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# Comparison of Segmental Colon Transit Time With Total Energy Expenditure in Psychiatry Unit Patients

## ABSTRACT

Physical activity is associated with a reduced risk of colorectal cancer. We examined the colon transit time (CTT) according to the total energy expenditure (TEE) in psychiatry unit patients. The study participants included 67 adults, with a mean age of 49.8 years. The participants used an accelerometer for 7 days to measure their 1-week TEE. They took a capsule containing 20 radio-opaque markers for 3 days. On the 4th day and 7th day, a supine abdominal radiography was performed. According to the TEE of all study participants, the upper 30%, middle 30%, and lower 40% were classified into groups according to high (H), moderate (M), and low (L) physical activity. The mean total CTT was 52.0 hours. The segmental CTT for the right, left, and recto-sigmoid colon were 15.3 hours, 19.2 hours, and 17.4 hours. Total CTT in the H group was significantly shorter than that in the L group ( $p = .010$ ). A comparison of the segmental CTT between the L, M, and H groups showed that the right CTT ( $p = .010$ ) of the H group was significantly shorter than that of the M group. The left CTT of the M group ( $p = .028$ ) and H group ( $p = .004$ ) was significantly shorter than that of the L group. The recto-sigmoid CTT ( $p = .016$ ) of the M group was significantly shorter than that of the L group. The study showed that moderate and high TEE was assisted with reduced CTT.

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## Introduction

Colorectal cancer is the third most common cancer in humans, accounting for nearly 9.8% of all cancers with a mortality rate of 8.0%, according to recent studies performed in Western countries (Jemal et al., 2011; Pham et al., 2012). The risk factors of colorectal cancer include eating habits, obesity, constipation, the lack of physical activity (PA), and genetic factors (Pham et al., 2012; Power, Talley, & Ford, 2013; Speed-Andrews et al., 2014). Physical activity has been reported to significantly increase the survival rate of patients with colorectal cancer (Barton, 2013; Pham et al., 2012; Spence, Heesch, & Brown, 2009).

An increase in physical activity level (PAL) with regular PA is profoundly correlated with relieving constipation, which is the potential etiological mechanism of colorectal cancer (Power et al., 2013; Shemerovskii, 2005). The outcome is attributable to reduced colonic transit time (CTT) shortened by increased PA, ultimately leading to reduced risk factors of colorectal cancer (Barton, 2013; Kim, 2012; Metcalf et al., 1987; Pham et al., 2012; Power et al., 2013; Robertson et al.,

1993; Song, Cho, Jo, Oh, & Kim, 2012; Speed-Andrews et al., 2014; Spence et al., 2009).

The PAL of long-term care patients hospitalized because of chronic diseases decreases drastically compared with normal individuals (Metsios et al., 2011). Moreover, mentally ill patients hospitalized in a closed ward rarely maintain physical activities on a regular basis because of insufficient opportunities of PA. In addition, the physical and social functioning of such patients is reduced because of the adverse effects of psychostimulant medication (Nyboe & Lund, 2013).

Mentally ill patients hospitalized in a closed ward for a long period of time are exposed to the risk factors of various chronic diseases and cancers because of the reduction of physical and social functioning. Therefore, sustaining and increasing PAL play crucial roles in treating mental disorders and preventing cancers in patients with mental illnesses (Alvarez-Jimenez, Hetrick, Gonzalez-Blanch, Gleeson, & McGorry, 2008; Richardson, Avripas, Neal, & Marcus, 2005).

A previous study performed to measure the PAL and CTT of normal individuals reported that increased PA levels result in significant shortening of CTT (Cho, Jo, Song, Oh, & Kim, 2013; Song et al., 2012). Other previous studies reported that CCT is more significantly shortened as PA levels increase in the case of individuals with a sedentary lifestyle, and that walking, running, cycling, and other exercises reduce CTT (Annells & Koch, 2003; Dukas, Willett, & Giovannucci, 2003). Furthermore, individuals who have regularly carried out PA for several years exhibited significantly shortened CTT even during the period without PA (Bartram & Wynder, 1989; Meshkinpour et al., 1998).

A large number of studies conducted on normal individuals indicate the importance of PA in colonic function. However, no previous studies have investigated and compared colonic function according to the PA levels of mentally ill patients who have relatively more risk factors than normal individuals.

Therefore, the purpose of this study was to assess the PA levels of mentally ill patients who have been hospitalized for a long term in a closed ward and have relatively higher risk of chronic diseases and cancers. The study also examines how CTT affects colorectal cancer.

Colonic transit time measurement using a radiopaque marker is widely used as a method to determine slow CTT (Jung, Kim, & Moon, 2003; Metcalf et al., 1987; Song et al., 2012; Xu et al., 2011). When the radiopaque marker (Kolomark, MJ Tech, Pyeongtaik, Korea) is ingested and remains for a longer period in the right intestine, colonic inertia or slow transit-constipation can be diagnosed. When many markers remain in the colon and rectum, pelvic floor dysfunction can also be diagnosed (Prokesch et al., 1999). The CTT measurement using radiopaque markers is also

widely used as a method to differentiate constipation subtypes based on pathological physiology (Metcalf et al., 1987). Although it is difficult to differentiate constipation subtypes, if there are two pathological physiology types, CTT measurement using a radiopaque marker is effective in determining chronic constipation because it is easy to perform, repeatable, and inexpensive (Jung, Kim, Moon et al., 2003; Jung, Kim, Moon, & Hong, 2003; Metcalf et al., 1987).

## Materials and Methods

### Participants

Patients were recruited from the Somang Hospital Psychiatry Unit from March 1, 2012, to June 1, 2012. The study participants included 67 adults with a mean age of 49.8 years and an age range of 26–79 years. All participants voluntarily gave written informed consent for us to use their data. Of all potential participants, those with a possible restriction in normal PA, those with cardiovascular or orthopedic diseases that might affect CTT, those with an inability to discontinue drugs because of functional stomach diseases, those who were on a prescription course of anticonstipation drugs, and those with diabetes mellitus or hypertension were excluded from the current analysis (Jung, Kim, Moon, 2003; Jung, Kim, Moon, & Hong, 2003; Song et al., 2012).

### Measurement of Physical Characteristics

Bioelectrical impedance analysis (Inbody, Biospace, Korea) was used in the measurement of height, weight, and body mass index (BMI). Blood pressure was measured using a sphygmomanometer (SPRIT CK-101, Sankei, Tokyo, Japan) in the prone position after a 5-minute rest. Attempts were made to rule out any extrinsic factors that might affect blood pressure, such as temperature, degree of PA, smoking, and diet (Jung, Kim, Moon et al., 2003; Song et al., 2012).

### Measurement of Physical Activity Level

Total energy expenditure was measured over a 1-week period using an Actigraph GT3X accelerometer (Actigraph, Pensacola, Florida). For accurate PA measurement, the participants were advised to freely perform their daily physical activities. The accelerometers were worn on an elastic belt positioned over the wrist. Before the measurement, the participants' age, sex, height, and weight were input. The TEE, step count, energy expenditure of sedentary-intense activity, energy expenditure of light-intense activity (EEL), energy expenditure of moderate-intense activity (EEM), energy expenditure of vigorous-intense activity (EEV), and time of activity depending on the PA intensity and frequency were individually measured according to time

(Sasaki, John, & Freedson, 2011). The results were automatically stored. Accelerometers were programmed to record data at 1-minute intervals over 7 consecutive days (McGuire & Ross, 2011; Sasaki et al., 2011). Using the recorded data, the energy expenditure was calculated on the basis of Mifflin's formula to calculate the basal metabolic rate. To differentiate the PA amount according to the TEE of all study participants, the upper 30%, middle 30%, and lower 40% were classified into the high (H group), moderate (M group), and low (L group) PA groups, respectively.

### Measurement of Colonic Transit Time

Colonic transit time was measured using a multiple marker technique with a radio-opaque marker. The participants were administered one gelatin capsule containing 20 radio-opaque markers at the same time every day for 3 days (Kolomark). At the same time on Days 4 and 7, a supine abdominal radiography was performed. Mean CTT (hour) was calculated by counting the number of radio-opaque markers that were left in the total colon and the segment of the colon and then multiplying this by 1.2 (Chaussade, Gosselin, Hostein, Leman, & Ponsot, 1990; Metcalf et al., 1987; Prokesch et al., 1999; Song et al., 2012; Xu et al., 2011).

### Ethics

This work was carried out in accordance with the Declaration of Helsinki (2000) of the World Medical Association. The study was awarded full approval from the institutional review board of Seoul National University (IRB No: 1203/001-002). All patients provided informed written consent.

### Statistical Analysis

The study data, expressed as mean  $\pm$  standard deviation, were analyzed using SPSS PC+ for Windows version 18.0 (SPSS Inc., Chicago, IL). To analyze the comparison of segmental CTT with TEE between the three groups, one-way ANOVA was performed. LSD post hoc analysis was performed on the variables showing a statistically significant difference. A value of  $p < .050$  was considered statistically significant.

## Results

### Physical Characteristics

The participants' physical characteristics such as age, height, body weight, BMI, and blood pressure are indicated in Table 1. The average age, height, body weight, and BMI of the participants were 49.8 years old, 166.1 cm, 68.5 kg, and 24.7, respectively, while the average maximum and minimum blood pressures were 129.6 and 83.5 mmHg, respectively.

**TABLE 1.** Physical Characteristics of the Participants

	Mean	SD	Range
Age (years)	49.8	10.5	26–79
Height (cm)	166.1	6.5	149.0–177.7
Weight (kg)	68.5	12.2	45.5–101.1
BMI (kg/m <sup>2</sup> )	24.7	3.7	17.7–35.3
SBP (mmHg)	129.6	15.5	101–174
DBP (mmHg)	83.5	9.0	66–106

Note. Values are mean  $\pm$ SD. BMI = body mass index; DBP = diastolic blood pressure; SBP = systolic blood pressure.

### Level of Physical Activity

The PA level and the differences among the three groups classified according to TEE are shown in Table 2. First, the average energy expenditure of the participants was 794.9 kcal. From the analysis, the average energy consumption for the L group, M group, and H group was 478.5, 824.1, and 1,242.6, respectively, and the differences were statistically significant ( $p < .000$ ). Second, the average distance the participants walked was 10,466.8. The average distance walked by each group was 7,551.3 steps, 11,149.6 steps, and 14,090.3 steps for the L group, M group, and H group, respectively, and the differences were also statistically significant ( $p < .000$ ). Third, the average energy expenditure of sedentary intense activity for the participants was 84.3%. The average energy consumption of the L group, M group, and H group was 89.9%, 84.0%, and 77.0%, respectively, and there were statistically significant differences ( $p < .000$ ). Fourth, the average EEL of the participants was 8.2%. The average EEL of the L group, M group, and H group was 6.3%, 8.2%, and 11.0%, respectively, and even if the differences were statistically insignificant, significant differences were observed within 6.7% of a margin of error. Fifth, the EEM of the participants was 6.8% on average. The average EEM of each group was 3.6%, 7.1%, and 10.8% for the L group, M group, and H group, respectively, and the differences were statistically significant ( $p < .000$ ). Finally, the average EEV for the participants was 0.4%. The average EEV for the L group, M group, and H group was 0.1%, 0.4%, and 0.9%, respectively, and there were statistically significant differences ( $p < .003$ ).

### Colonic Transit Time According to Physical Activity Level

The total colonic transit time (TCTT) and partial colonic transit time (RCTT, LCTT, RSCTT) of the three groups and the differences among the three groups are presented in Table 3. First, the average

**TABLE 2.** Physical Activity Level of Participants

	Group				p
	L (n = 28)	M (n = 22)	H (n = 17)	Total (n = 67)	
TEE (kcal)	478.5 ± 164.4	824.1 ± 121.8	1242.6 ± 370.5	794.9 ± 383.3	<.000
Step count	7551.3 ± 2748.4	11149.6 ± 4408.9	14090.3 ± 3466.0	10466.8 ± 4411.1	<.000
EES (%)	89.8 ± 4.2	84.0 ± 5.6	77.0 ± 6.5	84.3 ± 7.4	<.000
EEL (%)	6.3 ± 3.6	8.2 ± 6.3	11.0 ± 7.4	8.2 ± 6.0	.067
EEM (%)	3.6 ± 2.0	7.1 ± 1.6	10.8 ± 4.3	6.8 ± 4.0	<.000
EEV (%)	0.1 ± 0.1	0.4 ± 0.3	0.9 ± 1.2	0.4 ± 0.7	.003

Note. Values are mean ±SD. EEL = energy expenditure of light intense activity; EEM = energy expenditure of moderate intense activity; EES = energy expenditure of sedentary intense activity; EEV = energy expenditure of vigorous intense activity; H = high physical activity group; L = low physical activity group; M = moderate physical activity group; TEE = total energy expenditure.

TCTT of the participants was 52.0 hours. Analysis of the average TCTT of each group showed 65.1 hours, 46.8 hours, and 37.2 hours for the L group, M group, and H group, respectively, and there were statistically significant differences between the L group and H group ( $p = .010$ ). Second, the average RCTT of the participants was 15.3 hours. The average RCTT of the L group, M group, and H group was 14.9 hours, 20.3 hours, and 9.3 hours, respectively; RCTT in the H group was significantly shorter than that in the L group and M group ( $p = .010$ ). Third, the average LCTT of the participants was 19.2 hours. The average LCTT of the L group, M group, and H group was 27.9 hours, 15.5 hours, and 9.8 hours, respectively, and statistically significant differences were observed between the L group and M group and between the L group and H group ( $p = .004$ ). Finally, the average RSCTT of the participants was 17.9 hours. The average RSCTT of

each group was 22.2 hours, 10.9 hours, and 17.9 hours for the L group, M group, and H group, respectively, and a statistically significant difference occurred between the L group and M group ( $p = .016$ ).

## Discussion

The results in the study showed that the average TCTT in the participants was 52.0 hours, representing relatively faster results (<70 hours) compared with the results in the study performed by Martelli et al. (1978) with a Western population and compared with the result of 67 hours in the study performed by Chaussade, Roche, Khyari, Couturier, and Guerre (1986). In studies performed in Asia, Y.-K. Chan et al. (2004) obtained 21 hours for TCTT of males, indicating relatively faster TCTT than that of the results in the present study (Jung, Kim, Moon, & Hong, 2003; Meir et al., 1992). It has been reported that the factors

**TABLE 3.** Segmental Colon Transit Time According to Total Energy Expenditure (TEE)

	TEE			
	L (n = 28)	M (n = 22)	H (n = 17)	Total (n = 67)
RCTT (hour)	14.9 ± 12.2	20.3 ± 15.5	9.3 ± 9.3 <sup>a</sup>	15.3 ± 13.3
LCTT (hour)	27.9 ± 26.9	15.5 ± 10.1 <sup>b</sup>	9.8 ± 11.9 <sup>c</sup>	19.2 ± 20.6
RSCTT (hour)	22.2 ± 16.6	10.9 ± 11.1 <sup>d</sup>	17.9 ± 20.0	17.4 ± 16.5
TCTT (hour)	65.1 ± 39.8	46.8 ± 25.8	37.2 ± 34.4 <sup>e</sup>	52.0 ± 35.9

Note. Values are mean ±SD. H = high total energy expenditure group; L = low total energy expenditure group; LCTT = left colon transit time; M = moderate total energy expenditure group; RCTT = right colon transit time; RSCTT = recto-sigmoid colon transit time; TCTT = total colon transit time.

<sup>a</sup>Difference between the M and H at RCTT ( $p = .010$ ).

<sup>b</sup>Difference between the L and M at LCTT ( $P = .028$ ).

<sup>c</sup>Difference between the L and H at LCTT ( $p = .004$ ).

<sup>d</sup>Difference between the L and M at RSCTT ( $P = .016$ ).

<sup>e</sup>Difference between the L and H at TCTT ( $p = .010$ ).

affecting CTT include age, gender, BMI, fiber intake, water intake, lifestyle, and so on. (Meir et al., 1992; Metcalf et al., 1987), but this is still controversial.

Many controversies persist regarding the differences in CTT, depending on the amount of PA. Several researchers showed that PA or exercise did not make a difference in CTT (Metcalf et al., 1987). It has been reported that although lifestyle and diet habits showed significant differences in CTT for patients with chronic constipation, no differences were shown for exercise (Metcalf et al., 1987; Robertson et al., 1993). According to recent studies however, variable PA levels induced differences in body composition and diet habits so that CTT would also differ (Irwin, 2009; Stephenson, Bebb, Reimer, & Culos-Reed, 2009). In addition, other studies determined that females showed significant differences in CTT, depending on the levels of PA; however, the controversies remain unresolved (Kim, 2012; Robertson et al., 1993; Song et al., 2012).

In this study, TCTT was compared by classifying PA levels into three groups, the H group (top 30%), M group (MIDDLE 30%), and L group (lower 40%), on the basis of TEE. The results show that there was no significant difference between the L group and M group, whereas there were significant differences between the L group and H group. These results are in agreement with the results in other studies as follows. An increase in physical activities will have positive effects on the prevention of adult diseases by providing changes in body fat composition along with body weight reduction and PA induces appropriate and balanced food intake in terms of lifestyle and diet habits, thereby facilitating defecation and physical development (Papathanasopoulos & Camilleri, 2010; Stephenson et al., 2009).

Furthermore, the results of this study show that RCTT in the H group was significantly shorter than that in the L group and M group, and that LCTT in the M group and H group was significantly shorter than that in the L group. These results were similar to the study carried out by Prokesch et al. (1999) in that CTT in the group with high physical activities was shortened because of the increase of bowel movement. In the case of RCTT, no statistically significant differences were observed between the L group and M group and the results agreed with the studies performed by Meir et al. (1992) and Hinds, Stoney, and Wald et al. (1989) that demonstrate that PA and exercise did not significantly affect CTT and that various diet habits and diet styles affected the differences.

On the contrary, this study concluded that there were statistically significant differences in RSCCTT between the L group and M group but not between the M group and H group. These were shorter compared with those of the results in the studies performed by Chaussade et al. (1986), Hinds et al. (1989), and Meir,

et al. (1992), but longer than those of the results from the study performed by Chan et al. (2004) in Asia. RSCCTT differs according to fiber and water intake and further studies regarding the differences based on amount of PA or exercise need to be performed in the near future (Chan et al., 2004; Chaussade et al., 1990; Hinds et al., 1989; Metcalf et al., 1987).

The objective of this study was to investigate CTT on the basis of TEE amount. Among the variables affecting CTT, however, food intake such as fiber and water intake was not included in the study. Although this might be a limitation of the study, the study does provide an important implication regarding the relationship between physical activities and constipation. Thus, as this study investigated the relationship of PA level and CTT without considering the food intake, this limitation should be considered when analyzing the results.

Given the results of the study, the average CTT of 67 males was 52.0 hours and TCTT, RCTT, and LCTT were significantly shortened as TEE increased.

## Conclusion

We report a comparison of segmental CTT with TEE in psychiatry unit patients. Colon transit time was associated with TEE and PA. Regardless the gender, the intake of fiber and water modulated to reduce CTT. This study can provide the general advice for psychiatry unit patients with constipation. ✪

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