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EFFECT OF THE MILWAUKEE BRACE ON VITAL AND VENTILATORY CAPACITY OF SCOLIOTIC PATIENTS

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The vital capacity (VC) and the maximal voluntary ventilation (MVV) were studied in 29 patients with scoliosis (predominantly idiopathic). The results obtained confirmed earlier observations that scoliotic patients have decreased VC and MVV. The immediate effect of the application of the Milwaukee brace was a slight though statistically significant decrease in MV, whereas there was no significant effect on VC. Treatment with the Milwaukee brace for a mean period of 15 months did not appreciably influence the VC or MVV, as a percentage of the predicted normal values of the patients, when measured without the brace applied.

Key words: Milwaukee brace; pulmonary function; scoliosis

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The influence of thorax deformity on the cardiopulmonary function of scoliotic patients has been examined previously by several investigators. Impaired pulmonary function in scoliotic patients has been reported by Gucker (1962), Mankin et al. (1964), James et al. (1968), Scheier (1967) and others. Nilsonne & Lundgren (1968) as well as Nachemsson (1968) pointed out the significantly higher morbidity and rate of mortality due to cardiopulmonary affection.

Gucker (1962) reported that preoperative correction of scoliotic deformity, by means of a Milwaukee frame on a supine patient for 6 weeks or more, increased somewhat the vital capacity of some of the patients. There is, however, no previous report concerning comparative studies of pulmonary function with and without application of a Milwaukee brace in ambulatory scoliotic patients.

In this study the immediate and long-term effects of the application of a Milwaukee brace on the respiratory mechanism in scoliotic patients was examined.

PATIENTS

During the years 1967–1971 more than 100 scoliotic patients were examined at the Department of Orthopaedic Surgery in Umeå. Twenty-nine of these patients, 6 males and 23 females, were included in the present study (Table 1). There were three congenital and 26 idiopathic scolioses. The vertex of the primary curve was localized in the lower thoracic spine, Th 8–11, in 24 cases and in the upper thoracic or the upper lumbar

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Table 1. Anthropometric and clinical data of the patients.

Patient no.	Sex	Measured body height (cm)	Body weight (kg)	Age at diagnosis (years)	Age at first examination (years)	Type of scoliosis	Vertex	Side of convexity	Degree of curve (Cobb)	Clinical estimation of the deformity
Group I										
1	M	162	52	3	20	C	Th4	R	105	Pr
2	F	157	49	11	15	I	L1	L	87	Mod
3	F	163	54	12	20	I	Th9	R	65	Pr
4	F	160	41	11	12	I	Th9	R	59	Mod
5	F	161	67	12	15	I	Th8	R	56	Mod
6	F	169	47	14	15	I	Th10	R	40	Mod
7	M	164	56	14	14	I	Th9	R	55	Mod
8	F	159	42	13	14	I	Th9	R	40	Mod
9	F	171	67	13	19	I	Th8	R	54	Mod
10	F	150	52	8	13	I	Th9	R	46	Mod
11	F	176	77	12	23	I	Th11	R	54	Mod
12	F	157	40	14	14	I	Th8	R	40	Mod
13	F	168	50	13	14	I	Th11	R	54	Mod
Group II										
14	F	166	44	14	17	I	Th8	R	40	Mod
15	F	164	57	14	16	I	Th9	R	48	Mod
16	F	162	57	15	17	I	Th8	R	36	Mod
17	F	164	51	14	16	I	Th9	R	56	Mod
18	F	145	34	6	12	I	Th8	R	90	Pr
19	F	165	48	9	14	I	Th8	R	51	Pr
20	F	166	53	13	15	I	Th11	L	38	Mod
21	M	147	37	6	11	I	Th8	R	80	Pr
22	M	181	80	13	15	I	Th8	R	53	Mod
23	F	169	52	14	15	I	Th8	R	28	Mod
24	F	158	49	12	14	I	Th9	R	75	Pr
25	M	156	44	7	13	C	Th8	L	72	Pr
26	F	165	67	14	18	I	Th9	R	33	Mod
27	M	133	36	1	9	C	L2	L	55	Mod
28	F	171	59	15	20	I	Th9	R	38	Mod
29	F	170	53	13	13	I	Th	R	28	Mod

F = Female M = Male C = Congenital I = Idiopathic L = Left R = Right Mod = Moderate Pr = Pronounced

spine in 5 patients. The convexity of the scoliotic curve was right-sided in 24 patients. The deformity of the thorax and the spine was estimated clinically by one examiner (J.A.S.) according to a four grade scale: slight, moderate, pronounced and severe. It was considered moderate in 22 cases and pronounced in 7. The degree of deformity measured according to Cobb (1948) ranged between 28 and 105°. There were no cases of slight or severe deformities of the thorax in this material. The mean age of the patients at the time of the first examination was 15.3 years.

METHODS

General procedure. Spirometric examination of lung function was performed routinely in all patients in connection with their first visit as out-patients to the Department of Orthopaedic Surgery. The examination was performed regardless of the degree of scoliosis, the deformity of the thorax, or the indication for treatment with a Milwaukee brace, and before respiratory or other exercises were recommended. Some of the patients were treated with the Milwaukee brace immediately after the lung function examination (Group I) and some were observed for some time before treatment with the Milwaukee brace was introduced (Group II). The two groups were fairly similar with regard to the factors included in Table 1.

The examinations to study the immediate effect of application of the Milwaukee brace on lung function were performed in close succession, usually on the same day or within 2–3 days.

In 13 patients (Group I) this was done before treatment with the Milwaukee brace had started and in 16 patients (Group II) after 2.5–33 months (mean 15 months) of treatment.

The examinations to study the effect of treatment with the Milwaukee brace for several months (Group II) were made with an interval of 8.2–33 months and without the brace applied.

Lung function test. The vital capacity (VC) and the maximal voluntary ventilation at a free rate (MVV) were determined spirometrically using a Bernstein spirometer. The results of the VC and MVV measurements were expressed as a percentage of the predicted normal values (Birath et al. 1963, Grimby & Söderholm 1963, Bjure 1963). The normal values of lung function were calculated with and without correction of the body height for the scoliosis deformity. The angle of the scoliosis measured according to Cobb (1948) was used in the correction of the

Table 2. Effect of application of the Milwaukee brace on lung function.
Means of vital capacity (VC) and maximum voluntary ventilation at a free rate (MVV), as a percentage of predicted normal values, of patients examined without and with the application of the Milwaukee brace. Figures within brackets are calculated from "corrected body height (17)". Patients of Group I had not been treated with the Milwaukee brace before the measurements while the patients of Group II had been treated for 2.5-33 months (mean 15 months).

	Group I n = 13	Group II n = 16	Groups I + II n = 29
VC per cent of normal			
without M.br.	76 (69)	71 (66)	73 (67)
SD			14 (14.9)
with M.br.	73 (66)	70 (65)	71 (65)
SD			13.6 (13.9)
D	−3 (−3)	−1 (−1)	−2 (−2*)
MVV per cent of normal			
without M.br.	74 (68)	76 (69)	75 (69)
SD			14.3 (17.1)
with M.br.	65 (60)	72 (65)	69 (63)
SD			18.1 (15.5)
D	−9*** (−8***)	−4** (−4*)	−6*** (−6***)

D = the mean difference ("with" minus "without" Milwaukee brace).
n is the number of patients.
* = $0.01 > P > 0.05$; ** = $0.001 > P > 0.01$; *** = $P > 0.001$.
P is the probability that the difference was caused by chance.

body height using the formula introduced by Bjure et al. (1968).

Statistical methods. The significance of observed intraindividual differences was tested by Student's t-test for paired experiments using the method of least squares for calculating standard deviations. A statistically significant difference caused by chance was 1 per cent or less.

RESULTS

The VC and the MVV were lower than predicted normal values (Tables 2 and 3).

The effect of the application of the Milwaukee brace on the VC and MVV was examined in patients who had not been treated (Group I) and in patients who had been treated for some time with the Milwaukee brace (Group II). The mean values of the VC and MVV as a percentage of predicted values were slightly lower after the application of the Milwaukee brace in both groups. The differences were statistically significant in the case of MVV (Table 2). There was no significant difference between the group that had been treated for some months with the Milwaukee brace and the one which had not been treated.

Treatment with the Milwaukee brace for periods varying between 2.5–33 months (mean 15 months) did not change the VC or MVV, as a percentage of the predicted normal values, when measurement was performed without the Milwaukee brace (Table 3).

During the period of treatment with the Milwaukee brace there were only minor changes in the scoliotic angle.

DISCUSSION

Diminished VC in scoliotic patients was first reported by Schneevogt (1854) (cited by Caro & Dubois 1961) and was later confirmed by Gucker (1962). Flagstad & Kollman (1928) found that the VC was reduced to the greatest extent when the scoliotic curvature was localized in the thoracic spine. The total lung capacity and its subdivisions were found by Chapman et al. (1939) to be decreased in scoliosis. The reduced total lung capacity, the normal residual volume and intrapulmonary gas mixing with only a moderate reduction of the MVV, investigated by Iticovici & Lyons (1956) and Bergofsky et al. (1959), were considered to indicate that emphysematous changes of the lungs were not responsible for the impaired lung function.

Reduced lung volumes were observed in young and adult patients alike, but

Table 3. Effect of treatment with Milwaukee brace on lung function.

Mean vital capacity (VC) and mean maximum voluntary ventilation at free rate (MVV) as a percentage of predicted normal values at the first examination and after a period of treatment (mean 15, range 2.5–33 months) with the Milwaukee brace in a group of 16 scoliotic patients (Group II). No Milwaukee brace was applied during the spirometric examination.

	At first examination	After treatment	D
VC per cent of normal			
M	75 (68)	71 (66)	4* (2)
SD	± 14.3 (± 12.8)	± 13.1 (± 15.4)	
MVV per cent of normal			
M	73 (67)	76 (69)	−3 (−2)
SD	± 13.0 (± 15.1)	± 15.8 (± 18.0)	

D = the mean difference between the first and second examination.
Other symbols as in Table 2.

whereas in young patients the thoracic cage was normally distensible, it was more rigid in older patients. Caro & Dubois (1961) found that chest cage rigidity appeared to be a late complication of the disease. The relation between the degree of the scoliotic curve and the pulmonary impairment was studied by Mankin et al. (1964) who found that the greater the curvature the greater was the deficit of the VC. The observations made in the present study that the VC and the MVV in scoliotic patients were lower than expected normal values are in agreement with earlier observations.

As pointed out by Hepper et al. (1965) and Bjure et al. (1968) the predicted normal estimates for spirometric values based on body height are falsely low in scoliosis. This tends to hide the decrease in VC and MVV caused by scoliosis when expressed as a percentage of the normal values. By correcting body height for the scoliosis angle, according to Bjure et al. (1968), the deviation of the lung function of scoliotic patients from normal values is shown more accurately (Tables 2 and 3). However, this correction does not appreciably affect the results of the evaluation of the effect of the Milwaukee brace on lung function.

One of the advantages of the Milwaukee brace compared with other methods of conservative treatment, preoperative correction, or postoperative support of the curved scoliotic spine, is supposed to be its lack of affect on the distensibility of the chest cage and hence the ventilatory capacity of the lungs. The present study of 29 patients examined without the Milwaukee brace and soon afterwards with the brace applied showed that the Milwaukee brace *per se* does not appreciably influence the VC of the patients whereas the observed slight decrease of MVV was statistically significant.

In the report by Gucker (1962) preoperative correction of the scoliotic deformity by means of a Milwaukee brace for 6 weeks or more resulted in a slight increase of the vital capacity in three out of five patients with paralytic scoliosis. In the present series of mainly idiopathic scolioses no significant changes in VC or MVV were observed in 16 patients treated with the Milwaukee brace for a mean period of 15 months (Table 3). Contrary to the effect of casts used previously, reported by Gucker to reduce the VC up to one third, treatment with the Milwaukee brace does not decrease the VC or MVV appreciably.

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