been treated surgically five had rheumatic complaints persisting after surgery. None were examples of colitic arthritis. In one patient the pains were apparently a result of sacro-iliitis which had developed during the course of the colitis.

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Sacro-iliitis and Ulcerative Colitis*

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A relation between ankylosing spondylitis and bowel complaints has been postulated by several authorities. In a number of series of patients with ulcerative colitis an increased incidence of ankylosing spondylitis has been noted (Table I) and in the extensive series of 555 patients from the Lahey Clinic at Boston 28 were found to have ankylosing spondylitis (Fernandez-Herlihy, 1959). Conversely, in a number of series of patients with ankylosing spondylitis the incidence of ulcerative colitis has been variously reported as 1.5% to 3.9% (Table II). Although the frequency of ulcerative colitis in the general population is unknown, this frequency seems higher than its occurrence in hospital admissions, estimated by Spriggs (1934) at 5 in 1,000 and by Melrose (1955) at 10.9 in 10,000. Melrose suggested it occurred less often in northern towns.

Court Brown and Doll (personal communication, 1958) studied a population of 13,352 spondylitics who had received x-ray therapy between 1935 and 1954. They calculated on the basis of certified deaths from colitis between 1950 and 1953 that the expected numbers of deaths from ulcerative colitis in this population would be 0.65. However, at the time of inquiry 13 certified deaths from colitis had occurred—that is, 20 times more than had been previously predicted. They were unable to advance an estimate for the morbidity from the ulcerative colitis in the same period. Such a vast and careful survey must carry considerable weight, and there would seem to be a definite relation between deaths from colitis and spondylitis.

In a previous study of the arthritis of ulcerative colitis we reported three patients who had ankylosing spondylitis among

108 with colitis (Wright and Watkinson, 1959). Bywaters and Ansell (1958) included six patients with sacro-iliac joint involvement in their 37 patients with colitic arthritis, being unable to distinguish radiologically sacro-iliac arthritis in colitic arthritis and in ankylosing spondylitis. In none of the previously reported studies had an attempt been made to investigate the true incidence of arthritis by taking radiographs of all patients with ulcerative colitis, with particular reference to the sacro-iliac joints and lumbar spine, and in none had the frequency of sacro-iliitis in a matched control group of patients unaffected with colitis been studied. We have therefore conducted a prospective study in which 234 patients with ulcerative colitis have been assessed simultaneously by both a gastro-enterologist and

TABLE I.—Incidence of Ankylosing Spondylitis in Ulcerative Colitis (Various Authors)

Place	Date	Total with Colitis	% with Spondylitis	Authors
New York ..	1956	148	1.3	Flood <i>et al.</i>
Vancouver ..	1959	371	1.1	Ford and Vallis
Leeds ..	1959	108	2.8	Wright and Watkinson
Boston ..	1959	555	5.0	Fernandez-Herlihy
Bethesda ..	1960	100	6.0	Zvaifler and Martel
Washington, D.C.	1960	1,175	2.0	Acheson
U.S.A. ..	1962	1,200	1.6	McEwen <i>et al.</i>
New York ..	1963	333	2.7	Rotstein <i>et al.</i>
Glasgow ..	1963	170	2.9	McBride <i>et al.</i>
Leeds ..	1965	234	6.4	Wright and Watkinson

TABLE II.—Incidence of Ulcerative Colitis in Ankylosing Spondylitis (Various Authors)

Place	Date	Total with Spondylitis	% with Colitis	Authors
Stockholm ..	1953	117	2.6	Romanus
London ..	1957	399	1.5	Steinberg and Storey
..	1958	211	1.9	Wilkinson and Bywaters
Edinburgh ..	1963	870	1.8	McBride <i>et al.</i>
Montpellier ..	1964	103	3.9	Serre and Simon

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a rheumatologist. The x-ray films of the sacro-iliac joints and lumbar spine have been taken routinely and compared with a control series of films from subjects without colitis, matched by age and sex. It has been demonstrated that in patients with ulcerative colitis there is a considerably increased incidence of sacro-iliitis, which may not be manifest clinically; its characteristics have been defined and its relation to various aspects of the associated ulcerative colitis have been carefully analysed.

Material and Methods

Of 269 unselected patients with ulcerative colitis reported in the preceding paper (Wright and Watkinson, 1965), radiographs of the sacro-iliac joints (antero-posterior view) and lumbar spine (antero-posterior and lateral views) were taken in 234 patients. In some instances oblique views of the sacro-iliac joints were also obtained. The patients were interviewed and examined on the same day by both of us. One (G. W.) concerned himself with the assessment of the clinical type, extent, and course of the patient's colitis, while the other (V. W.) examined all

patients with regard to the occurrence and nature of rheumatic complaints. The clinical type and extent of the colitis was assessed by methods described elsewhere (Wright and Watkinson, 1965), and a modification of the classification employed by Bockus *et al.* (1956) was used. We obtained 234 control films from subjects without ulcerative colitis who were matched by age and sex with the patients in the series: 136 films obtained from the general population surveys in the Leigh and Wensleydale districts were read by courtesy of Dr. J. Lawrence; the remainder were obtained from intravenous pyelogram and cystogram studies by courtesy of Dr. C. N. Pulvertaft, of York.

The films were read without knowledge of the clinical findings in the patients, and graded for sclerosis, erosion, and ankylosis on the scale: 0=no change, 1=doubtful, 2=mild, 3=moderate, 4=severe. An overall grading for sacro-iliitis was then made with the categories: 0=no change, 1=mild, 2=moderate, 3=severe. Examples of these changes are shown in Figs. 1 and 2. In the lumbar spine, particular attention was paid to ligamentous calcification, disk degeneration, osteophytosis, and deformity.

General Review of Results

The overall incidence of sacro-iliitis in the colitic and control populations is shown in Table III. It will be seen that the incidence of mild sacro-iliitis was similar in the two groups.

TABLE III.—Incidence of Sacro-iliitis, Classified by Severity, in 234 Patients With Ulcerative Colitis and in the Same Number of Control Subjects. The Difference is Highly Significant

Patients	Sacro-iliitis				
	Absent	Mild	Moderate	Severe	Total
Colitis ..	150 (64.1%)	42 (17.9%)	30 (12.8%)	12 (5.1%)	234
Control ..	188 (80.3%)	35 (14.9%)	10 (4.3%)	1 (0.4%)	234
Total	338	77	40	13	468

For the purpose of this study, therefore, we have grouped together moderate and severe grades in analysis. The incidence in the control group of films supplied by Dr. J. Lawrence corresponded with the incidence obtained by him, reading the films independently (Lawrence, personal communication, 1965). It will be seen that the incidence of severe sacro-iliitis was 12 times greater in patients with ulcerative colitis than in the control population (5.1% to 0.4%), and moderate sacro-iliitis was three times as common (12.8% to 4.3%). In the moderate and severe categories together, 18% of patients with ulcerative colitis showed sacro-iliitis, compared with 4.7% of those without colitis. The difference is highly significant ($P<0.001$).

There was little difference in the sex incidence of sacro-iliitis in patients with ulcerative colitis; 10% of the males and 14.8% of the females had moderate sacro-iliitis, and severe sacro-iliitis was equally common in the sexes (5%). The individual features, sclerosis, erosion, and ankylosis, related to the sex of the patients, are shown in Table IV.

There was no significant difference between the sexes so far as sclerosis and ankylosis were concerned—9% compared with 7.4%, and 5% compared with 4.4%. The overall incidence of these two features was 8.1% and 4.7% respectively. Erosion, however, was more than twice as common in women (14.8%) as in men (6.1%). Of the 42 patients with ulcerative colitis who had sacro-iliitis, 11 had unilateral disease and in 31 it was bilateral.

TABLE IV.—Incidence of Sacro-iliac Joint Changes in 234 Patients with Ulcerative Colitis

	Male	Female	Total
No. of patients ..	99	135	234
Sclerosis ..	9 (9%)	10 (7.4%)	19
Erosion ..	6 (6%)	20 (14.8%)	26
Ankylosis ..	5 (5%)	6 (4.4%)	11

FIG. 1.—Moderate sacro-iliitis (grade 2). The film shows sclerosis, erosion, and possibly some ankylosis.

FIG. 2.—Severe sacro-iliitis (grade 3). Ankylosis of both sacro-iliac joints is present.

Despite the high incidence of sacro-iliitis radiographically, only nine patients had typical ankylosing spondylitis which was apparent clinically. Ligamentous calcification was seen in the radiographs of four patients (three men and one woman). Marked narrowing of the lumbar-disk spaces was present radiographically in nine men and nine women and osteophytosis in 27 men and 32 women. These findings were more common with advancing age (Fig. 3).

In contrast to the findings with disk degeneration and osteophytosis of the lumbar spine, sacro-iliitis bore no apparent relation to the age of the patient (Fig. 3). Sacro-iliitis developed in five patients below the age of 25 years (Fig. 4 A and B).

FIG. 3.—Incidence of lumbar-disk degeneration and sacro-iliitis related to age in 234 patients with ulcerative colitis.

Relation of Sacro-iliitis to Colitis

Sacro-iliitis was least common in patients with proctocolitis, only 8 of 68 (11.8%) such patients showing radiological changes. There was no significant difference in the incidence of sacro-iliitis in patients with acute fulminating disease and in those with a chronic course—4 (25%) of 16 patients with acute fulminating disease and 29 (21%) of 140 patients with chronic ulcerative colitis showed sacro-iliitis. When individual features of sacro-iliac disease were analysed (Table V) it was apparent that erosion was equally common in all types of ulcerative colitis and that it was sclerosis and ankylosis which were least frequently seen in patients with proctocolitis. Of 118 patients with colitis of less than four years' duration 14.4% showed sacro-iliac joint disease, whereas of 116 with ulcerative colitis exceeding four years' duration 22.0% had sacro-iliitis. When individual features of the sacro-iliac joint disease were analysed none appeared to be associated with more long-standing bowel disease.

There was some suggestion that sacro-iliitis was related to the extent of the colitis, since sacro-iliitis was more common in more extensive disease, although the differences were not great. The incidence of sacro-iliitis in those with the entire colon involved was 23.2%, in those with the distal colon involved 16.7%, and in those with only the rectum involved 13.0%. It was of interest that ankylosis of the sacro-iliac joints was similar in patients with entire and distal involvement of the colon (5.8% and 7.1% respectively) but absent in those with rectal involvement only.

TABLE V.—Sacro-iliac Joint Changes Related to the Clinical Type of Colitis

	Acute	Chronic	Proctocolitis
Total	16	140	68
Sacro-iliitis	4 (25%)	29 (21%)	8 (12%)
Sclerosis	2 (12%)	13 (9%)	4 (6%)
Erosion	2 (12%)	14 (10%)	8 (12%)
Ankylosis	1 (6%)	9 (6%)	1 (1.5%)

10 patients with segmental colitis have not been included in this analysis.

Twenty-six patients had been treated surgically by means of total colectomy and ileostomy. Five (19%) of these had sacro-iliitis compared with 37 (13%) of the 208 patients who had received medical treatment only. A follow-up study of 151 patients treated surgically, whose clinical features are reported separately (Watts, de Dombal, Watkinson, and Goligher, 1965), revealed that the only patient with rheumatic symptoms after surgery attributable to active joint disease was a woman aged 21 with marked sacro-iliitis. She had episodes of pain in the back and hips accompanied by recurrent iritis.

Association of Sacro-iliitis with Local and Systemic Complications

There was no relation between sacro-iliitis and local complications of ulcerative colitis, such as perianal disease or the presence of pseudopolypi. The incidence of sacro-iliitis in patients with perianal disease was 11.1% compared with 19.2% in those without perianal disease. The figures for pseudopolypi were similar—11.7% of those with pseudopolypi had sacro-iliitis compared with 20.0% of those without pseudopolypi.

The incidence of sacro-iliitis related to systemic complications is shown in Tables VI and VII. There was no relation between ulcers of the buccal mucosa or between uveitis and sacro-iliitis. There was, however, a significant association

FIG. 4.—Radiographs of sacro-iliac joints in a girl with ulcerative colitis. A, Aged 16, early changes right joint. B, Aged 19, moderate sacro-iliitis both joints.

between skin lesions and sacro-iliitis, and between colitic arthritis and sacro-iliitis. There was no sex difference in these associations, with the striking exception of colitic arthritis and sacro-iliitis.

TABLE VI.—Relation of Sacro-iliitis to Systemic Complications of Colitis

Systemic Complications:	Oral Ulcers		Uveitis		Skin Lesions	
	With	Without	With	Without	With	Without
No. with sacro-iliitis	8 (21.1)	34 (17.3)	6 (26)	32 (15.3)	6 (60)	36 (16.1)
No. with colitis	38	196	23	211	10	224
Statistical comparison	$t = 0.54$ $n = 234$ $P < 0.6$		$t = 1.27$ $n = 234$ $P < 0.3$		$t = 3.65$ $n = 234$ $P < 0.01$	

Percentage frequency is given in parentheses.

TABLE VII.—Relation of Sacro-iliitis to Colitic Arthritis in Both Sexes

Colitic arthritis:	Male		Female		Total	
	With	Without	With	Without	With	Without
No. with sacro-iliitis	2 (15.6)	13 (15.1)	8 (50)	19 (16)	10 (34.5)	32 (15.6)
No. with colitis	13	86	16	119	29	205
Statistical comparison	$t = 0.028$ $n = 99$ $P < 0.9$		$t = 3.19$ $n = 135$ $P < 0.01$		$t = 2.50$ $n = 234$ $P < 0.02$	

Percentage frequency in parentheses.

Association of Sacro-iliitis with Rheumatic Complaints

There was a very definite association between colitic arthritis and sacro-iliitis in women. Over three times as many women with colitic arthritis had sacro-iliitis compared with women without colitic arthritis (Table VII). However, the incidence was almost the same in men with and without colitic arthritis. There was no correlation in either sex between sacro-iliitis and other rheumatic complaints such as rheumatic fever, gout, osteoarthritis, and muscular rheumatism. The overall incidence of sacro-iliitis in patients with these rheumatic diseases was 14.8% compared with 19.1% in those without such rheumatic complaints.

There was a correlation between patients with low back pain and those with sacro-iliitis: 28.2% of patients with low back pain had sacro-iliitis compared with 12.8% of those without low back pain (a significant difference; $n = 234$, $t = 2.9$, $P < 0.01$). In both sexes there were just over twice as many patients with low back pain who had sacro-iliitis compared with those who had no such pain.

Ankylosing Spondylitis

Nine patients with ankylosing spondylitis were diagnosed clinically. Four other men with ulcerative colitis and ankylosing spondylitis were referred especially and have not been included in the overall survey. Of these 13 patients eight were men and five were women. In five spondylitic symptoms appeared after the onset of colitis (two and a half to eight years), in five spondylitic symptoms definitely preceded bowel disturbance (2 to 13 years), and in three there appeared to be a synchronous onset of symptoms from the back and colon. The difficulty of attaching significance to this is illustrated by one man who was admitted to hospital with an attack of acute fulminating colitis of seven weeks' duration. He was adamant that back symptoms dated from the onset of colitis. Radiographically the sacro-iliac joints were seen to be completely fused. It is difficult to believe that this could have occurred in a period as short as seven weeks.

Two patients had acute fulminating disease, in nine it had pursued a chronic course, and two had proctocolitis. Complications were frequent, especially uveitis (5) and arthritis (5) systemically, and pseudopolypi (5) locally. Ulcers of the buccal

mucosa were present in two patients, skin lesions in four, and perianal disease in three.

After examination of the radiographs a review of the clinical findings in the back showed features consistent with ankylosing spondylitis in a further six patients (three men and three women). In four there was a synchronous onset of symptoms in the bowel and back, and in the other two symptoms in the spine appeared four and eight years respectively after the onset of colitis. In five patients the colitis pursued a chronic course and one had proctocolitis: pseudopolypi were present in two, perianal disease in one, ulcers of the buccal mucosa in two, and skin lesions in one.

Ligamentous calcification was seen in four patients of the series (three men and one woman), and in three of the four men especially referred. The florid picture of ankylosing spondylitis with fusion of sacro-iliac joints and calcification of intervertebral ligaments was therefore seen much more commonly in men, contrasting with the overall group in whom only slightly more men were affected. In 27 other patients sacro-iliitis was present radiographically without clinical evidence of ankylosing spondylitis.

Discussion

A review of the literature leaves little doubt that there is an increased incidence of ankylosing spondylitis in patients with ulcerative colitis compared with the figures available for the general population—1 in 2,000 (West, 1949). The present study confirms this. Moderate sacro-iliitis was three times as common in patients with ulcerative colitis as it was in a matched control population, and severe sacro-iliitis twelve times as common. In none of the studies reviewed, however, were special views of the sacro-iliac joints taken, assessment being made usually from barium-enema examinations; the studies were not prospective in design, and no control population was studied.

Some studies have been highly selected—for example, the extensive epidemiological study of Acheson (1960), in which data were available from men only. The methods of other authors have resulted in figures based upon florid cases of ankylosing spondylitis. This may be fallacious, since our data show that although there were only 15 patients with ankylosing spondylitis recognizable clinically 42 had sacro-iliitis on radiographic examination. This may account for the difference in sex incidence between our figures and those of other workers. Others have found more men than women with ankylosing spondylitis in patients with ulcerative colitis (McEwan *et al.*, 1962; Rotstein *et al.*, 1963; Fernandez-Herlihy, 1959). This is in keeping with the known preponderance of men with ankylosing spondylitis (Sharp and Easson, 1954; Hart, 1955). In our study there was a slight preponderance of men with clinical ankylosing spondylitis, and those with severe spinal involvement were all men except one, but the sex incidence of radiographic sacro-iliitis was virtually equal. When individual features of sacro-iliac joint changes were analysed, erosions were found twice as commonly in women. It is interesting to notice that extended observations of Court Brown and Doll (1957) showed that in their series of spondylitics twice as many women as men were certified as having died of ulcerative colitis.

Relation of Sacro-iliitis and Intestinal Disease

There is evidence that ankylosing spondylitis may be present more frequently in a number of diseases of the bowel. An association with regional ileitis has been noted. Acheson (1960), for example, found 22 patients with sacro-iliac changes (3% of a series of 733 men with regional ileitis). Steinberg and Storey (1957) described two cases. Ansell and Wigley (1964) found that 5 out of 92 patients with regional ileitis had ankylosing spondylitis, and radiographic sacro-iliitis was present in 18. Ford and

Vallis (1959) found a clinical association of regional ileitis and sacro-iliitis in two patients. The incidence (19.6%) found by Ansell and Wigley (1964) in patients with regional ileitis was very similar to the incidence of 18% in this study of patients with ulcerative colitis.

Dysentery is well known to produce such an association and gives a picture similar to Reiter's syndrome (Marche, 1950). Although examples of Reiter's syndrome presenting in this way are uncommon in English literature it accords with the experience of Paronen (1948) in Scandinavia. It has been suggested on these grounds that the common link between the diseases is that there is a direct spread of an infecting agent by the venous plexus to the spine (Steinberg and Storey, 1957). These authors cite brucellosis as another disease producing a similar picture. It should be noted, however, that the lesions in brucellosis are not the same as those produced in the other intestinal diseases. They are the result of a low-grade osteomyelitis in which hypertrophied bone is well marked, so that adjoining vertebrae become invested in hypertrophic bone. The fact that spondylitis may precede the ulcerative colitis by many years is against the hypothesis of a direct spread of infection. The experience of Steinberg and Storey (1957) that colitis always antedates the spondylitis differs from that of most other workers. Eyler and Doub (1956) found sacro-iliitis in two out of four patients with intestinal lipodystrophy (Whipple's disease). In a recent review of 95 patients with Whipple's disease 18 (all of whom were male and had peripheral joint involvement) showed spinal involvement with radiographic changes of the sacro-iliac joints, compatible with ankylosing spondylitis in several instances (Kelly and Weisiger, 1963).

There was no striking relation between any aspects of the bowel disease and the incidence of sacro-iliitis, although there was a suggestion that sacro-iliitis was commoner in more long-standing and extensive colitis. Local complications were all evenly distributed among patients with and without sacro-iliitis. This accords with the experience of Zvaifler and Martel (1960).

Wilske and Decker (1965) have reviewed the hypotheses of immune mechanisms and of infection as a cause of the arthritic changes in intestinal diseases. They regard both as speculative, with a little more evidence for the infective theory. Our data do not support the suggestion of direct infection as a cause. It is possible that both infection and immune responses may play a part, in the same way that rheumatic fever is thought to be an immune response to beta-haemolytic streptococci. We have raised this possibility before in relation to colitic arthritis (Wright and Watkinson, 1959), but the occurrence of spondylitis before the onset of colitis suggests that with this association the primary source of infection is unlikely to be in the bowel.

Nature of the Sacro-iliitis

It has been suggested that colitic arthritis is a manifestation of ankylosing spondylitis to which these patients are prone (Rotstein *et al.*, 1963). It is true that we have found a significant association of sacro-iliitis with colitic arthritis. No such correlation was found with other rheumatic complaints apart from the symptom of low back pain, and this symptom in a patient with ulcerative colitis must always raise the suspicion of sacro-iliitis even though signs of spondylitis are absent. On the other hand, our experience has been that colitic arthritis never precedes bowel symptoms, whereas ankylosing spondylitis may. Zvaifler and Martel (1960) had a patient in whom spondylitis antedated the colitis by 15 to 20 years. Serre and Simon (1964) reviewed 99 cases in the literature with four of their own and noted that in 24 cases the spondylitis came first. Moreover, colitic arthritis differs from the arthritis associated with ankylosing spondylitis, as it is a transient synovitis the activity of which closely parallels that of bowel disease, and there is a significant association with bowel complications such as perianal

disease and pseudopolypi, an association not found with sacro-iliitis. Furthermore, ileostomy and colectomy have differing effects in colitic arthritis and in ankylosing spondylitis found in patients with ulcerative colitis.

In our series colitic arthritis did not occur or recur after surgery, and a review of 151 patients treated surgically revealed no recurrence of colitic arthritis. At the Lahey Clinic (Fernandez-Herlihy, 1959) 15 spondylitic patients underwent colectomy and ileostomy, and progressive symptoms referable to the spondylitis continued post-operatively in 12. Only one patient in our series had persistent rheumatic complaints after surgery, and she was a girl who had sacro-iliitis. Earlier in the course of her disease, before operation, she had suffered attacks of typical colitic arthritis, but was emphatic that her post-operative symptoms differed from the attacks of colitic arthritis, and on examination they appeared to be related to sacro-iliitis.

One possible explanation of the difference in sex incidence of the frank clinical spondylitis and radiographic sacro-iliitis is that there are two disease processes—ankylosing spondylitis with spinal involvement occurring more often in men as uncomplicated ankylosing spondylitis does, and erosive changes of the sacro-iliac joints of different origin occurring more commonly in women. It could be that erosive changes confined to sacro-iliac joints without spondylitis occur only after the onset of ulcerative colitis. However, one is reluctant to postulate two entities affecting the same joints, particularly as there seems to be a significant correlation between ankylosing spondylitis preceding bowel symptoms and ulcerative colitis. The age distribution at which the changes were found lends no support to the view that the sacro-iliitis differed from that found in ankylosing spondylitis. Sacro-iliitis was equally common in younger patients, in contrast to lumbar disk changes, which were more frequently seen in older patients.

Summary

A prospective survey into the frequency of sacro-iliitis and changes in the lumbar spine in 234 unselected patients with ulcerative colitis has been carried out. Combined assessment by a gastro-enterologist and a rheumatologist made it possible to correlate the radiological changes with colitic and arthritic symptoms and signs. The x-ray changes in the sacro-iliac joints were compared with a matched control population.

Fifteen patients had ankylosing spondylitis clinically. Forty-two (18%) had sacro-iliitis radiographically, a highly significant increase in incidence compared with the control population. Sacro-iliitis was present equally commonly in both sexes, but erosive changes occurred twice as often among women. The incidence of sacro-iliitis bore no striking relation to the colonic disease in its duration, extent, clinical type, or complications, unlike colitic arthritis. It was not related to uveitis, nor to ulceration of the buccal mucosa. There was a positive correlation with skin lesions and colitic arthritis. The significance of these findings in relation to other forms of arthritis occurring with diseases of the bowel is discussed, and the suggestion that colitic arthritis is a manifestation of ankylosing spondylitis is examined.

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Addendum.—Since the submission of this paper a study of 104 patients with ulcerative colitis has been reported by Wright *et al.* (1965), who examined in the first instance barium-enema films, noting sacro-iliac joint changes in 17.4%, an incidence very similar to that of the present study. A greater incidence was found among women than among men. There was some suggestion from their data that incidence of sacro-iliitis

increased progressively with the duration of the colitis. Despite the evidence of other workers from Oxford (Acheson, 1960) they felt that their data favoured the view that sacro-iliac joint changes are a direct complication of ulcerative colitis.

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Controlled Trial of Breathing Exercises

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Most clinicians accept breathing exercises as a useful way of treating certain chronic respiratory disorders, notably emphysema and asthma. Many attempts have been made to demonstrate their effect by the use of lung-function tests (Allan, 1952; W. F. Miller, 1954; Becklake *et al.*, 1954; Campbell and Friend, 1955; McNeill and McKenzie, 1955; Sinclair, 1955; Becker and Denny, 1959; McKinley *et al.*, 1961; Cole *et al.*, 1962). Most of these investigations have not produced convincing evidence of improvement; but they have been reasonably criticized by W. F. Miller (1958) and others on the grounds that a group of patients was studied and the results were pooled, thus disguising the possible benefit to individuals, however few, which would justify the method of treatment.

We have tried to meet this objection by a controlled trial of breathing exercises in which simple lung-function tests were used as objective evidence of improvement and particular note was taken of symptomatic change as stated by the patient. We have examined further those patients who improved either objectively or symptomatically within the treated and control groups.

Methods

The study was limited to patients with chronic bronchitis and/or emphysema. Chronic bronchitis was defined symptomatically as a disease characterized by persistent cough and sputum on most days for at least three months of the year. All patients complained that they were short of breath. The presence of minor old tuberculous lesions on x-ray films did not exclude any patient from the survey. The presence of emphysema was judged by chest x-ray examination; the criteria of Simon and Medvei (1962) were used and the relative profusion of peripheral vascular shadowing (Laws and Heard, 1962) was taken into account.

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One hundred out-patients who satisfied the above criteria were randomly divided into two groups according to their date of birth; 51 (even dates) to the control and 49 (odd dates) to the treated group.

On first attendance the M.R.C. Short Questionnaire on Respiratory Symptoms (1960) was completed. Peak expiratory flow rate (P.E.F.R.) was measured with the Wright flowmeter (Wright and McKerrow, 1959). Five readings were recorded and the mean of the last three was calculated. Forced vital capacity (F.V.C.) and forced expiratory volume in one second (F.E.V.₁) were measured with a McKesson Vitalor dry spirometer (McKerrow and Edwards, 1961). Three readings were made and the mean of the last two was calculated.

The patients attended again six weeks and three months later. On both these occasions a different questionnaire was completed which made detailed inquiry into change of symptoms, especially cough, sputum, and dyspnoea. P.E.F.R., F.E.V.₁, and F.V.C. were recorded on each attendance.

The patients in the treated group were given a course of breathing exercises according to accepted principles (Reed, 1952; M. E. Miller, 1953; Storey, 1958; W. F. Miller, 1958). The same physiotherapist, who was experienced in these methods, instructed all the treated patients. They were required to attend for a minimum of six weekly lessons, and requested to practise at home.

The survey was completed between August 1963 and April 1964. The random method of selection ensured that both groups were exposed to similar climatic conditions.

Student's t-test for testing differences between mean values has been used. Results were regarded as significant only if $P < 0.05$.

Comparison of Control and Treated Groups

During the course of trial three patients developed lung abscess, carcinoma of the bronchus, and active pulmonary tuberculosis respectively. These, together with 10 treated subjects who defaulted from the trial before receiving the full