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ORIGINAL ARTICLE

Clinical Trials Study

Combined exercise improves gastrointestinal motility in psychiatric in patients

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Abstract

AIM

To examine the effect of combined exercise on colonic transit time (CTT) in admitted psychiatric patients.

METHODS

Over a 6-mo period, consecutive in patients with mental illness were recruited from the Somang Hospital Psychiatry Unit. A combined exercise program that included 60 min per day of exercise 3 d per week for 12 wk was performed. Physical fitness and CTT of the patients were measured twice before and twice after the exercise program. CTT was measured using a multiple marker technique with a radio-opaque marker. Changes in the exercising patients' CTT and weight-,

cardiovascular- and fitness-related parameters were statistically assessed.

RESULTS

After the 12-wk combined exercise intervention, decreased intestinal transit time was observed in all CTTs of the exercise group, including the right CTT (exercise: 15.6 ± 15.2 *vs* 9.2 ± 11.9, control: 13.1 ± 10.4 *vs* 10.9 ± 18.7), left CTT (exercise: 19.7 ± 23.5 *vs* 10.4 ± 13.2, control: 19.2 ± 19.0 *vs* 16.9 ± 19.8), recto-sigmoid CTT (exercise: 14.3 ± 16.7 *vs* 6.7 ± 7.9, control: 15.0 ± 14.4 *vs* 19.3 ± 30.3), and total colonic transit time (TCTT) (exercise: 50.2 ± 38.1 *vs* 27.1 ± 28.0, control: 47.4 ± 34.6 *vs* 47.3 ± 47.3). After the 12-wk combined exercise period, TCTT was significantly shortened in the exercise group compared with that in the control group. In addition to eating habits, water intake, and fiber intake, the increased physical activity level as a result of the 12-wk combined exercise program reduced the CTT.

CONCLUSION

The CTT of the psychiatric patients was reduced due to increased physical activity *via* a 12-wk combined exercise program.

Key words: Combined exercise; Constipation; Colonic transit time; Radio-opaque marker; Psychiatry unit patient

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Core tip: Maintaining physical activity routine for in patients of closed wards in mental health facilities remains a major challenge. Long-term inactivity is a risk factor for decreased gastrointestinal motility, which leads to constipation, weight gain, and related metabolic and cardiovascular disorders and can affect drug absorption. In this study, implementation of a 12-wk combined exercise program was shown to be beneficial in reducing colonic transit time and increasing leg strength.

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INTRODUCTION

The estimated incidence of colorectal cancer according to the 2014 Cancer Statistics in the United States was 5.8% (96830 people), and the estimated mortality rate was 8.5% (50310 people) of overall cancer mortality[1]. Colon cancer is the third most common cancer and reportedly affected 9.7% (1.2 million people) of the world's population in 2008[2]. The risk factors for colon cancer can be divided into physiological factors, such as age and heredity, and lifestyle factors, such as smoking, drinking, and poor eating habits. Among the risk factors for several colon cancers, constipation is a concern in many countries and is a factor that can be reduced by lifestyle changes.

According to cohort research in 2010, 4176 people reportedly suffered from constipation[3]. Typical symptoms of constipation according to the Rome Criteria are excessive squeezing, hard stools, sensation of incomplete evacuation, sensation of anal closure, ongoing treatment for evacuation, and an abnormal number of evacuations (less than 3 times a week)[4]. Constipation is diagnosed when two or more symptoms are concurrent. In addition, constipation types are classified into "slow colonic transit" and "pelvic floor dysfunction" categories[5].

"Slow colonic transit" refers to slow movement from the proximal colon to the distal colon and then to the rectum and is thought to be caused by poor dietary habits, cultural habits, and pathophysiology. The method for measuring "slow colonic transit" frequently involves a radio-opaque marker[6], and the results can form the basis of a constipation diagnosis; if the radioactive non-transmission marker remains in the colon for a long time (KolomarkTM, MJ Tech, Pyeongtaik Korea), then a decrease in colonic inertia and disordered evacuative function are indicated. Previous studies have shown that increased prevalence of constipation is correlated with decreased levels of physical activity (PA)[7-9].

Lower PA (*e.g.*, sitting, watching television) may increase the risk of low gastrointestinal (GI) motility, and colorectal cancer[10,11], obesity[12], and diabetes[13] on mentally ill patients in a closed ward. Promoting PA levels can be challenging for medical care system working with mentally ill patients in a closed ward.

Many studies have been conducted to identify strategies to reduce colonic transit time (CTT) and thus improve constipation, including changes in food intake and increasing PA[14-17].

Some studies have shown that increasing PA levels may help to short colon transit time and to prevent constipation on mentally ill patients. Recently, various studies have been conducted on the effects of combined exercise, which entails both aerobic and resistance exercises to maximize their effects. However, no studies have been conducted on the effect of combined exercise on mentally ill patients hospitalized in closed wards.

Although studies on aerobic exercise among the exercise therapies for colon peristalsis are increasing, research on the effect of combined exercise on constipation is limited. Therefore, we examined the effects of a combined exercise program on CTT and physical characteristics of mentally ill patients in a closed ward to provide basic evidence for prescribing a combined exercise program to patients alongside medication.

Table 1 Combined exercise program for 12 wk

Combined exercise program		
Frequency	60 min, 3 times/wk, 12 wk	
Exercise Program	Exercise (time): Contents	
Warm-up	Stretching (10 min): Various stretches	
Main exercise (40 min)	Resistance exercise[1] (20 min)	Aerobic exercise (20 min)
	Chest press Seated row Squat Shoulder press Bicep curl Tricep extension Calf raise Reverse crunch	Jogging/running
	10 reps, 2 sets	VO2max 60%
Cool-down (10 min)	Stretching (10 min): Various stretches	

[1]With Thera band.

MATERIALS AND METHODS

Participants

Consecutive male in patients with mental illness admitted for treatment in the closed ward of Somang Hospital Psychiatry Unit (Eumsung-gun, South Korea) over a 6-mo period were recruited to the study. Men with mental illness who did not participate in any regular exercise program over the past year were selected; the combined exercise group included 31 men, and the control group included 21 men. Among the forty men selected to participate in the combined exercise group, 9 men left the study due to personal illness, nonparticipation in exercise, or a change in medication. Among the thirty men selected to participate in the control group, 9 men left the study due to nonparticipation at the time of measurement, discontinuation of further exercise, or for personal reasons.

All subjects voluntarily provided informed written consent for the use of their data. Among all potential subjects, those with a restriction in normal PA, those with cardiovascular or orthopedic disease that could affect CTT, those who were unable to discontinue drugs due to functional stomach diseases, those who were on a prescription course of anti-constipation drugs, and those with diabetes mellitus or hypertension were excluded from the current analysis[18-20].

Combined training

All subjects in the exercise group were asked to perform a combined exercise program for 12 wk. Elastic band exercises and a running program were used for resistance exercise and aerobic exercise, respectively. The elastic band program based on the Thera-band manual was used to determine exercise intensity. The Thera-bands are color-coded to match various intensities (kg) and stretch lengths; according to the manual, the green band was used for this program. The first 2 wk served as an adjustment period; from the third week, the intensity increased from 10 RM to 15 RM with a 10-s rest period between each interval. According to the ACSM (2006) guidelines, aerobic exercise was regulated to achieve a maximum volume of oxygen (VO2 max) of 60% for target heart rate and was maintained using a Heart Rate Analyzer (Polar Electro OY, Finland). The combined exercise program is presented in Table 1.

Measurement of physical characteristics

Bioelectrical impedance analysis (Inbody 3.0, Biospase, South Korea) was used to measure height, weight, and body mass index (BMI). Blood pressure (BP) was measured using a sphygmomanometer (SPRIT CK-101, Sankei, Japan) in the supine position after a 5-min rest. Efforts were made to rule out any extrinsic factors that could affect blood pressure, such as temperature, degree of physical activity (PA), smoking, and diet[10,12]. Thigh circumference was measured as the distance around the fullest part of the thigh. Waist circumference was measured as the distance around the abdomen, just above the hip bones.

Measurement of fitness

Physical strength measurements included grip strength, leg strength, standing high jump, sit and reach, balance, and cardiopulmonary endurance. Grip strength was measured using a dynamometer (T.K.K 5401, Japan), leg strength was measured using a leg-extension machine (to measure isometric knee extensor force) (T.K.K 5710M, Japan), and vertical jump was measured using a Sargent jump measurement device (T.K.K 5406, Japan). The cardiopulmonary function evaluation was performed using the YMCA step test. Heart rate was measured during recovery after the subject stepped up and down repeatedly on a 30.5-cm high step box 24 times per minute to a metronomic beat of 96 beats per minute for 3 min[18,20].

Measurement of CTT

CTT was measured twice, after exercise and before exercise using a multiple marker technique with a radio-opaque marker. The subjects were given one gelatin capsule containing 20 radio-opaque markers at the same time every day for three days (Kolomark™, MI Tech, Pyeongtaik, South Korea). At the same time on days 4 and 7, supine abdominal radiography was performed. The mean CTT (in hours) was calculated by counting the number of radio-opaque markers remaining in the entire colon and in the segments of the colon and then multiplying this number by 1.2[6,8,21-23].

Statistical analysis

The study data, expressed as the means ± SD, were analyzed using SPSS PC+ for Windows, version 18.0 (SPSS Inc., Chicago, IL, United States). Changes in fitness and segmental colon transit time pre- and post-

Table 2 Changes in the physical characteristics of the subjects after 12 wk of combined exercise training

Variable	Combined exercise (n = 31)		Control (n = 21)		P
	Pre	Post	Pre	Post	
Age (yr)	48.8 ± 9.5		49.9 ± 11.2		
Height (cm)	165.6 ± 6.7	165.7 ± 6.6	168.2 ± 4.1	167.8 ± 5.2	0.804
Weight (kg)	70.9 ± 12.8	69.1 ± 11.3	68.6 ± 13.9	67.0 ± 14.3	0.961
BMI (kg/m^2)	25.8 ± 4.4	25.0 ± 3.9	24.1 ± 4.1	24.2 ± 4.7	0.557
Lean body mass (kg)	47.4 ± 7.1	49.2 ± 8.1	44.7 ± 5.2	46.8 ± 7.3	0.890
Body fat percentage (%)	30.7 ± 9.5	28.0 ± 9.3	33.4 ± 10.4	30.9 ± 9.2	0.913
SBP (mmHg)	122.0 ± 20.1	115.7 ± 15.4	125.9 ± 16.9	112.8 ± 19.3	0.075
DBP (mmHg)	79.3 ± 10.2	73.8 ± 9.2	87.1 ± 15.3	76.9 ± 13.1	0.154
Resting heart rate	88.1 ± 15.7	81.2 ± 11.9	87.4 ± 10.2	80.5 ± 8.5	0.980
Thigh circumference (cm)	42.6 ± 5.9	47.0 ± 11.4	44.0 ± 6.0	46.3 ± 8.5	0.496
Waist circumference (cm)	90.8 ± 12.2	87.5 ± 11.7	91.8 ± 12.7	90.5 ± 14.6	0.532

The values are shown as the mean ± SD. BMI: Body mass index; SBP: Systolic blood pressure; DBP: Diastolic blood pressure.

Table 3 LChanges in the physical fitness of the subjects after 12 wk of combined exercise training

Variable	Combined exercise (n = 31)		Control (n = 21)		P
	Pre	Post	Pre	Post	
Grip strength (kg)	25.8 ± 9.3	28.0 ± 8.6	29.5 ± 10.0	29.3 ± 8.2	0.113
Leg strength (kg)	42.5 ± 21.0	62.6 ± 21.6[b]	42.4 ± 15.2	42.8 ± 5.5	0.009[d]
YMCA step test (beat per min)	122.4 ± 16.0	111.0 ± 13.9	120.3 ± 16.4	119.6 ± 11.7	0.084
Vertical jump (cm)	21.5 ± 10.1	27.8 ± 11.2[f]	21.5 ± 12.2	24.3 ± 11.2	0.159
Sit and reach (cm)	4.3 ± 8.9	5.7 ± 8.8[a]	3.9 ± 8.5	5.4 ± 8.1	0.549

The values are shown as the mean ± SD. The change in leg strength reflect the difference in the time × group interaction between the exercise and control groups ([d]P = 0.009); Significant differences between pre and post combined exercise group in leg strength ([b]P = 0.003). Significant differences between pre and post combined exercise group in vertical jump ([f]P = 0.001). Significant differences between pre and post combined exercise group in sit and reach ([a]P = 0.033).

exercise training were assessed by two-way repeated ANOVA. A value of $P < 0.05$ was considered statistically significant.

RESULTS

Changes in the physical characteristics of the subjects after 12 wk of combined exercise training

The physical characteristics of the subjects are shown in Table 2. The subjects in the exercise group showed decreases in body fat percentage (baseline: 30.7 ± 9.5 *vs* study-end: 28.0 ± 9.3), systolic blood pressure (SBP) (122.0 ± 20.1 *vs* 115.7 ± 15.4), diastolic blood pressure (DBP) (79.3 ± 10.2 *vs* 73.8 ± 9.2), resting heart rate (88.1 ± 15.7 *vs* 81.2 ± 11.9), and waist circumference (90.8 ± 12.2 *vs* 87.5 ± 11.7); however, the patients showed increases in lean body mass (47.4 ± 7.1 *vs* 49.2 ± 8.1) and thigh circumference (42.6 ± 5.9 *vs* 47.0 ± 11.4). No significant differences in demographic variables (*e.g.*, age, height, BMI, lean body mass, body fat percentage, SBP, DBP, resting heart rate, thigh circumference, and waist circumference) were shown between the combined exercise group and the control group.

Changes in the physical fitness of the subjects after 12 wk of combined training

The changes in physical fitness variables for the subjects are shown in Table 3. The patients in the exercise group showed significant improvement in leg strength (42.5 ± 21.0 *vs* 62.6 ± 21.6, P = 0.009). The improvements in grip strength, YMCA step test, vertical jump, and sit and reach exhibited by the exercise group (grip strength, 25.8 ± 9.3 *vs* 28.0 ± 8.6; YMCA step test, 122.4 ± 16 *vs* 111.0 ± 13.9; vertical jump, 21.5 ± 10.1 *vs* 27.8 ± 11.2; and sit and reach 4.3 ± 8.9 *vs* 5.7 ± 8.8) were not significantly different from the control group (grip strength, 29.5 ± 10.0 *vs* 29.3 ± 8.2; YMCA step test, 120.3 ± 16.4 *vs* 119.6 ± 11.7; vertical jump, 21.5 ± 12.2 *vs* 24.3 ± 11.2; sit and reach 3.9 ± 8.5 *vs* 5.4 ± 8.1) (exercise *vs* control, P = 0.113, P = 0.084, P = 0.159 and P = 0.549 for grip strength, YMCA step test, vertical jump, and sit and reach, respectively).

Changes in segmental colon transit time among the subjects after 12 wk of combined exercise training

Table 4 shows colon transit times according to colon segments among the subjects after the 12-wk combined exercise program. Right colonic transit time (RCTT) (15.6 ± 15.2 *vs* 9.2 ± 11.9), left colonic transit time (LCTT) (19.7 ± 23.5 *vs* 10.4 ± 13.2), recto-sigmoid colonic transit time (RSCTT) (14.3 ± 16.7 *vs* 6.7 ± 7.9), and total colonic transit time (TCTT) (50.2 ± 38.1 *vs* 27.1 ± 28.0) decreased in the combined exercise group. In contrast, in the control group, only the RCTT (13.1 ± 10.4 *vs* 10.9 ± 18.7, P = 0.593) and LCTT (19.2 ± 19.0 *vs* 16.9 ± 19.8, P =0.489) were decreased, whereas the RSCTT (15.0 ± 14.4 *vs* 19.3 ± 30.3, P =

Table 4 Changes in segmental colon transit time among the subjects after 12 wk of combined exercise training

Variable	Combined exercise (n = 31)		Control (n = 21)		P
	Pre	Post	Pre	Post	
RCTT (h)	15.6 ± 15.2	9.2 ± 11.9	13.1 ± 10.4	10.9 ± 18.7	0.370
LCTT (h)	19.7 ± 23.5	10.4 ± 13.2[f]	19.2 ± 19.0	16.9 ± 19.8	0.207
RSCTT (h)	14.3 ± 16.7	6.7 ± 7.9	15.0 ± 14.4	19.3 ± 30.3	0.041[a]
TCTT (h)	50.2 ± 38.1	27.1 ± 28.0[h]	47.4 ± 34.6	47.3 ± 47.3	0.019[d]

The values are shown as the mean ± SD. The change in RSCTT reflects the difference in the time × group interaction between the exercise and control groups ([a]P = 0.041). The change in TCTT reflects the difference in the time × group interaction between the exercise and control groups ([d]P = 0.019). Significant differences between pre and post combined exercise group in LCTT ([f]P = 0.040). Significant differences between pre and post combined exercise group in TCTT ([h]P = 0.017). RCTT: Right colon transit time; LCTT: Left colon transit time; RSCTT: Recto-sigmoid colon transit time; TCTT: Total colon transit time.

0.412) increased. The items with significant differences between time points and groups were the RSCTT (P = 0.041) and TCTT (P = 0.019).

DISCUSSION

We analyze that the effect of combined exercise on CTT of mentally patients in a closed ward through a combined exercise program including resistance training with an elastic band and an aerobic exercise. Implementation of the combined exercise program resulted in a significant improvement in muscle strength and decreased colon transit time in the exercise group compared with that before the program.

In general, patients held in a closed ward lack PA because of long-term hospitalization and medical treatment. Therefore, various consequences, such as obesity, weakening of heart function, and depressive symptoms, manifest due to lethargy, weight increases, and muscle weakness. Problems such as lack of physical strength and symptoms of constipation in schizophrenic patients can be reduced by implementing the exercise program presented in this study as an alternative to medication.

The results of this study are meaningful, as they provide baseline physical fitness data among schizophrenic subjects and their data after a 12-wk combined exercise program aimed at schizophrenic patients. The results of the combined exercise program show that leg strength significantly improved.

Among the many studies examining the direct relationship between exercise and colon transit time between two groups of subjects, one study included one group that engaged in a sedentary lifestyle for one week and another group that participated in aerobic exercise 3 times in the same week. However, significant differences were not observed in colon transit time between the sedentary lifestyle group and the exercise group[24]. In addition, another study reported that 4 wk of aerobic exercise did not improve constipation[25]. However, in these previous studies, the exercise effect was observed over a relatively short period (1-4 wk). In this research, although the transit time of each colon segment decreased, it was not significantly reduced compared with that in the control group. The reduced colon transit time in the control group was attributed to the effect of balanced meals and a regular lifestyle during hospitalization. Although significant differences in the colon transit time of RCTT and LCTT were not observed, the RSCTT and TCTT were significantly reduced in the exercise group compared with those in the control group. The results of this research may be related to the relatively long-term (12 wk) observation period compared with that in previous research. Therefore, combined exercise can improve constipation by reducing the colon transit time, thus preventing colon cancer. Moreover, the colon transit time decreased despite general confounding variables, which were well controlled in this study because the patients in the exercise group and the control group were admitted to closed wards. Future research is required to examine the effects of exercise on colon transit time and constipation according to the dose of exercise, the exercise type, and exercise intensity in a greater number of subjects. This research showed that increased PA through long-term exercise (12 wk), in addition to eating habits, water intake, and dietary fiber intake, can reduce the colon transit time. Additionally, the results indicated that the risk of colon cancer can be reduced through exercise, which has an effect on functional constipation relief. This research is significant, as it provides basic evidence in support of prescribing exercise to specific patients who are admitted to a closed ward. In conclusion, among the patients who were admitted to a closed ward, participation in an exercise program improved leg strength and reduced colon transit times. Therefore, regular exercise is considered essential to improve physical health and reduce colon transit times among schizophrenia patients.

ARTICLE HIGHLIGHTS

Research background

The importance of exercise in the prevention of colorectal cancer has been well documented. However, an insufficient number of studies have examined the effects of the exercise or type of exercise on a colonic transit time (CTT). This study was performed to identify differences in CTT depending on the combined exercise. This study was designed to investigate the relationship between

combined exercise and colon transit time in mentally ill patients to elucidate how a combined exercise program could promote gastrointestinal (GI) motility.

Research motivation

The previous studies that have investigated the effects of increasing physical activity by participation in an exercise program and changes in CTT have largely involved healthy subjects with a normal lifestyle. However, no studies reported in the publicly available literature to date have reported on the effects of exercise on colonic function in mentally ill patients residing in a closed hospital ward. Therefore, we examined the effect of a combined exercise program on CTT among mentally ill patients who were admitted to a closed ward.

Research objectives

The research objective of this investigation was to examine the effects of physical activities and exercise on CTT in mentally ill patients in a closed ward and determine whether physical activity and exercise improve GI motility.

Research methods

Over a 6-mo period, 52 consecutive patients with mental illness were recruited from the Somang Hospital Psychiatry Unit. A combined exercise program was implemented 60 min per day, 3 d a week, for 12 wk. Fitness and CTT were measured twice before and twice after the exercise program. The CTT of patients in the two groups were compared for different clinical situations (combined exercise group vs control group).

Research results

The patients in the exercise group showed exercise-induced improvement in leg strength. Improvements in grip strength, YMCA step test, vertical jump, and sit and reach were also exhibited by the exercise group. Segmental colon transit times (RSCTT and TCTT) decreased in the combined exercise group. The results of this study are meaningful, as they provide physical fitness data for mentally ill patients at baseline and after a 12-wk combined exercise program aimed at this population.

Research conclusions

This research is significant, as it provides basic evidence in support of prescribing exercise to specific patients who are admitted to a closed ward. Among the patients who were admitted to a closed ward, participation in an exercise program improved leg strength and reduced CTT. Therefore, regular exercise is considered essential to improve physical health and reduce CTT among mentally ill patients.

Research perspectives

One of the most common signs of low GI motility is constipation. An important cause of low GI motility, and one of the easiest to correct, is physical inactivity. A long-term (12-wk) combined exercise program is sufficient to reap the potential benefits for GI motility and positively impact fitness and CTT to affect the overall health of mentally ill patients.

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