RESEARCH PAPER

Core Stability Exercises Versus Tai Chi Exercises on Dynamic Balance After Colo–Rectal Surgeries

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Received: 04th June, 2026; Revised: 25th June, 2026; Accepted: 28th June, 2026; Available Online: 20th July, 2026

ABSTRACT

Objectives: To compare core stability exercises effects with Tai Chi exercises program on dynamic balance and back pain in the patients after Colo-rectal surgeries.

Material and methods: In this single-blinded, randomized parallel-group trial, sixty participants who undergone colorectal surgeries, between 25 and 40 years, were put in a random way in two groups equal in size: Group A (Core stability group) participated in a core stability training program in addition to conventional physiotherapy program, while Group B (Tai Chi group) received Tai Chi exercises alongside with conventional physical therapy program. Both groups performed the exercises in 3 sessions/week for 8 weeks. The dynamic balance was the primary outcome and was evaluated by both Star excursion balance test (SEBT) and Berg balance scale (BBS), while secondary outcome was pain intensity assessed by the visual analogue scale (VAS). Data was collected at start and after 8 weeks.

Results: Analysis of post-treatment outcomes revealed significant improvements in VAS, SEBT, and BBS scores in the two groups ($p < 0.001$). Comparing the two groups has shown that Core Stability Group achieved significantly better post-treatment scores than Tia chi Group ($p < 0.001$).

Conclusion: Core stability exercises may have a short-term effect in enhancing dynamic balance and decreasing back pain than Tai Chi exercises in patients following colorectal surgeries. Therefore, core stability exercises can be recommended as a preferred intervention to optimize balance performance and decrease the falling risks.

Keywords: Colo-rectal Surgeries, Core Stability Exercises, Tai Chi Exercises, Dynamic Stability, Back Pain.

How to cite this article: Aziz M.V, Abd El Baky A.M, Shabaan E.E, Ali K.M, Core Stability Exercises Versus Tai Chi Exercises on Dynamic Balance After Colo–Rectal Surgeries. 2026;16(69s): 399-407. DOI: 10.25258/ijddt.16.69s.44

Source of support: None

Conflict of interest: None

INTRODUCTION

Colo rectal cancer Is a type of cancer that starts slowly at the beginning as an inner lining of the rectum or colon growth (1). Toping as third common type of cancer and the second as cancer related deaths cause around the world; with more than 1.9 million patients discovered and 904,000 cases of death in 2022 (2). For Egypt, the incidence of early onset CRC represents 42.4% (3). Moreover, there is an increasingly occurrence rate of CRC in the young age, and more percentage of cases are expected to occur in the age group between 20–49 years by 2030. The primary method of treating CRC is surgical intervention (4).

After surviving CRC patients face various sequels of both the illness and its management that cause suffering of immense morbidities of physical, social, and mental aspects resulting from exposure to different treatment methods that may include surgery, chemotherapy and radiotherapy these morbidities usually continue even after the treatments have ended (5,6). The physical complications due to cancer and its management include neuropathic pain from direct effects on nerves (7), gait and balance disorders affecting activities daily living (8), and muscle weakness which is associated with physical disabilities, deterioration in life quality, impaired treatment tolerance, and may also lead to shorter survivability (9). Thus, post CRC patients need medical help to maintain their healthy life style.

Exercise-based rehabilitation programs have been shown to enhance neuromuscular coordination, proprioception, and muscle strength, all of which are fundamental for improving balance performance (10). Core stabilization exercises (CSE) help in improving control of neuromuscular system, muscular strength and endurance as it targets the deep trunk muscles that have connections with the pelvis, shoulders and the spine and it assists in maintaining balance aslo giving a stable base for the extremities movements (11). Furthermore, CS training has the ability to reverse the motor cortex engramming due to pain, improve muscular performance and restore the spinal stability function of the trunk muscles (12).

Tai Chi (TC) exercises, which is a Chinese traditional practice enhancing both the mind and the body teaming slow, careful movements patterns, rhythmic diaphragmatic breathing, and meditation (13). Tai chi uses slow movements performed while the person is semi squatting using the coordinated movements in addition to meditation practicing. There are 8 forms of simplified Tai Chi practices which have been proved to decrease the falling risk in old aged population and to improve the balance of the old aged people (14). The Tai Chi exercises frequently address the balance and stability of the practitioner while doing the exercises thus Tai Chi leads to improving the balance and the stability of the person in life situations when balance

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and stability are needed (15), improving flexibility, strength of muscles and enhancing the function of proprioceptors , flexibility, which are the most important factors in low back pain, it also decreases stress, sleeping problems which also cause increase in pain and disability in the patients (16).

Despite both core stability exercises and Tai Chi have demonstrated goof effects on balance (11, 15) and pain (12, 16), their underlying mechanisms differ. Core stability exercises primarily focus on trunk muscle activation and biomechanical stability, whereas Tai Chi integrates sensorimotor, cognitive, and postural control processes. However, there is limited evidence directly comparing these two interventions, particularly in patients following colorectal surgeries. Identifying the most effective intervention is essential for optimizing rehabilitation strategies and improving postoperative recovery. Therefore, the goal of current study is comparison of the effects of core stability exercises versus Tai Chi exercises on dynamic balance in patients after colorectal surgeries.

The materials and the methods

Study design

The study was performed as a single-blind (Assessor only), randomized parallel-group trial that was performed from February 2025 to February 2026 at oncology unit of Materia teaching Hospital, Cairo. Following the ethical guidelines set forth in the Declaration of Helsinki and was approved by the Ethics Committee of the Faculty of Physical Therapy at Cairo University University (P.T.REC/012/004061). At the beginning of the study, it was registered on ClinicalTrials.gov under the identifier (NCT07451444). All participants were informed in details about the study's goals and steps, and about their right to withdraw the study at any time without facing any consequences. Participants signed the consent form before participating in the study. The study protocol was conducted in accordance with CONSORT reporting guidelines **(Figure 1).**

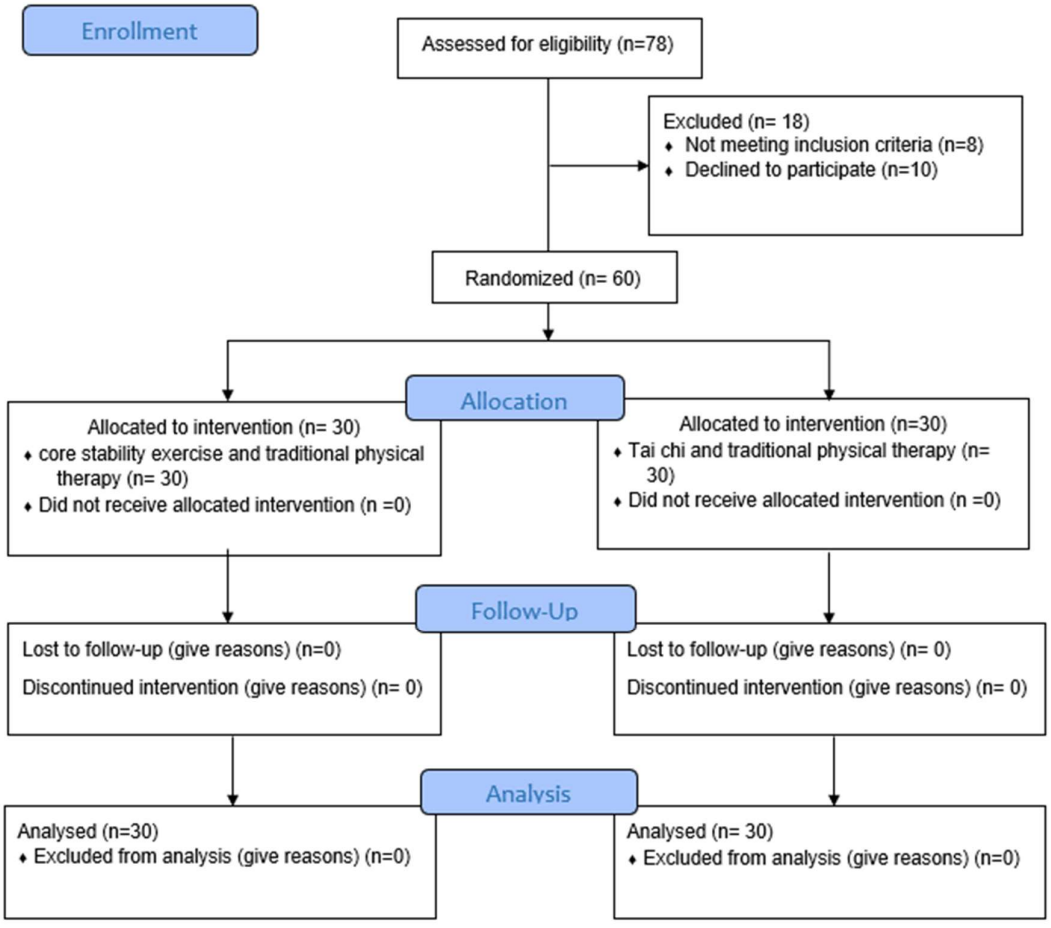

Figure 1. Consort flow chart of the study.

Participants

A total of 60 participants who had undergone colorectal surgeries were assigned in this randomized controlled trial. The inclusion criteria were: adults aged 25 and 40 years, 10 days after colo-rectal surgeries and/or complete incision healing. Participants were required to be hemodynamically stable postoperatively, and able to ambulate independently without assistive devices. and had a body mass index (BMI) < 30 kg/m² to ensure safe participation in rehabilitation. Patients were excluded if they were hypertensive, diabetic, suffering from previous neurological problems, low back pain before surgery, or suffering from balance problems.

Sample size calculation

Calculating the sample size using balance as reported from pilot study, with 90% power at $\alpha = 0.05$ level, number of measurements 2, for 2 groups and effect size = 0.45 using F-test MANOVA repeated measures within and between interaction. proper sample size was a minimum of 54 subjects, 6 subjects was added (11% as drop out), so total sample size is 60 subjects, 30 subjects in each group. sample size calculated using the G*Power software (version 3.0.10) **(Figure 2).**

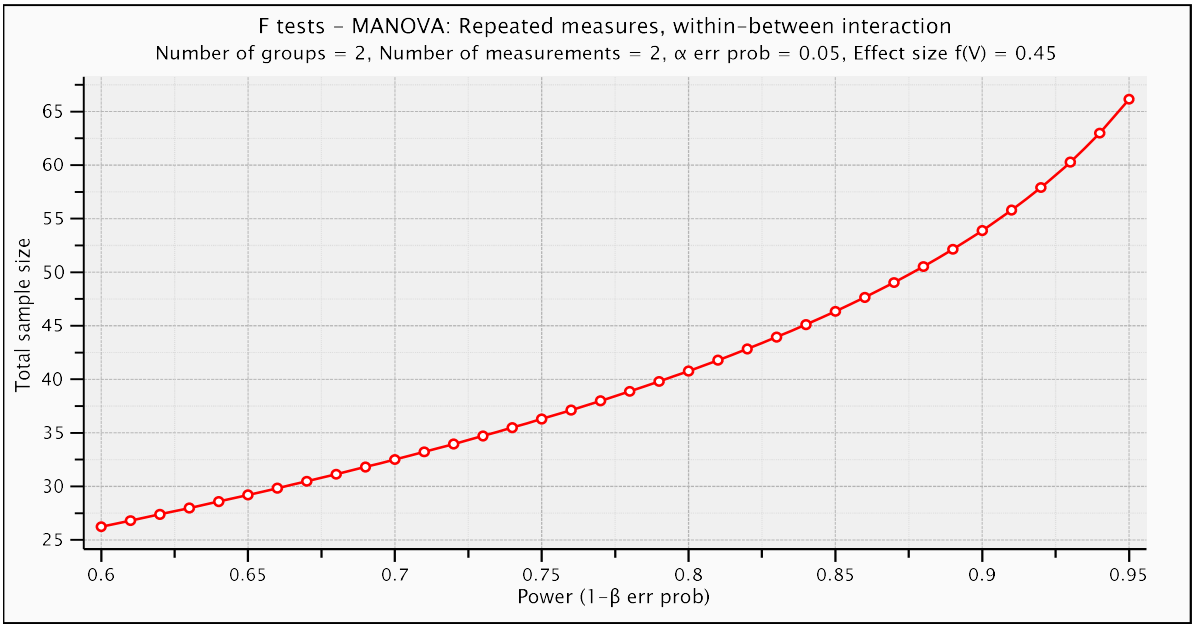

Figure 1. Sample size Calculation

Randomization

Sixty participants who undergone colorectal surgeries chosen randomly 30 for group A (Core stability group) and 30 for group B (Tai chi group) utilizing the block randomization program created at http://www.randomization.com/. To decrease bias and group variability, subjects had been chosen randomly with1:1 ratio. Randomization was done by a research assistant with no contribution in the treatment program, collecting data, or selecting subjects. To assure unbiased subject choice, random codes were consecutively marked and held unknown in closed dark files.

Outcomes measures:

Assessment of outcome measures was done by a researcher who was blinded to the group allocation. Subjects' demographic data such as BMI, weight, both leg lengths, chemotherapy and number of radiotherapy sessions if any received were listed before the study. The primary outcome measure was dynamic balance measured using star excursion balance test and Berg balance scale. While visual analogue was used for measuring secondary outcome (low back pain).

Primary outcome measure

- *Star Excursion Balance Test (SEBT)*

The SEBT which has a high intra rater reliability was used to measure the dynamic balance with the intra class correlation coefficient (ICC)= 0.87 for dominant leg and 0.74 for nondominant leg (17). The subject was told to keep his balance while he reaches with his free lower limb as far as he can (Starting from the anterior, anterolateral, lateral, posterolateral, posterior, posteromedial, medial, and anteromedial directions) while squatting on the other limb, then to return to standing position. As he reaches further the reach the better the subjects balance. The subject fails if he lost balance at any point of the test, if he moved his supporting foot, if he missed a tape line or if he lifted his hands from beside his hips. The distances of the reaches are divided with the subjects leg length (from the anterior superior iliac spine and the medial malleoli) and expressed as 'normalised' percentages. The scores are calculated for each direction separetly, a summation of the scores of all

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directions for each person is calculated then divided by the directions number to make composite score. The average of three trials in each direction is calculated to be analyzed. (18).

- *Berg Balance Scale (BBS)*

A 14 items scale used in assessing balance the items including standing and sitting without support. Forward reaching, and putting legs alternately on a stool. With an inter rater reliability with ICC= 0.992-0.994 (19) its considered with high inter rater reliability. The total time to finish the scale is 15 minutes. The scoring of the fourteen items are graded from 0 to 4 on a 5-level ordinal scale from 0 ("unable or requiring help") to 4 ("normal"), so the maximum points is 56 and the more points you get the better your balance is (20).

Secondary outcome measure

- *Visual analogue scale (VAS)*

VAS scale is a way to assess pain with a high validity its used to assess the patients pain perception. A 10 cm scale is used the pain is scaled from 0 (no pain) to 10 (the worst pain ever) grades from one to three are considered mild, four to six are moderate and seven to ten are sever pain. The participant was instructed to mark the point reflecting the degree of pain he or she was feeling, the further the mark from the zero point the greater the pain the subject feels (22).

Intervention

Two groups of patients were formed among which the sample of 60 participants was divided randomly each consisting of 30 patients. The two groups each assigned to a different intervention: GroupA (Core stability group) (n=30) who practiced core stability exercises along with conventional physio therapy and GroupB (Tai chi group) (n=30) who received Tai chi exercises plus conventional physical therapy. The training was to be practiced 3 times / week for 8 weeks. Before starting the intervention, familiarization sessions was done to all patients who participated to review the recommended training and to receive guidance on appropriate exercise techniques.

- *Core stability exercise program*

Core stability exercise program started with 10 minutes warming up including stretching and range of motion exercises for trunk and lower limbs. The exercise program lasted for 20 min/session which was carried out by a specialized physical therapist and followed by 5 min cooling down including stretching exercises. The core stability exercises including abdominal drawing-in maneuver, aiming to enhance the skills of neuromuscular control, aiding in relearning normal function and to improve strength and muscle indurence of the muscles around the lumbar region, such as the transversus abdominis (TrA) and lumbar multifidi (LM) muscles, to keep static and dynamic balance. As shown in Supplementary **(1)** the exercise program was a 3 phases program that took 8 weeks to implement. The 1st phase (1-2 weeks) isolating the TrA and LM muscles was learned well. low-load activation using an abdominal drawing-in maneuver (ADIM) technique. The 2nd phase (3-6 weeks) introduction of controlled upper and lower limbs movements to provide low load exercises for the muscles. The last phase (7-8 weeks) integrated co activation into functional movements (23).

- *Tai Chi exercise program*

Tai Chi training performed for sixty min of Yang Style 8-Form as it's the most gentle Tai chi form and it can be easily tailored according to the physical abilities of any person . Each session started with checking the home program practicing, 10 min of postural exercises and abdominal breathing warming up exercises (24, 25), then forty-five minutes Tai Chi consisted of Tai Chi walking drills and the eight forms including: Commencing Form, Repulse Monkey, Grasp Peacock's Tail, Wave Hands Like Clouds, Fair Lady Works at Shuttles, Golden Cock Stands on One Leg, Brush Knees, and Closing Form. The intial form included moving the upper limbs, such as Commencing Form, requiring minimal control pf posture and the coordination of the whole body. More difficult movements are introduced gradually increasing the difficulty requiring more postural and coordinational control of the whole body, such as Brush Knees (with breaks of 12 to 15 min), and 5 min of cooling down accompanied with breathing exercises (15).

- *Conventional physical therapy*

Including light intensity walking stretching and relaxation the conventional program of physical therapy was practice beside both the CSE and the Tai Chi training. At the beginning of each session 15 min of low intensity ambulation (60% – 65% of the HRmax) then 30 min stretching of large muscles . At the end 15 min of breathing deeply, meditation and relaxation are performed. (15).

Statistical analysis

The expression of data was performed as mean ± SD. Using ANOVA in comparing the subjects characteristics in both groups. using Shapiro-Wlik test to test data distribution normality. Repeated measures MANOVA was utilized for the comparison of within and between groups' effects for measured variables. Statistical package for the social sciences computer program (version 20 for Windows; SPSS Inc., Chicago, Illinois, USA) utilized for analyzing the data. *P* less than or equal to 0.05 was considered significant.

RESULTS:

General characteristics of the subjects:

As shown in **Table (1),** there was no statistically significant difference between groups in the mean values of subjects age, weight, height and BMI (p=0.879, 0.842, 0.180 and 0.302) respectively.

Table (1): ***General characteristics of subjects of both groups.***

Subject characteristic	Group A	Group B	t-value	p-value
Age (years)	30.8 ± 4.38	30.63 ± 4.03	0.153	0.879
Weight (kg)	73.23 ± 3.82	73.43 ± 3.91	-0.20	0.842
Height (cm)	177.27 ± 4.58	178.8 ± 4.17	-1.36	0.180
BMI (kg/m^2)	23.32 ± 0.82	23.05 ± 1.15	1.04	0.302

Data was expressed as mean ± standard deviation

Shapiro-Wilk test for normality showed that all variables were of a normal distribution. For analysis of the treatment effect on the variables repeated measures MANOVA were conducted, and revealed statistical significance of the effect of treatment Wilk's A= 0.693; F (3, 56) = 8.25 ($p<0.001$), η^2 = 0.307. For the effect of time Wilk's A= 0.055; F (3, 56) = 322.92 ($p<0.001$), η^2 = 0.945 and interaction effect (treatment * time) Wilk's A= 0.150; F 3, 56) = 105.69 ($p<0.001$), η^2 = 0.850

Pain intensity:

Regarding within group comparisons, a statistically significant decrease in mean value of VAS in both groups post study compared to pre study (p = 0.001) was found. For between groups comparison**,** and no statistically significant difference in the mean values of VAS pre-study between both groups (p = 0.721). On the contrary a statistically significant decrease in VAS post study in group A than group B (p = 0.001) **(Table 2).**

Table (2): ***Comparison between pre- and post-treatment mean values of VAS between and within groups***

VAS (cm)	Group A	Group B	MD (95% CI)	P value	η^2
Pre-treatment	7.2± 1.13	7.1 ± 1.03	0.1 (-0.46, 0.66)	0.721	0.002
Post-treatment	3.1 ± 0.96	4.03 ± 0.93	-0.93 (-1.42, -0.45)	0.001*	0.202
MD (95% CI)	4.1 (3.66, 4.54)	3.07 (2.63, 3.51)			
% of change	57%	43%			
(P-value)	0.001*	0.001*			

*Data is represented as mean ±SD, *: significant, η^2: partial eta square, MD: mean difference, CI: confidence interval*

Balance:

A statistically significant decrease in mean value of SEBT in both groups A and B post study was found in comparison to pre study (p = 0.001 and 0.016) respectively. Regarding between groups comparison, there was no significant difference in the mean values of SEBT pre-study between the two groups (p = 0.827). While there was statistical significant difference post study (p = 0.001) in favor to group A. There was statistical significant increase in mean value of BBS in both groups post study compared to pre study by 9% (p = 0.001). For the comparisons between the both groups, no significant difference in the mean values of BBS pre-study between both groups (p = 0.413). While there was a statistically significant increase in BBS post study in group A than group B (p = 0.001) **(Table 3).**

Table (3): ***Comparison between pre- and post-treatment mean values of SEBT and BBS between and within groups***

	Group A	Group B	MD (95% CI)	P value	η^2
Star excursion balance test score Pre-treatment	64.37± 7.6	64.83 ± 8.4	-0.46 (-4.59, 3.69)	0.827	0.001
Post-treatment	73.33 ± 6.57	63.82 ± 7.89	9.51 (5.76, 13.26)	0.001*	0.307
MD (95% CI)	-8.96 (-9.77, -8.13)	1.01 (0.19, 1.38)			
% of change	14%	1.6%			
(P-value)	0.001*	0.016*			
Berg balance scale					
Pre-treatment	40.4± 2.72	39.83 ± 2.6	0.57 (-0.81, 1.94)	0.413	0.012
Post-treatment	47.53 ± 2.13	43.47 ± 2.96	4.07 (2.74, 5.4)	0.001*	0.392
MD (95% CI)	-7.13 (-7.89, -6.38)	-3.63 (-4.39, -2.88)			
% of change	14%	9%			
(P-value)	0.001*	0.001*			

*Data is represented as mean ±SD, *: significant, η^2: partial eta square, MD: mean difference, CI: confidence interval*

DISCUSSION:

The findings of the current study have demonstrated that incorporating CSE into a conventional physiotherapy program yields significantly greater gains in balance and reducing pain compared with the addition of Tai Chi exercises in patients following colorectal surgery. At the end of the study period that extended for eight weeks, patients in the core stability group demonstrated superior outcomes, with statistically significant differences observed ($p < 0.001$).

CSE enhances balance after colorectal surgery through combining mechanical and neuromuscular mechanisms that restore trunk control and postural stability. The trunk muscles function synergistically during both voluntary and unexpected movements and play a key role in anticipatory postural adjustments (26), the core stability exercises benefits the timing and coordination of muscle activation (27). Postoperatively, reduction of deep stabilizers activation such as the transversus abdominis due to pain and muscle inhibition, affecting balance and leading to trunk stiffness; CSE counteract this by promoting co-contraction of abdominal and spinal muscles, increasing intra-abdominal pressure, and stabilizing spine (28). This enhanced stability minimizes center-of-mass displacement and improves alignment during dynamic activities. Additionally, core training enhances proprioception and neuromuscular responsiveness, allowing quicker and more effective reactions to perturbations. Together, these adaptations lead to improved dynamic balance and functional mobility, supported by evidence showing increased abdominal activation and balance performance following trunk stabilization training (23, 29). In the present study, CSE targeted the localized abdominal and back musculature to enable earlier ambulation and gait training, which in turn contributed to improved balance following colorectal surgery. In accordance with this finding, trunk stabilization training significantly enhanced standing balance, postural alignment (30), and trunk control in stroke population (31). Adding CSE to physical therapy treatment program was found to have a significant improvement of the postural stability and both static and dynamic balance in patients stuffing from stroke in comparison conventional physical therapy alone as shown in a systematic review and meta-analysis (32).

Tai Chi might increase balance by improving sensory integration and neuromuscular coordination. Its slow, controlled movements and continuous weight transfer stimulate vestibular, visual, and proprioceptive inputs, resulting in improved control of posture and reduction of swaying (33). Additionally, repeated single-leg and coordinated movement patterns strengthen lower-limb proprioception and joint stability, thereby enhancing both static and dynamic balance and lowering fall risk (34). TC as a training technique for balance and coordination has been found to enhance the control of posture and improve balance decreasing the falling risks (35). TC can induce greater improvement in balance at old age (36). In a systematic review and meta-analysis TC improves related balance ability in both healthy elders and also in elderly with chronic illnesses such as arthritis, COPD or fibromyalgia (37). Also, a meta-analysis indicated that individuals at low risk of falls may achieve meaningful improvements in balance following a three-month Tai Chi intervention (38). TC exercise has had a significant improvement in balance and decreasing the falling tendency in elderly population. Evidence suggests that short-term interventions lasting ≤12 weeks, particularly those involving more than two 45-minute sessions per week, yield greater improvements in balance outcomes (39). But, recent randomized controlled trial has shown that TC has a lesser effect than other types of exercises in improving both active and reactive balance, this may be because of the low speed moves involved in tai chi training(15).

A well-supported explanation for why CSE can outperform Tai Chi in balance improvement might be attributed to that CSE more directly target the deep trunk muscles that help keeping the centre of gravity of the person inside its base of support, especially in unstable situations, as opposed to Tai Chi's slow, continuous movements that primarily develop general proprioception and controlled weight shifting. This targeted activation improves dynamic balance and anticipatory postural modifications, particularly when reacting to abrupt disturbances. Because of this, core training's higher intensity and instability may more successfully trigger quick neuromuscular reactions and trunk control, resulting in more noticeable improvements in balance (11).

This study's findings have shown that CSE had significantly greater improvements in pain reduction compared with TC exercises in patients following colorectal surgery, after an 8-week intervention ($p < 0.001$). The main mechanisms behind the pain relieving might be attributed to the ability of CSE to decrease any malfunction or effect in the motor control around the spinal segment neural area, as it restores the surrounding muscles normal stabilizer function, and in addition to the increased chance that the contractile action of the muscles during the stabilization of the spine exercises activating the pain inhibitory system in the CNS as a direct result of the sensory input improving levels of blood serotonin, as a possible explanation of pain relief due to spinal stabilization. (40). In line with our findings, CSE group showed more decrease in pain scores in comparison to the strengthening exercise group in patients with subacute nonspecific low back pain (41). It was also superior to general exercise for short-term pain reduction and disability improvement in chronic low back pain (42- 44).

The way that Tai Chi effects pain relief might be attributed to improving flexibility and structural mobility; increasing the strength of muscles and their endurance; improving the ligaments and capsules tensile strength; enhancing the cardiac and pulmonary functions, decreasing depression, anxiety, and stress; and changing of health related beliefs and control (45). Ten-week TC program was effective in decreasing pain for people with persistent low back pain (46). On contrary, 3-armed randomized trial with 176 older adults stated that TC was not of a higher quality to no treatment in pain reduction (47), this might be attributed to different populations.

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CSE may provide greater pain reduction than TC by specifically activating deep spinal stabilizers, namely the transversus abdominis and multifidi, that enhance lumbopelvic stability and reduce mechanical stress on pain-sensitive structures (42), improved neuromuscular control and spinal stabilization achieved through core training may therefore more effectively address the underlying biomechanical dysfunction associated with chronic low back pain (43), while, TC in general uses slowly , coordinated movements and postural control, which can enhance general function and proprioception but provide less direct strengthening of the spinal stabilizers involved in pain modulation (45).

Clinical relevance:

This study demonstrates that both core stability exercises and Tai Chi exercise can improve rehabilitation outcomes after colorectal surgery, with core stability exercises showing greater overall effectiveness. Incorporating core stability training into postoperative rehabilitation may enhance pain reduction, balance, leading to improved quality of life and faster return to daily activities for colorectal surgery patients.

LIMITATIONS:

Several limitations are in the current study that need to be considered; limited sample size may have compromised the statistical power and reduced the results generalizability to the more broad patients population undergoing colorectal surgery. Furthermore, an intervention of a relatively short period of time and follow-up durations limit the ability to determine long-term efficacy and sustainability of the interventions. patients who participated in the study were from a single place may also have affected the study's external validity outcomes. In addition, the assessment tools utilized may not have fully captured the multidimensional aspects of postoperative recovery, including functional capacity, balance, and pain-related outcomes. Future research should incorporate larger sample sizes and more heterogeneous populations to enhance the external validity and generalizability of the findings. Studies employing extended intervention and follow-up periods are warranted to assess the efficacy and sustainability of core stability exercise programs following colo rectal surgery on the long-term. Furthermore, the implementation of more comprehensive and objective outcome measures is recommended for a better assessment of the impact of core stability training on balance, functional capacity, and pain-related outcomes. Additional comparative studies evaluating the cost-effectiveness and clinical feasibility of core stability exercises relative to conventional rehabilitation protocols are also needed. Moreover, including participants across different age groups would provide further insight into the age-related effectiveness of core stability interventions in postoperative colorectal rehabilitation.

CONCLUSION

This study's results suggested that core stability training has an effective role in enhancing balance and alleviating pain among patients after colorectal surgery. In addition, core stability exercises showed greater effectiveness than Tai Chi in improving the assessed rehabilitation outcomes. Accordingly, integrating core stability exercises into postoperative physical therapy programs may promote better functional recovery and improve overall rehabilitation outcomes in patients undergoing colorectal surgeries.

Implications for Rehabilitation:

- Physical therapists are encouraged to incorporate core stability exercises into postoperative rehabilitation programs as an effective way of intervention for improving balance and reducing pain in patients undergoing colorectal surgeries.
- Core stability exercises may represent a safe, non-pharmacological, and low-risk therapeutic approach for enhancing stability and alleviating pain following colorectal surgery, potentially contributing to reduced dependence on analgesic medications.

Acknowledgment

The authors would like to express their sincere appreciation to all participants who took part in this study for their valuable cooperation and contribution to the successful completion of this trial.

Conflict of interest

The authors showed no interest conflict.

Funding

No outer funding was received.

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