



# OPEN The impact of locus of control on somatic and psychological profiles of patients with irritable bowel syndrome engaging in aerobic exercise

Laura Prospero<sup>1,5</sup>, Giuseppe Riezzo<sup>1,5</sup>, Benedetta D'Attoma<sup>1</sup>, Antonia Ignazzi<sup>1</sup>, Antonella Bianco<sup>2</sup>, Isabella Franco<sup>2</sup>, Ritanna Curci<sup>2</sup>, Angelo Campanella<sup>2</sup>, Claudia Beatrice Bagnato<sup>2</sup>, Piero Porcelli<sup>3</sup>, Gianluigi Giannelli<sup>4</sup> & Francesco Russo<sup>1</sup>✉

Irritable bowel syndrome (IBS) is a chronic and recurrent disorder characterized by gastrointestinal (GI) symptoms and psychological disorders. Individuals with an external locus of control (LoC), a personality trait influencing one's actions and outcomes, are more vulnerable to IBS. Physical activity can deal with GI symptoms, preserving mental and physical health. In this context, our study aimed to investigate differences in symptom and psychological profiles among IBS patients classified by internal or external LoC when patients engaged in an aerobic exercise program (AEP). Each IBS patient was administered the International Physical Activity Questionnaire—Short Form (IPAQ-SF) before treatment, and the Physical Capacity Assessment Tests were applied before and after treatment. Participants filled out a GI symptom questionnaire before and after the intervention and some validated psychological tests to evaluate the changes induced by AEP. The AEP consisted of 180 min of moderate-intensity aerobic walking activity a week. Fifty-four IBS patients completed the 12-week study; 37 belonged to the internal LoC group and 17 to the external one. The internal LoC subgroup had a higher percentage of physically active subjects and a better physical capacity at baseline than those with external LoC. Only patients with an internal LoC achieved a statistically significant increase in physical capacity as the effect of the AEP. However, there was no statistically significant difference when Delta was considered. The somatic and psychological health status of IBS patients in the external LoC group was poorer than that of the internal LoC group at the baseline, particularly abdominal pain, psychosocial functioning, and emotional distress. After AEP, patients showed significant improvement in scores on the IBS-related and psychological scales, regardless of whether they belonged to the external or internal LoC. The present study confirmed the importance of considering both the GI symptoms and the psychological profile when dealing with IBS. AEP organized in walking groups has shown significant improvements for all IBS patients. Since external LoC was associated with poorer health status, individually tailored interventions should be planned to increase patients' self-motivation to treatment.

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**Keywords** Aerobic exercise, Gastrointestinal symptoms, Irritable bowel syndrome, Locus of control, Psychological profile

<sup>1</sup>Functional Gastrointestinal Disorders Research Group, National Institute of Gastroenterology, IRCCS "Saverio de Bellis", Via Turi 27, 70013 Castellana Grotte, BA, Italy. <sup>2</sup>Laboratory of Movement and Wellness, National Institute of Gastroenterology, IRCCS "Saverio de Bellis", 70013 Castellana Grotte, BA, Italy. <sup>3</sup>Department of Psychology, University of Chieti-Pescara, 66100 Chieti, Italy. <sup>4</sup>Scientific Direction, National Institute of Gastroenterology, IRCCS "Saverio de Bellis", 70013 Castellana Grotte, BA, Italy. <sup>5</sup>Laura Prospero and Giuseppe Riezzo contributed equally to this work. ✉email: francesco.russo@irccsdebellis.it

### Abbreviations

AEP	Aerobic Exercise Program
GI	Gastrointestinal
GSI	Global Severity Index
HR	Heart rate
IBS	Irritable bowel syndrome
IBS-C	Constipation-predominant IBS
IBS-D	Diarrhea-predominant IBS
IBS-M	Mixed IBS
IBS-U	Unspecified IBS
IBS-QoL	IBS Quality of Life Questionnaire
IBS-SSS	IBS severity scoring system
IPAQ-SF	International physical activity questionnaire, short form
LoC	Locus of Control
MCS	Mental Component Score
PCS	Physical Component Score
QoL	Quality of life
SCL-90-R	Symptom Checklist-90-Revised
SF-36	36 Items Short-Form Health Survey
WHO	World Health Organization

Irritable bowel syndrome (IBS) is a chronic, recurrent disorder affecting people worldwide. According to a recent meta-analysis, the global prevalence of IBS is 9.2% when using the Rome III criteria and 3.8% with the Rome IV criteria<sup>1</sup>.

This disorder is more common in women under the age of 50<sup>2</sup> and is characterized by abdominal pain related to altered evacuation<sup>1</sup>. The Rome III-IV criteria include persistent discomfort at least once a week, linked with changes in bowel habits or stool consistency<sup>3,4</sup>. The Bristol Stool Form Scale categorizes IBS into four subtypes: constipation-predominant (IBS-C), diarrhea-predominant (IBS-D), mixed (IBS-M), and unspecified (IBS-U)<sup>5</sup>.

In recent years, the concept that IBS is a complex disorder has gained acceptance, going far beyond the Rome criteria based only on gastrointestinal (GI) symptoms<sup>6</sup>. It has been demonstrated that IBS, particularly IBS-D, differs in intestinal permeability<sup>7</sup> and vitamin D levels<sup>8</sup>. Besides, IBS exhibits abnormalities in the gut-brain axis, often due to an amplified response to stress through physiological and psychological mechanisms (e.g., anxiety, depression, somatization)<sup>9</sup>, and it is frequently associated with psychiatric comorbidities and a compromised quality of life (QoL)<sup>10</sup>. Therapies focusing on mind–body interactions and reducing stress can be helpful supplementary or alternative treatments for managing IBS, complementing conventional approaches like dietary modifications and pharmacological interventions<sup>11</sup>.

In this framework, physical activity and exercise may be promising alternatives to various therapeutic approaches. Caspersen's definition<sup>12</sup>, also adopted by the World Health Organization (WHO), describes physical activity as any skeletal muscle action involving energy expenditure (e.g., working, playing). On the other hand, exercise refers to a specific type of physical activity that is planned, regulated, and repetitive to enhance or preserve one or more physical fitness-related characteristics. According to scientific research, exercise and physical activity positively affect health. Regular physical activity can enhance cardiovascular health, boost moods, and improve overall well-being. Indeed, research has shown that physical activity not only helps to prevent the onset of GI symptoms in healthy individuals but is also essential for maintaining both physical and mental wellness<sup>13</sup>. Long-term aerobic exercise also lowers mild to moderate anxiety and depression<sup>14</sup> and raises parasympathetic and serotonin activity in the central nervous system<sup>15</sup>. Physical activity improves abdominal transit time<sup>16</sup>, reduces bloating<sup>17</sup>, and exerts anti-inflammatory and antioxidant effects on IBS<sup>18</sup>. Based on existing studies, including our previous paper<sup>19</sup>, we can assert that appropriately tailored exercise regimens may positively impact disease management in individuals with IBS<sup>20</sup>.

While the positive effects of physical activity on IBS symptoms have been observed, the actual amount of physical activity in individuals with IBS is lower than that in healthy subjects<sup>21</sup>. It is critical to note that an individual's motivation and psychological state may significantly influence the effectiveness of therapy, especially in the case of physical exercise. One underlying psychological factor that motivates individual engagement in active intervention is the locus of control (LoC), a mental disposition influencing one's actions and outcomes. Introduced by Rotter in 1966, it refers to the subjective evaluation of factors attributed to the cause of events and their consequences<sup>22</sup>. According to Rotter, an individual's LoC ranges from internal—the belief that most results are caused by one's actions—to external—the belief that results are achieved through other forces beyond one's control. Based on the literature, individuals with an internal LoC tend to be more committed to their goals than those with an external LoC. This is a result of their conviction that their deeds determine their fate. Furthermore, people with an internal LoC report feeling happier and less stressed<sup>23</sup>. On the other hand, individuals with an external LoC are more stressed and feel that they have little control over their lives. They attribute their success or failure to external factors such as luck, fate, or coincidence<sup>22</sup>.

Research has demonstrated that LoC is an important moderator of the relationship between stressors and their consequences<sup>24</sup>. Studies have suggested that individuals with an external LoC are more vulnerable to stress-related disorders<sup>25</sup>. For instance, de Dios-Duarte<sup>26</sup> found that those with an external LoC experienced a stronger association between stressful life events and health disorders. Similarly, Kobasa's study on people who had experienced high levels of stress showed that those with an internal LoC were more resilient to stress-related illnesses<sup>24</sup>.

Over the past 20 years, the relevance of the LoC construct in healthcare has gained some attention. Recent research has primarily focused on examining LoC as a factor contributing to adequate adherence to therapy in patients suffering from organic diseases, such as cardiovascular<sup>27</sup>, neurological (Parkinson's disease)<sup>28</sup>, and metabolic diseases (e.g., diabetes<sup>29</sup> and hepatic steatosis<sup>30</sup>). Patients with IBS and Crohn's disease showed less internal LoC than healthy controls, and Crohn's disease patients had higher passive reliance on physicians than IBS patients<sup>31</sup>. IBS patients with external LoC were found to be more adherent to the kind of treatment recommended by their physicians than those with internal LoC, thus suggesting that individual disposition to LoC may impact the course of treatment<sup>32</sup>. To our knowledge, no study has investigated whether internal or external LoC may influence somatic symptoms and psychological aspects of IBS patients participating in a supervised walking group Aerobic Exercise Programme (AEP).

## Methods

### Patients recruitment

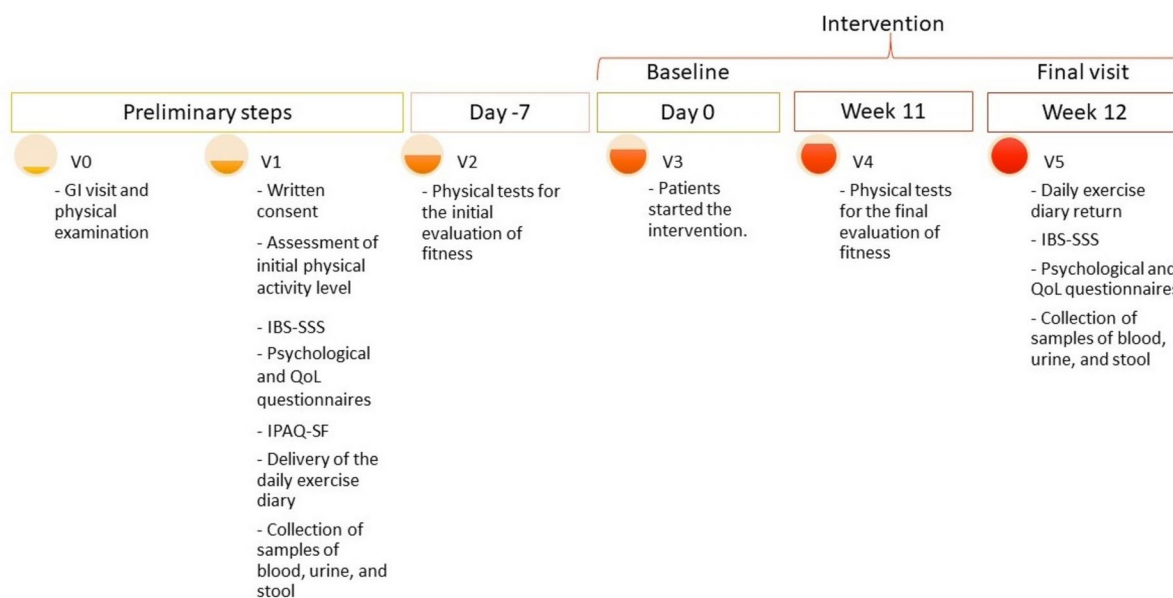
The Functional Gastrointestinal Disorders Research Group and the Laboratory of Movement and Wellness of the National Institute of Gastroenterology IRCCS "Saverio de Bellis" Castellana Grotte, BA, Italy, collaborated to recruit study participants.

Individuals who met the Rome IV criteria for IBS and were recommended by local physicians or attended the outpatient clinic for functional gastrointestinal disorders were included in the study. The inclusion criteria were age 18 to 65, the ability to join the walking group and a medical certificate of non-competitive sports fitness. The exclusion criteria included the following: (1) the existence of serious neurological, psychiatric, cardiac, or hepatic diseases; (2) GI disorders, including celiac disease, other than IBS; (3) subjects who had previously followed a low-(fermentable oligosaccharides, disaccharides, monosaccharides and polyols) – FODMAPs, vegan, or gluten-free diet; (4) patients taking antidepressants; (5) notable restrictions related to orthopedics or neuromuscular disorders, (6) complete prohibitions against exercise. The Institutional Ethics Committee of the IRCCS Oncological Hospital—John Paul II Cancer Institute, Bari, Italy, approved the study, which was carried out in accordance with the Helsinki Declaration (Prot. N. 167/CE De Bellis). The trial was registered at [www.clinicaltrials.gov](http://www.clinicaltrials.gov) (First Posted Date 12/07/2022, registration number NCT05453084, last accessed on 08/04/2024).

### Study design

The study included five visits (Fig. 1):

In the initial stage, patients received a GI and physical examination for screening (V0). During V1, participants signed informed consent forms and provided information on their beginning level of physical activity. In addition, structured questionnaires on IBS symptoms, psychological variables, QoL, and level of physical activity were administered. Patients are given a daily workout diary to complete during the project. Lastly, skilled personnel collected blood samples for biochemical evaluations. Tests of physical condition (V2) were administered to patients a week before AEP (V3) to assess their initial fitness level. The physical condition tests (V4) are repeated one week before the completion of the 12-week intervention, and the investigations performed in V1 are repeated at the end (V5).



**Fig. 1.** Study design timeline. GI: gastrointestinal; IBS-SSS: irritable bowel syndrome- severity scoring system QoL: quality of life; IPAQ-SF: International Physical Activity Questionnaire, Short Form.

### Irritable Bowel Syndrome-Severity Scoring System (IBS-SSS).

The Irritable Bowel Syndrome-Severity Scoring System (IBS-SSS) was used to assess the GI symptom profile. This validated questionnaire has five items with scores ranging from 0 to 500: Intensity Of Abdominal Pain, Frequency Of Abdominal Pain, Severity Of Abdominal Distension, Dissatisfaction With Bowel Habit, and Interference With Life In General. To assess the severity of IBS, the generally accepted cut-off of IBS-SSS scores was used: > 75–175 for mild IBS, 175–300 for moderate IBS, and > 300 for severe IBS<sup>33</sup>.

### Psychological questionnaires

#### *Rotter's locus of control scale*

Rotter's LoC scale consists of 23 items and 6 filler items, each given equal weight. The test consists of 29 pairs of statements, 23 of which are scored. Six filler items are included to minimize bias. The participant must select one of the two statements based on their beliefs. A high score indicates an external LoC (belief in luck, chance, etc.). The scores for each item range from 0 to 1. The scale allows for scores ranging from 0 to 23. An individual's total score on the 23 significant items in this scale represents his LoC. LoC is measured in two directions: internal and external. A low score (less than or equal to 12) indicates an internal direction, whereas a high score (greater than or equal to 13) indicates an external direction<sup>22</sup>.

#### *Thirty-six item short-form health survey (SF-36)*

The 36-item Short-Form health survey (SF-36) is a brief generic questionnaire designed to assess patients' health status and QoL, regardless of the underlying illness. The subscales and global indices are structured so that the higher the score, the better the health state. The first three subscales concern physical health (physical activity, limits in role-specific activities due to physical difficulties and pain). The intermediate two subscales (general health and vitality) describe global health in general. The final three subscales examine characteristics of psychological and emotional well-being (social activity restrictions and role-specific activity limitations brought on by emotional or mental health issues). A separate, unscaled single question provides information on the respondent's health changes during the previous 12 months. Scores were coded, summed, and transformed for each variable on a scale of 0 (the worst possible health condition) to 100 (the best possible health state). Overall somatic health is summarized in a composite Physical Component Score (PCS), and overall psychological health in a composite Mental Component Score (MCS) is derived from the eight scales. Again, the higher the score, the more positive the perception of health<sup>34</sup>.

#### *Irritable Bowel Syndrome Quality Of Life Questionnaire (IBS-QoL)*

The Irritable Bowel Syndrome Quality of Life Questionnaire (IBS-QoL) evaluates the QoL of IBS patients. The questionnaire contains 30 items divided into nine subscales: overall score, dysphoria, interference with activity, body image, health worry, food avoidance, social reaction, sexual concerns, and relationship. Raw scores are converted to scale scores ranging from 0 to 100, with higher scores indicating a higher QoL<sup>35</sup>.

#### *Symptom Checklist-90-Revised (SCL-90-R)*

The Symptom Checklist-90-Revised (SCL-90-R) is a well-known tool for self-reporting symptoms. The SCL-90-R assesses nine major symptom dimensions (somatization, obsessive–compulsive, interpersonal sensitivity, depression, anxiety, hostility, phobic anxiety, paranoid ideation, and psychoticism) and three global indexes. The Global Severity Index (GSI) was the only one investigated in this study since it best represents the severity of psychological suffering perceived by individuals. The raw score is transformed into a T score, and a value of 63 or higher is considered a clinically relevant symptom<sup>36</sup>.

### International Physical Activity Questionnaire, Short Form (IPAQ-SF)

The International Physical Activity Questionnaire Short Form (IPAQ-SF) was used to assess physical activity levels. Through the Metabolic Equivalent (MET), the IPAQ-SF assesses the frequency, duration, and intensity of physical activity over the previous seven days in all settings and displays the total amount of weekly physical activity<sup>37</sup>. Three groups of subjects were identified based on total METs of physical activity: inactive (<701 METs), sufficiently active (701–2519), and active (>2520).

### Exercise protocol

#### *Physical capacity assessment tests*

At the beginning of the project and the end of the three months, three field tests were conducted to check the subjects' basic conditions, establish the program's intensity and evaluate the results obtained. These included strength and flexibility, measured with the Hand Grip and Sit and Reach tests<sup>38,39</sup>, and cardiorespiratory capacity calculated by the 2 km walk test<sup>40</sup>. The tests were replicated as closely as possible under the same conditions: (a) in the same location, (b) supervised by the same operators, (c) at the same time, and (d) monitored with the same instruments.

The results of each test were combined to obtain an overall physical capacity score, the Global Physical Capacity Score (GPCS). This score gives a value between 0 and 6 ( $\leq 2$  indicates below average, >2–4 average, and >4–6 above average physical capacity), as described in a previous study<sup>41</sup>.

#### *Exercise intervention*

The AEP intervention was described in our previous study<sup>19</sup>. Briefly, for three months, “walking group” activities were performed outdoors on predetermined routes three times a week on non-consecutive days, for a total of 180'. The intensity was moderate (60/75% of maximum heart rate—HR), customized with Tanaka's formula<sup>42</sup>

and measured with an HR monitor. The whole activity was supervised by specialists (graduates in preventive and adapted physical activity science and techniques), and participants at each training session were recorded.

### Statistical analysis

Unless otherwise stated, all results are expressed as mean  $\pm$  SD. Delta was calculated as a percentage change using the following formula:  $[X(\text{final}) - X(\text{initial})] / X(\text{initial}) * 100$ ]. Moreover, the analysis would not have included subjects who had missed more than 20% of their training sessions. Non-parametric tests were used to avoid violating the normal distribution assumption. The Mann–Whitney test was used to compare differences between the internal and external LoC subgroups at baseline and the end of the AEP activity. The Wilcoxon–matched pairs signed rank test was used to determine differences before and after AEP. A chi-squared test was used to calculate the difference in the proportion of physical capacity levels. Statistics were performed with Sigma Stat 11.0 (Systat Software, Inc., San Jose, CA, USA) and GraphPad Prism 5 (GraphPad Software, Inc., La Jolla, CA, USA). Statistical differences were set to  $p < 0.05$ .

## Results

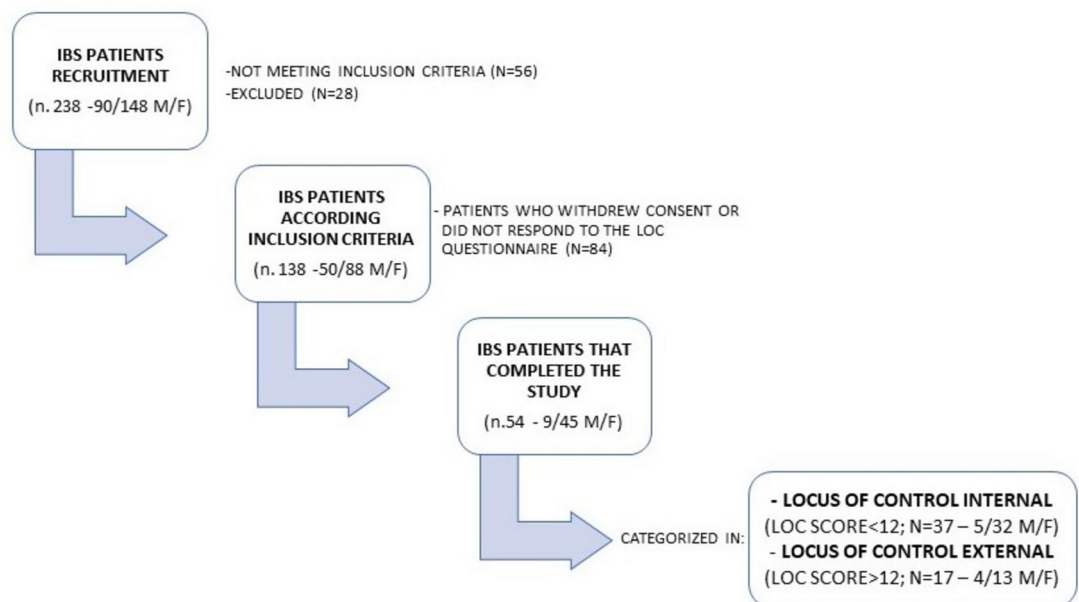
### Study group members description

Figure 2 shows the patient flow throughout the study. Initially, 238 participants (90 males and 148 females) were selected, of whom 138 (50 males and 88 females) met the inclusion criteria for the study. Due to time constraints and limited interest, only 54 out of the 138 patients (9 males and 45 females) provided consent and completed the LoC questionnaire. The IBS group was then categorized into two groups based on their LoC score: internal LoC (LoC score  $\leq 12$ ) and external LoC (LoC score  $> 12$ ). Following the intervention, all 54 patients, with a mean age of  $50.91 \pm 8.30$  years, completed the 12-week study. Among these 54 IBS patients, 37 (68.5%) belonged to the internal LoC group (5 males and 32 females) with a mean age of  $52.32 \pm 6.81$  years, and 17 (31.5%) belonged to the external LoC group (4 males and 13 females) with a mean age of  $47.82 \pm 10.44$  years.

Regarding the assessment of activity levels according to the IPAQ-SF, 18 subjects (25.9%) in the entire patient group were sufficiently active, 14 (33.3%) were active, and 22 (40%) were inactive. About the GPCS, the total group of IBS patients had a baseline score of  $2.30 \pm 1.42$ , placing them in the average. At the end of the intervention, the score rises to  $3.06 \pm 1.82$ , thus remaining in the range of the mean ( $p < 0.0001$ , Delta 10%).

Table 1 shows the symptom profile of the whole group of IBS patients before and after AEP. The total IBS-SSS score at the start of the intervention indicates a moderate level of IBS severity. As expected, the IBS-SSS total score significantly improved after AEP ( $p < 0.001$ ). Specifically, all individual items decreased following the intervention, leading to a reduction in the IBS-SSS total score to a mild level ( $p < 0.001$ ). Notably, there were dramatic percentage reductions in the total score (Delta = -36.9%) as well as in specific items, particularly Abdominal Pain Intensity (Delta = -33.9%) and Abdominal Distension Severity (Delta = -36.4%).

Table 2 presents the overall values for psychological profile, health status, and QoL before and after AEP in the entire group of IBS patients. The comparison of all the subscales for each questionnaire is shown in the Additional files 1, 2, 3, and 4. After completing the intervention, the SF-36 score showed a notable improvement in PCS ( $p = 0.009$ ) with a Delta = 7.7% and MCS ( $p = 0.0003$ ) with a Delta = 25.5%. Only “social functioning” and “role emotional” were unaffected by the AEP. Similarly, the IBS-QoL overall score showed a statistically significant improvement ( $p = 0.0002$ ). The comparison of the subscales showed a notable improvement, except



**Fig. 2.** The flowchart of the study.

	IBS patients (n 54)		
	Before	After	Delta
<b>IBS-SSS</b>			
Abdominal Pain intensity	32.87 ± 30.38	16.37 ± 21.33*	-33.9%
Abdominal Pain frequency	24.91 ± 28.02	11.57 ± 20.18*	-28.9%
Abdominal Distension severity	46.91 ± 22.35	28.26 ± 20.58*	-36.4%
Dissatisfaction with bowel habit	48.02 ± 29.41	33.00 ± 22.34*	-20.9%
Interference with life in general	48.81 ± 22.20	33.94 ± 24.70*	-19.7%
Total	201.5 ± 68.26	123.1 ± 74.22*	-36.9%

**Table 1.** IBS—SSS single-item and total score of IBS patients before and after AEP. Data are expressed as means ± DS. Delta: Delta: percentage change measure. Wilcoxon matched-pair signed rank test to compare data before and after physical activity. \*  $p < 0.0001$ . Abbreviations: IBS, Irritable bowel syndrome; IBS-SSS, IBS Severity scoring system.

	IBS (n 54)		
	Before	After	Delta
<b>SF-36</b>			
Physical component score	49.97 ± 08.70	52.86 ± 07.47*	7.7%
Mental component score	40.08 ± 13.09	45.62 ± 12.48*	25.5%
<b>IBS-QoL</b>			
Total score	77.77 ± 13.02	83.33 ± 18.55*	7.4%
<b>SCL-90-R</b>			
GSI	62.76 ± 17.69	55.19 ± 16.54*	-10.8%

**Table 2.** SF-36, IBS-QoL, SCL-90-R subscales and total score of IBS patients before and after AEP. Data are expressed as means ± DS. Delta: percentage change measure. \*  $p < 0.0001$ . Wilcoxon matched-pair signed rank test to compare data before and after physical activity. Abbreviations: IBS, Irritable bowel syndrome; SF-36, 36-Item Short-Form Health Survey; IBS-QoL, IBS Quality of life; SCL-90-R, Symptom Checklist-90-Revised; GSI, Global Severity Index.

	Internal LoC (37)	External LoC (17)	p
<b>IPAQ-SF</b>			
Inactive	14 (37.8%)	8 (47.1%)	
Sufficiently active	15 (40%)	3 (17.6%)	0.232
Active	8 (21.6%)	6 (35.3%)	

**Table 3.** IPAQ-SF score in patients with internal and external LoC IBS patients before and after AEP. Data are expressed as number of patients and percentage. Differences in proportions were calculated using the Chi-squared test. \* All differences were considered significant at  $p < 0.05$ .

for the “sexuality” and “relations” subscales. Regarding SCL-90-R, after AEP, the GSI dramatically decreased ( $p < 0.001$ ), with a Delta of -10.8%. In particular, the mean “somatization” subscale was higher than the clinical threshold before the study ( $64.31 \pm 19.37$ ) and returned to the normal range following the intervention ( $58.11 \pm 16.87$ ).

### Internal and external Locus of control

#### *Physical activity level and physical capacity*

When IBS patients were classified according to LoC, they were further divided based on their level of physical activity (Table 3). Nearly half of the patients with external LoC (47.1%) were inactive at baseline, whereas more than half of the patients with internal LoC were either active (21.6%) or sufficiently active (40%).

Table 4 presents the GPCS results concerning the physical ability score. Subjects with an internal LoC at baseline exhibited a significantly higher physical capacity compared to those with an external LoC ( $2.57 \pm 1.32$  vs.  $1.71 \pm 1.49$ , respectively,  $p = 0.02$ ). By the end of the AEP, the physical capacity of patients with an internal LoC improved significantly, unlike those with an external LoC ( $p < 0.0001$  vs.  $p = 0.16$ , respectively). However, at the end of the intervention, there were no significant differences in physical capacity between the two groups ( $p = 0.27$ ).

	LoC Internal (37)				LoC External (17)					
	Before A	After B	A vs. B	Delta A-B	Before C	After D	C-D	Delta C-D	A vs. C	B vs D
GPCS	2.57 ± 1.32	3.49 ± 1.66	< 0.0001	5%	1.71 ± 1.49	2.12 ± 1.83	0.16	10%*	0.02	0.27

**Table 4.** GPCS score in internal and external LoC IBS patients before and after AEP. Data are expressed as means ± DS. Delta: percentage change measure. \* All differences were considered significant at  $p < 0.05$ .

	Internal LoC (37)		p	Delta	External LoC (17)		p	Delta	p	p
	Before A	After B	A vs. B	A-B	Before C	After D	C vs. D	C-D	A vs. C	B vs. D
<i>IBS-SSS items</i>										
Abdominal Pain intensity	24.86 ± 26.76	13.49 ± 21.37	< 0.0001	-27.5%	50.29 ± 31.25	22.65 ± 20.47	0.0001	-47.9%*	0.004	0.03
Abdominal Pain frequency	20.54 ± 26.97	10.27 ± 19.65	0.0007	-29.9%	34.41 ± 28.72	14.41 ± 21.64	0.02	-28.6%	0.04	0.17
Abdominal Distension severity	48.19 ± 21.90	28.16 ± 20.08	< 0.0001	-38%	44.12 ± 23.73	28.47 ± 22.26	0.0005	-32.7%	0.64	0.95
Dissatisfaction with bowel habit	51.62 ± 27.36	37.24 ± 22.90	0.001	-20.5%	40.18 ± 32.96	23.76 ± 18.47	0.01	-23.4%	0.24	0.05
Interference with life in general	51.05 ± 22.83	37.14 ± 25.64	0.002	-13%	43.94 ± 20.56	27.00 ± 21.58	0.03	-36.3%	0.18	0.16
<b>Total score</b>	196.3 ± 73.06	126.3 ± 77.00	< 0.0001	-33.4%	212.9 ± 56.76	116.3 ± 69.53	0.0002	-44.5%	0.17	0.43

**Table 5.** IBS-SSS scores in internal and external LoC IBS patients before and after AEP. Data are expressed as means ± DS. Delta: percentage change measure. \* All differences were considered significant at  $p < 0.05$ . Mann–Whitney test compares differences between the groups at baseline (A vs. C), after AEP (B vs. D), and between Delta. Wilcoxon matched-pair signed rank test to compare data before and after AEP (A vs B and C vs D). Abbreviations: LoC, Locus of control; IBS-SSS, Irritable bowel syndrome–Severity scoring system. \*Delta C-D,  $p = 0.02$ .

Mann–Whitney test compares differences between the groups at baseline (A vs. C), after AEP (B vs. D), and between Delta. Wilcoxon matched-pair signed rank test to compare data before and after AEP (A vs B and C vs D). Abbreviations: LoC, Locus of control; GPCS, Global Physical Capacity Score. \*  $p < 0.005$ .

#### Severity of IBS symptoms

At baseline, patients with external LoC had significantly higher scores on the IBS-SSS for “abdominal pain intensity” ( $p = 0.004$ ) and “abdominal pain frequency” ( $p = 0.04$ ). (Table 5). No other significant differences between the groups were found at the start of the study. Following the AEP, all IBS-SSS items showed significant improvement in both LoC groups. However, the “abdominal pain intensity” score improved significantly more in the external LoC group (Delta = -47.9%) compared to the internal LoC group (Delta = -27.5%), likely due to the different baseline levels.

#### Psychological factors

At baseline, patients with external LoC exhibited greater impairment in the mental component of the SF-36 (MCS,  $p = 0.0002$ ) than those with internal LoC (Table 6). Compared to patients with internal LoC, those with external LoC demonstrated poorer levels of psychosocial functioning. This was evident in the SF-36 subscale scores for “role physical”, “vitality”, “social functioning”, “role emotional”, and “mental health”, (Additional file 2), as well as in the IBS-QoL subscale scores for “social reactions” and “sexuality (Additional file 3). Furthermore, the Delta values of the SF-36 indicate that QoL significantly improved after AEP, regardless of whether patients were in the internal or external LoC group (Table 6). In particular, there was a dramatic improvement in the MCS (Delta = 56.5%) and the “role emotional” subscale (Delta = 57.5%) scores in the external LoC group compared to the internal LoC group (11.2% and 2.3%, respectively), likely due to the different baseline levels (Table 6 and Additional file 2). Of note, the between-group comparison following AEP revealed that patients with external LoC still displayed significantly lower mental health than those with internal LoC ( $p = 0.001$ ), despite the dramatic improvement in MCS from pre- to post-AEP (Table 6).

Similarly, AEP benefited both LoC groups by significantly reducing the SCL-90-R GSI scale ( $p = 0.0005$  for internal LoC patients and  $p = 0.003$  for external LoC patients). However, no significant differences were found when the Delta values were considered for each specific scale. Notably, the mean scores for “somatization” ( $69.65 \pm 17.47$ ), “obsession-compulsion” ( $71.53 \pm 15.81$ ), “interpersonal sensitivity” ( $65.24 \pm 16.67$ ), “depression” ( $72.00 \pm 17.01$ ), “anxiety” ( $69.59 \pm 19.34$ ), “hostility” ( $63.65 \pm 16.70$ ), “psychoticism” ( $77.29 \pm 22.05$ ), and GSI ( $77.29 \pm 22.05$ ) were higher than the clinical threshold before the study. They returned to the normal range following the intervention in the external LoC group (Additional file 4). At the end of the AEP, most SCL-90-R subscales showed a significant difference between the two subgroups, confirming the influence of the external LoC (Additional file 4).

	Internal LoC (N = 37)		p	Delta	External LoC (N = 17)		p	Delta	p	p
	Before A	After B			A vs. B	A-B				
<b>SF-36</b>										
MCS	44.45 ± 11.52	46.90 ± 14.03	0.12	11.2%	30.57 ± 11.37	42.82 ± 07.79	0.001	56.5%*	0.0002	0.01
PCS	49.81 ± 08.87	53.29 ± 07.56	0.01	9.2%	50.32 ± 08.58	51.93 ± 07.42	0.31	4.4%*	0.77	0.40
<b>IBS-QoL</b>										
Total score	79.22 ± 13.35	83.82 ± 21.32	0.01	5.5%	74.60 ± 12.04	82.25 ± 10.74	0.001	11.6%	0.16	0.16
<b>SCL90-R</b>										
GSI	57.00 ± 13.59	50.78 ± 14.31	0.0005	-9.8%	75.29 ± 19.43	64.76 ± 17.42	0.003	-13%	0.0001	0.001

**Table 6.** Psychological profile and QoL in IBS patients with internal and external LoC before and after AEP. Data are expressed as means ± DS. Delta: percentage change measure. \* All differences were considered significant at  $p < 0.05$ . Mann–Whitney test compares differences between the groups at baseline (A vs. C), after AEP (B vs. D), and between Delta. Wilcoxon matched-pair signed rank test to compare data before and after AEP (A vs B and C vs D). Abbreviations: LoC, Locus of control; SF-36, 36 item Short-form health survey; MCS, Mental Component Score; IBS-QoL, Irritable bowel syndrome Quality of life; SCL-90-R, Symptom Checklist-90-Revised, GSI, Global Severity Index. SF-36: \* Delta MCS  $p = 0.004$ ; Delta Physical Function  $p = 0.03$ ; Delta Role emotional  $p = 0.003$ ; IBS-QoL: \*\*Delta Social Reactions  $p = 0.004$ , Delta Sexuality  $p = 0.0001$ . SCL-90-R, No difference in Delta was found.

## Discussion

To our knowledge, this is the first study investigating the joint role of individual LoC dispositions and somatic and psychological symptoms in the effectiveness of AEP in patients with IBS. Key findings reveal that patients with external LoC experience more severe GI symptoms and emotional distress, along with poorer QoL compared to those with internal LoC. However, AEP effectively improved somatic symptoms and psychological distress across both LoC groups. These results underscore the efficacy of alternative approaches like physical activity and highlight the importance of addressing GI symptoms and psychological factors in managing IBS.

Physical activity is known to have anxiolytic and antidepressant effects, which can significantly improve well-being<sup>19</sup>. Group therapy, in particular, is highly effective for functional patients<sup>43</sup>. This combination of physical and psychological benefits can be crucial in managing IBS. Regular exercise helps alleviate symptoms such as bloating, abdominal pain, and irregular bowel movements while reducing stress and enhancing mental health. By incorporating various physical activities into their daily routines, IBS patients can experience a marked improvement in the QoL<sup>19</sup>, even in terms of positive, long-lasting effects<sup>44</sup>. However, there is currently no specific exercise protocol tailored for these patients. Major international organizations such as the American College of Sports Medicine<sup>45</sup> recommend adhering to the guidelines established for healthy adults. Thus, we developed a physical exercise intervention based on the FITT (frequency, intensity, type, and time) principles, focusing on intensity. Moderate intensity is more effective in enhancing the overall well-being of these patients<sup>18</sup>.

The biopsychosocial model confirms that GI symptoms and psychosocial factors interact to cause IBS<sup>10</sup>. Indeed, patients with IBS present different biochemical and psychological profiles, and treating the condition is undeniably challenging<sup>46</sup>. Long-term approaches such as diet and physical activity, specifically organized walking groups, effectively treat IBS patients<sup>47</sup>. In this framework, the present study confirmed that after 12 weeks, the AEP considerably decreased GI symptoms and positively affected IBS patients' psychological state and QoL. Psychological alterations commonly observed in IBS patients include increased anxiety, depression, and somatization<sup>19</sup>, while chronic stress can contribute to the development of IBS and worsen its symptoms<sup>48</sup>. Thus, it is essential to properly evaluate IBS patients by determining the biochemical and psychological variables that, on an individual basis, account for disparate reactions to a particular treatment strategy<sup>49</sup>. Our previous research focused on the clinical and psychological profile of patients with somatization, demonstrating an association with specific biochemical alterations in IBS-D patients, such as altered intestinal permeability<sup>50</sup>.

Our study examined a non-cognitive personality trait, the LoC, which influences how individuals react to life events<sup>51</sup>. Precisely, LoC reflects "whether or not the person perceives a causal relationship between their behavior and rewards"<sup>22</sup>. An internal LoC allows for full responsibility over life events, while an external LoC expresses dependency on external events without any control over them<sup>22</sup>. This construct applies to various fields, including behavioral, economic, and medical domains. Individuals with an internal LoC are more likely to follow a healthy diet, exercise regularly, and refrain from smoking<sup>52</sup>. Overall, they maintain a high level of well-being and are less likely to exhibit anxiety and depression traits<sup>53</sup>. This holds for healthy people and patients with organic or functional diseases<sup>26,27,29,31</sup>, and LoC seems to have the same role in both types of patients<sup>30</sup>.

Since the LoC influences lifestyle, individuals having an internal LoC are more likely to engage in appropriate physical activity. For this reason, the subjects' physical activity levels were measured at baseline. As expected, the external LoC group had a higher percentage of inactive subjects (47.1%) than the internal LoC group (37.8%), even if the difference was not significant. The physical condition was determined using the multiple field test total score (GPCS) in order to find any differences between the two subgroups both before and after the intervention. At baseline, patients with internal LoC had an average physical capacity score significantly higher than those with external LoC. In addition, only patients with an internal LoC achieved a statistically significant score in GPCS after AEP, although there was no statistically significant difference when Delta was considered.

These findings suggest that individuals with an internal LoC may be more motivated to fully engage in the intervention, potentially leading to more pronounced improvements.

IBS patients with an external LoC had a higher total GI symptom score at baseline. Specifically, Abdominal Pain had a score as twice as high in patients with an external LoC compared to those with an internal LoC. Similarly, patients with an external LoC had a higher frequency of Abdominal Pain. The differences in the Abdominal Pain score persisted even at the end of the treatment. Considering the psychological profile and QoL of IBS patients, those with an external LoC seem much more impaired and influenced by their mental health rather than physical health, as demonstrated by the MCS of the SF-36 and the GSI of the SCL-90-R at baseline. In contrast, patients with an internal LoC showed scale scores closer to the normal values. At the end of the AEP, comparing the QoL-related scales did not reveal any differences between the two subgroups. Both subgroups benefited from AEP, making it a recommended treatment type.

After AEP, the IBS-SSS total score and SCL-90-R confirmed the differences between the two groups, with higher scores in almost all subscales of the SCL-90-R in the external LoC group. The literature emphasizes the close relationship between internal LoC and subjective well-being—life satisfaction and mental health<sup>23</sup> and, conversely, the relationship between external LoC and symptoms of anxiety and depression<sup>54</sup>.

Our study supports the above-described relationship by showing that, after the intervention, there is a consistent difference in symptom and psychological parameters between the two groups. Although the LoC construct influences the subjective perception of health status, it has no impact on the intervention's efficacy, which may explain why LoC profiles do not affect the outcome of AEP.

Additionally, while the intervention was not intended to modify LoC directly, the observed differences in the symptom and psychological profiles of patients with internal versus external LoC highlight the importance of this construct in shaping the perceived benefits of AEP. It is possible that the 12-week duration was sufficient to influence emotional states such as anxiety and depressive symptoms but not to alter stable psychological traits like LoC significantly. Future studies could explore additional psychological dimensions, such as self-control, which may mediate the relationship between LoC and health outcomes<sup>55</sup>.

While some limitations may affect the procedure and reproducibility of the research (e.g., the small sample size, the absence of a control group, and the lack of data on biochemical variables and their potential correlations with psychological factors), it was considered important to share these results to encourage scientific discussion and further research in the field. Furthermore, considering the wax and wave nature of IBS symptoms over time, we plan to conduct additional trials incorporating a more balanced recruitment strategy for LoC-related patients, including a control group and feature an extended follow-up period to enhance the robustness of the conclusions.

## Conclusions

The current study's findings underscore the importance of considering both the psychological profile and GI symptoms when treating patients with IBS. The AEP conducted in walking groups significantly improved the QoL for all IBS patients, regardless of whether they had an internal or external LoC. However, LoC played a significant role in the mental and physical health outcomes and the overall QoL of these patients. Since no treatment has demonstrated definite efficacy in IBS patients, the role played by individual LoC may help clinicians shed light on patients' reporting and clinical manifestations of IBS symptoms and enhance their active role in managing their involvement in the different intervention programs.

## Data availability

Data is provided within the manuscript or supplementary information files.

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### Author contributions

Conceptualization, F.R., G.R. and L.P.; methodology, A.B., I.F., R.C., A.C. C.B., L.P.; formal analysis, G.R., L.P. and F.R.; investigation, A.I., B.D., L.P., A.B., I.F., R.C., A.C. C.B.; data curation, L.P., G.R.; writing—original draft preparation, G.R., L.P. and F.R.; writing—review and editing, F.R., G.R., P.P.; supervision, G.G. F.R., P.P.; project administration, F.R.

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### Declarations

### Competing interests

The authors declare that they have no competing interests.

### Ethics approval

Informed consent was obtained from all subjects involved in the study.

### Consent for publication

All authors have read and agreed to the published version of the manuscript.

### Additional information

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**Correspondence** and requests for materials should be addressed to F.R.

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