment (10.47±4.10 mV·sec) compared with before treatment (7.71±1.63 mV·sec) (p<0.01). The changing rates in bowel sounds between before and after the physiotherapies were 20.1% for PELT, 33.0% for TT, and 35.8% for COM, respectively. The changing rate was largest for COM.

The temporal changes in bowel sounds following each physiotherapy showed that PELT resulted in a significant increase in bowel sounds at 1 minute after treatment compared with before treatment (p<0.05). Although the bowel sounds remained increased until 5 minutes, they did not reach statistical significance. TT resulted in an increase in bowel sounds at 1 to 5 minutes after treatment compared with before treatment. However, the increases in bowel

sounds did not reach statistical significance. COM also resulted in an increase in bowel sounds compared with before treatment. However, the increase did not reach statistical significance (Table 2).

We obtained data for heart rate (HR), LF/HF ratio, and the HF component for 9 subjects (Table 3). The heart rate was significantly decreased by PELT and TT (p<0.05, p<0.01, respectively). The LF/HF ratio did not reach statistical significance in any of the physiotherapies. The HF component increased after treatment in all physiotherapies; however, the increases did not reach statistical significance.

There were no statistically significant relations between the change in bowel sounds (ΔBS) [(posttreatment bowel sounds – pretreatment bowel sounds) / pretreatment bowel sounds×100] and the change in HR (ΔHR) [(posttreatment HR – pretreatment HR) / pretreatment HR×100], HF(ΔHF) [(posttreatment HF – pretreatment HF) / pretreatment HF×100], or LF/HF (ΔLF/HF) [(posttreatment LF/HF – pretreatment LF/HF) / pretreatment LF/HF×100] (Table 4).

DISCUSSION

In the current study, we found that PELT significantly increased bowel sounds, which was similar to the results of our previous study in which PELT increased bowel sounds by 14%⁴⁾. The significant increase in bowel sounds right after physiotherapy was also similar to the results of our previous study. The intestine is composed of smooth muscle, in which stretch stimulation of the intestine depolarizes the smooth muscle cell membrane potential and increases the action potential, resulting in muscle contraction, which is called stretch induced contraction¹³⁾. Stretching of the alimentary tract is an important factor that facilitates intestinal motility, and we speculate that passive exercise of the lower limbs and trunk affects stretching of the intestinal smooth muscle in the abdomen. In addition, the fact that the increase in bowel sounds continued for several minutes after PELT suggests that the effect of PELT on smooth muscle contraction of the alimentary tract is sustained for a certain period.

Following TT, although bowel sounds significantly increased compared with before treatment in the resting state, the temporal changes in bowel sounds did not reach statistical significance, and the increased bowel sounds tended to be sustained throughout the treatment.

Previous studies showed that TT increases bowel sounds by 1.6 to 2.3 times, although the assessment methods were different¹⁴⁾. We speculate that TT increases alimentary tract blood flow and parasympathetic activation. In the current study, TT increased bowel sounds by approximately 30%, and this result was similar to those of previous studies. While it remains unknown what the exact mechanism of the effect of TT is, the significant HR reduction and 40% increase in the HF component after TT suggest that parasympathetic nerve activation facilitates intestinal motility.

After the COM treatment, bowel sounds increased by more than after the individual treatments of PELT and TT. This result may be due to the combined effects of stretching of the intestine resulting from PELT, and the increase in blood flow in the alimentary tract and parasympathetic activation resulting from TT.

In the current pilot study, we investigated the effect of different physiotherapies on intestinal motility within the same patients. We found that all the tested physiotherapies resulted in increased bowel sounds, suggesting that they can be applied to patients with limited spontaneous movement or prolonged immobility in clinical practice.

A limitation of the current study is that we cannot prove

the underlying mechanisms responsible for facilitating as a result of physiotherapy. It is practically quite difficult to directly measure intestinal motility without applying invasive approaches to patients, which is also ethically problematic. Further studies are necessary to prove the underlying mechanisms in the future.

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