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BRIEF ARTICLE

Colon transit time according to physical activity and characteristics in South Korean adults

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Abstract

AIM: To investigate factors contributing to the colon transit time (CTT), physical activity and characteristics were examined.

METHODS: Forty-seven Korean adults (males, *n* = 23; females, *n* = 24) took a capsule containing 20 radio-opaque markers to measure the CTT. The subjects used an accelerometer to measure the physical activity and underwent a bioelectrical impedance analysis to determine the physical characteristics. Macro-nutrient was also surveyed.

RESULTS: The mean total CTTs (TCTT) in the males and females were 8.8 and 24.7 h (*P* = 0.002), respectively. In the male subjects, the right CTT (3.5 ± 4.9 h *vs* 10.0 ± 11.6 h, *P* = 0.023) and recto-sigmoid CTT (4.4 ± 4.7 *vs* 13.6 ± 12.5 h, *P* = 0.004) were significantly shorter and the total energy expenditure (637.6 ± 44.3 kcal *vs* 464.3 ± 64.9 kcal, *P* = 0.003), total activity count (247 017 ± 75 022 count *vs* 178 014 ± 75 998 count, *P* = 0.003), energy expenditure of light intensity (148.5 ± 6.9 kcal *vs* 120.0 ± 16.8 kcal, *P* = 0.006), energy expenditure of moderate intensity (472.0 ± 36.2 kcal *vs* 281.4 ± 22.2 kcal, *P* < 0.001), fat intake (65.5 ± 23.3 g *vs* 51.2 ± 17.4 g, *P* = 0.010), and water consumption (1714.3 ± 329.4 g *vs* 1164.7 ± 263.6 g, *P* = 0.009) were significantly higher than in the female subjects. Regarding correlations, when adjusted for gender, fiber (*r* = -0.545, *P* < 0.001) and water intake (*r* = -0.257, *P* < 0.05) correlated significantly with the TCTT in all subjects. In addition, the body mass index (*r* = -0.424, *P* < 0.05) and fiber intake (*r* = -0.417, *P* < 0.05) in the males as well as the fiber intake (*r* = -0.655, *P* < 0.001) in the females showed significant correlations with the TCTT.

CONCLUSION: The subjects showed significant gender differences in the TCTT, right CTT, and recto-sigmoid CTT. Furthermore, the intake of the fiber and water contributed to the CTT.

Key words: Colon transit time; Physical activity; Characteristics; Macro-nutrient; South Korean

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INTRODUCTION

Colorectal cancer is the third most prevalent human cancer worldwide, with 1 million estimated new case annually, of which, about 50% lead to death[1]. The recog-

nized risk factors include westernized eating habits, obesity, insufficient physical activity and genetic factors[2,3]. However, the effects of gender and individual behavior on the colon transit time (CTT) remain controversial. In some studies, some factors affecting the CTT include age, gender, body mass index (BMI), dietary fiber, water intake, and living habits[4-6]. On the other hand, in a literature review of factors affecting the CTT, age[7], gender[2,3,7], BMI[8], and dietary fiber[9] were not found to be statistically significant.

The impact of exercise and physical activity (PA) on the gastrointestinal and colonic tracts is an area of emerging interest, with recent research focusing on the potential benefits of PA[3,4]. PA is known to be associated with colonic function and constipation[9,10]. In addition, walking, running, and strength training are known to reduce the CTT[10,11]. Also, a period of physical inactivity in subjects who had been engaged in regular PA for several years significantly increased the CTT[12,13]. At present, leisure time activities and transport activities constitute the majority of one's daily physical over all activity[14-16]. Increasing PA is an important health goal for everyone, but doing this requires an accurate method of measuring daily PA. To solve this problem, accelerometers are now being utilized in studies of PA. Accelerometers measure the acceleration of movement and can quantify the intensity, frequency and duration of movement. Lightweight, small and very durable, accelerometers are practical for all ages and activities and can be used indoors or outdoors. Several studies to date have supported the use of accelerometers to assess energy expenditure during locomotion and have confirmed a validity range of 0.77-0.89[11,12,16,17]. For this reason, to measure PA, we analyzed total energy expenditure and energy expenditure of low-, moderate-, and vigorous intensity physical activities using an accelerometer.

Measuring the CTT by the radio-opaque marker method is simple, widely available and important for the diagnosis of slow transit constipation[18-20]. Although there are several reports which sought to measure the CTT using Kolomark™, a radio-opaque marker, normative data on South Koreans are still lacking. Thus, to understand colonic motor function in Koran adults, the CTT was analyzed using Kolomark™ in the present study. To investigate the factors which influence the CTT in South Korean adults, we examined the effects of gender, physical characteristics, physical activity, and macro-nutrient and water intake on the CTT.

MATERIALS AND METHODS

Participants

The study subjects were 47 adults, 23 of whom were male and 24 female. The mean age was 36.0 years with a range of 25-59 years, and all voluntarily gave written informed consent. Of all potential subjects, those with any possible restriction on their normal PA or diet, those with cardiovascular or orthopedic disease which may affect the CTT, menstruating woman those who cannot ingest drugs due to functional stomach diseases, and those on any prescription of anti-constipation drugs or for diabetes mellitus or hypertension were excluded from the current analysis.

Measurement of physical characteristics

A bioelectrical impedance analysis (Inbody, Biospace, Seoul, South Korea) was used to measure the height, weight, BMI, lean body mass (LBM), and percentage of body fat (BF) at the beginning of the study in a fasted state.

Measurement of physical activity

PA was measured over a 1-wk period using an accelerometer (Actical, Mini Mitter, Chicago, IL, United States). To measure PA accurately, the study subjects were advised to perform their daily PA as they normally would. The accelerometer was attached to the iliac crest using a belt. Prior to measurement, the age, sex, height and weight of each participant were entered into the device. The total energy expenditure, activity energy expenditure, and time of activity depending on the PA intensity and frequency were individually measured according to the time. The results were automatically stored. Using the recorded data, the energy expenditure was calculated based on Muffin's formula to calculate the basal metabolic rate[11,17].

Analysis of macro-nutrient intake

To determine the average daily energy, carbohydrate, protein, fat, fiber and water intake, all participants recorded their daily dietary information using the dietary recall method over a 1 wk period during the accelerometer phase. Foods that could not fit into a standard measure were described by the dimensions of their shape, with a grid measured in centimeters to allow these measurements to be done accurately. The dietary records were analyzed using the nutrient analysis program.

Measurement of the CTT

To measure the colonic motor function, the CTT was measured using a multiple marker technique with a radio-opaque marker (Kolomark™, MI Tech, Pyeongtaek, South Korea). The subjects took one capsule containing 20 radio-opaque markers at the same time every day for three consecutive days. On the fourth day, following the first administration, a supine abdominal radiograph was performed. The mean CTT (hours) was calculated by counting the number of radio-opaque markers that were left in the total colon and in each segment of the colon and then multiplying this number by 1.2[18-20].

Ethics

This work was carried out in accordance with the Declaration of Helsinki (2000) of the World Medical Association. This study was approved ethically by the Institutional Review Board of Seoul National University (IRB No. 2011/1006). All patients provided informed written consent.

Table 1 Physical characteristic of the participants

Variable	Male (n = 23)	Female (n = 24)	Total (n = 47)	P value
Age (yr)	37.3 ± 5.8	35.9 ± 5.6	36.0 ± 5.9	0.108
Height (cm)	172.1 ± 5.1	159.6 ± 6.3	165.2 ± 8.5	< 0.001
Weight (kg)	75.6 ± 12.5	55.2 ± 6.8	64.4 ± 14.1	< 0.001
BMI (kg/m^2)	24.5 ± 3.5	21.7 ± 2.5	23.4 ± 3.5	< 0.001
LBM (kg)	57.1 ± 15.3	41.1 ± 5.0	48.3 ± 13.5	< 0.001
BF (%)	21.1 ± 8.7	25.5 ± 3.5	23.5 ± 6.7	0.009

Data are presented as mean ± SD. BMI: Body mass index; LBM: Lean body mass; BF: Body fat.

Table 2 Physical activity amount and intensity of the subjects

Variable	Male	Female	Total	P value
TEE (kcal)	637.6 ± 44.3	464.3 ± 64.9	542.4 ± 54.9	0.003
TAC (count)	247 017 ± 75 022	178 014 ± 75 998	212 515.5 ± 75 501	0.003
EEL (kcal)	148.5 ± 6.9	120.0 ± 16.8	133.1 ± 16.8	0.006
EEM (kcal)	472.0 ± 36.2	281.4 ± 22.2	367.4 ± 22.2	< 0.001
EEV (kcal)	24.5 ± 6.7	11.1 ± 47.8	17.8 ± 13.8	0.214

Data are presented as mean ± SD. TEE: Total energy expenditure; TAC: Total activity count; EEL: Energy expenditure of light intense activity; EEM: Energy expenditure of moderate intense activity; EEV: Energy expenditure of vigorous intense activity.

Table 3 Daily macro-nutrients intake of the subjects

Variable	Male	Female	Total	P value
Totalenergy (kcal)	2193.1 ± 259.2	2091.5 ± 229.2	2147.2 ± 233.6	0.292
Protein (g)	85.0 ± 18.6	82.5 ± 20.9	83.6 ± 19.6	0.493
Fat (g)	65.5 ± 23.3	51.2 ± 17.4	59.0 ± 21.9	0.010
Carbohydrate (g)	338.8 ± 71.7	298.5 ± 42.4	305.8 ± 61.2	0.054
Fiber(g)	8.1 ± 4.5	9.9 ± 4.7	8.9 ± 4.6	0.133
Water (g)	1714.3 ± 329.4	1164.7 ± 263.6	1227.0 ± 286.8	0.009

Data are presented as mean ± SD.

Table 4 Segmental colon transit time of the subjects

Variable	Male	Female	Total	P value
LCTT (h)	0.9 ± 2.2	1.1 ± 3.0	1.0 ± 2.6	0.592
RCTT (h)	3.5 ± 4.9	10.0 ± 11.6	6.8 ± 9.6	0.023
RSCTT (h)	4.4 ± 4.7	13.6 ± 12.5	9.0 ± 8.6	0.004
TCTT (h)	8.8 ± 9.4	24.7 ± 23.6	16.8 ± 16.2	0.002

Data are presented as mean ± SD. RCTT: Right colon transit time; LCTT: Left colon transit time; RSCTT: Recto-sigmoid colon transit time; TCTT: Total colon transit time.

Statistical analysis

Data analysis was conducted using the SPSS software package (version 18.0, SPSS Inc., Chicago, IL, United States), and descriptive statistics were presented using mean ± SD. The differences in the variables between the males and females were verified by an independent samples t-test. To assess the correlation between the total CTT and all of the experiment variables, Partial's correlation coefficient (r) was determined. An adjustment was made for gender. The level of significance (P) was 0.05 for all statistical analyses.

RESULTS

Physical characteristics

The physical characteristics of all subjects are presented in Table 1. The mean age was 37.3 and 35.9 years in the male and female subjects, respectively. The variables associated with the physical characteristics of the height, body weight, BMI and LBM were significantly higher in the males than in the females ($P < 0.001$). On the other hand, the BF was significantly lower in the male subjects than in the female subjects ($P = 0.009$).

Physical activity amount and intensity

The amounts and intensities of the PA of the male and female subjects are shown in Table 2. The total energy expenditure (173.3 kcal, $P = 0.003$), total activity count (69 003 count, $P = 0.003$), energy expenditure of light intensity (EEL) (28.5 kcal, $P = 0.006$), and energy expenditure of moderate intensity (EEM) (190.6 kcal, $P < 0.001$) were significantly higher in the male subjects than in the female subjects.

Macro-nutrient intake

Daily macro-nutrient and water intake by the subjects are presented in Table 3. The intake levels of fat (14.3 g, $P = 0.010$) and water (549.6 g, $P = 0.009$) were significantly higher in the males than in the females.

Segmental CTT and total CTT

The mean total CTT (TCTT) was 8.8 h and 24.7 h in the male and female subjects, respectively. This gender difference was statistically significant ($P = 0.002$). Although there was no significant difference in the left CTT, the right CTT ($P = 0.023$) and recto-sigmoid CTT ($P = 0.004$) showed significant gender difference (Table 4).

Correlation between the TCTT and parameters

Correlations between the TCTT and related parameters for the male and female subjects are shown in Table 5. In the male subjects, the BMI ($r = -424$, $P < 0.05$) and fiber intake levels ($r = -417$, $P < 0.05$) showed significant correlations with the TCTT. On the other hand, only the fiber intake ($r = -655$, $P < 0.001$) showed a significant correlation with the TCTT in the female subjects. Moreover, when adjusted for gender, the fiber ($r = -545$, $P < 0.001$) and water ($r = -257$, $P < 0.05$) intake levels showed significant correlations with the TCTT in all subjects.

DISCUSSION

All physical characteristics were higher in the male subjects, except for the BF, but even those values were within the normal range. These values indicate that the South Korean adults who participated in this study were relatively healthy.

Table 5 Correlations between the total colon transit time and parameters

Variable	Male	Female	Total[1]
Physicalcharacteristics			
Age	0.060	-0.112	-0.067
Height	0.071	-0.157	-0.108
Weight	-0.344	-0.014	-0.098
BMI	-0.424	0.127	-0.031
LBM	-0.053	-0.107	-0.050
BF	-0.243	0.149	0.051
Physicalactivity			
TEE	-0.244	-0.022	-0.031
TAC	-0.191	-0.164	-0.180
EEL	-0.067	-0.211	-0.182
EEM	-0.197	-0.092	-0.101
EEV	-0.256	0.092	0.078
Macro-nutrientintake			
Energy	0.196	0.158	0.290
Protein	-0.102	-0.247	-0.123
Fat	0.024	-0.155	-0.008
Carbohydrate	0.346	-0.221	0.250
Fiber	-0.417	-0.655	-0.545
Water	-0.266	-0.326	-0.257

[1]Adjusted for gender. BMI: Body mass index; LBM: Lean body mass; BF: Body fat; TEE: Total energy expenditure; TAC: Total activity count; EEL: Energy expenditure of light intense activity; EEM: Energy expenditure of moderate intense activity; EEV: Energy expenditure of vigorous intense activity.

Despite longstanding disputes, it is uncertain as to whether or not there is any difference in the CTT between males and females. In our study, the comparison of the TCTTs according to gender showed that the mean TCTTs of the males and females were 8.8 and 24.7 h, respectively. Drossman *et al*[21] and Heaton *et al*[22] reported that the prevalence of constipation is higher in women in than in man, and that it becomes more prominent in woman of childbearing age, suggesting a role of the female sex hormone. Jung *et al*[6] reported that the mean TCTT of healthy South Korean subjects was 22.3 h in male subjects and 30.1 h in female subjects and that was no significant difference in the TCTT between male and female subjects. In our study, however, a significant difference was noted in the TCTT according to gender. Moreover, the RCTT and RSCTT in females showed were significantly longer than they were in males. A radio-opaque marker study can provide us with information about the segmental CTT. Our study showed that gender and the LCTT were unrelated. Jung *et al*[6] showed that the RSCTT was significant longer in the female subjects, whereas TCTT, RCTT, and LCTT differences in terms of gender were not significant. Rao *et al*[23] in a study that used ambulatory 24 h colonic manometry revealed that women showed less pressure activity than men and that this difference was particularly significant in the transverse descending colon. Therefore, a gender difference may contribute to the prevalence of constipation in women. However, more studies of variables and sample sizes regarding this mechanism are required.

Because a sedentary lifestyle is a risk factor for chronic disease, promoting PA is very important[24,25]. Some studies reported that factors that can influence the CTT are regular PA and regular physical exercise, both of which are considered to be useful in the management of chronic constipation[26,27]. This is based partly on the assumption that exercise shortens the CTT through the gastrointestinal tract. However, studies testing the influence of exercise on the CTT in healthy young subjects show conflicting results. Some studies showed a decrease in the CTT after physical training[11-13], whereas other studies did not show a reduction partly owing to large intra-individual differences[28-30]. In our study, although South Korean male adults engaged in more PA with or without an adjustment for gender, the CTT did not correlate with the PA levels.

Regarding the intake of dietary fiber and water, several studies have shown that the CTT was shortened and the stool frequency increased when the amounts of dietary fiber and water increased[31-34]. In our study, the mean CTT also showed a significant correlation with the amount of dietary fiber intake in all subjects. This result is similar to those of previous studies, which found that the CTT is significantly correlated with dietary fiber intake. We observed an inverse association between the TCTT and fiber intake in males, females, and in all subjects with or without an adjustment for gender. This result indicates that fiber intake is a strong contributing factor which affects the CTT in South Korean adults. For water intake, although all subjects showed significant correlation between this and the TCTT, the discrepancy in water consumption may be due to the limitation of the measurement methods based on the subjects' food diaries. The Can-pro program by the Korean Nutrition Society does not analyze the moisture content of food. Thus, the surveyed amounts of consumed water were used for the water intake amounts. As a result, the amounts of water contained in the subject's food intake level were excluded from total water consumption in our study. However, although our ability to analyze water consumption was limited, water consumption was shown to help the CTT in all subjects in the present study. The current study was also limited by the small sample size, which prevents any generalization of the study results. Therefore, further studies should be conducted with more subjects.

Other factors that can influence the CTT include physical characteristics such as weight, and height and age[4,5]. In our study, the average BMI of the subjects was 24.5 kg/m^2 for the men and 21.7 kg/m^2 for the women. Considering that the normal range of BMI reported by the World Health Organization was 18.5-25.0 kg/m^2 for adults, these values indicate that the South Korean adults who participated in this study were relatively healthy. The finding of a correlation between the TCTT and BMI in the male subjects, but not in the female subjects, showed that the BMI increased the CTT, as in previous studies. The precise mechanism between the BMI and CTT could not be explained, although possible reasons include differences in eating habits and living patterns.

In our study, the BMI was a factor contributing to the CTT in only males. Martelli *et al*[4] showed that the CTT of healthy older subjects (age 55-74 years) was longer on average than that of healthy young subjects (age 21-27 years). However, in our study, age did not correlate with the CTT for those aged 25-59 years.

Based on these results, significant gender differences were noted in the TCTT, RCTT and RSCTT. The BMI and fiber intake in males and fiber intake in females were shown to assist the CTT. Moreover, the intake of the fiber and water intake was shown to help the CTT in all subjects.

COMMENTS

Background

The recognized risk factors of colorectal cancer include westernized eating habits, obesity, insufficient physical activity and genetic factors. However, the effects of gender and individual behavior on the colon transit time (CTT) remain controversial.

Research frontiers

The impact of exercise and physical activity (PA) on the gastrointestinal and colonic tracts is an area of emerging interest, with recent research focusing on the potential benefits of PA.

Innovations and breakthroughs

The authors measured physical activity by accelerometer, colon transit time by radio-opaque marker method and food intake by the nutrient analysis program that are all very good and relevant. Colon transit time in South Korean general population showed gender difference and modulation of CTT by the intake of fiber and water.

Applications

CTT has a gender difference which are involved total calories, energy expenditure, physical activity, and water consumption. Regardless the gender, the intake of fiber and water modulated to reduce colon transit time. It can help the general advise for life habit with patients of constipation. A further study that including larger sample size and physical activity intervention may assist to elucidate the precise relationship between physical activity and colon movement.

Peer review

The authors have studied CTT according to physical activity and characteristics in South Korean, finding that significant gender differences in the total CTT, right CTT, and recto-sigmoid CTT adults. The manuscript is a good study and should be acceptable.

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