

MORPHOLOGIC AND MORPHOMETRIC STUDIES OF MUSCLE IN IDIOPATHIC SCOLIOSIS

VINOD SAHGAL*, ANU SHAH*, NORTON FLANAGAN*, MICHAEL SCHAFER**, WILLIAM KANE**, VENKA SUBRAMANI* & HARVINDER SINGH*

*Department of Rehabilitation Medicine and Department of Neurology, Northwestern University, Rehabilitation Institute of Chicago, and **Department of Orthopaedic Surgery, Northwestern University, Chicago, Illinois, USA

The gluteus maximus and paraspinal muscles in 15 cases of idiopathic scoliosis at the apex of the curve showed myopathic changes and a significant decrease in the type II fibers. Fiber type II atrophy was observed only on the concave side. Ultrastructure of paraspinal and gluteus muscle biopsies showed disruption of myofilaments, Z band streaming and subsarcolemmal accumulation of glycogen, lipid and mitochondria. Quantitative estimation of these subcellular organelles pointed out that a higher glycogen content was significant in both paraspinal as well as the gluteus muscles while a higher mitochondrial content was significant only on the convex side and the gluteus muscle but not the concave side of the apex when compared to normal quadriceps muscle. These findings suggest that idiopathic scoliosis is a diffuse disease process and may be considered a primary muscle disease.

Key words: histochemistry; morphometry; muscle; myopathy; scoliosis; ultrastructure

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Involvement of the spinal muscles in the production and/or progression of idiopathic scoliosis has been indicated by a number of electromyographic studies (Riddle & Roaf 1955, Zuk 1957, 1962, LeFebvre et al. 1961, Oi 1966, Kaplan et al. 1980). However, only a few histological (Gruca 1958, Saito 1964, Kaneko 1968, Spencer & Zorab 1976) and ultrastructural studies (Hirano 1972, Wong et al. 1977, Yarom & Robin 1979a,b) are available. The pathogenesis and etiology of idiopathic scoliosis are still not clearly known. The purpose of the present investigation was to study the histochemical and morphologic changes in the paraspinal muscles of patients with idiopathic scoliosis and to compare these changes with the non-spinal gluteus maximus muscle of the same patient.

We present here morphologic, histochemical, histometric and ultrastructural studies of paraspinal as well as gluteus muscle biopsies from 15 cases of idiopathic scoliosis.

MATERIALS AND METHODS

Clinical material

The 15 patients studied consisted of 11 females and 4 males. These patients were 8-17 years of age and had a confirmed diagnosis of idiopathic scoliosis with no clinical evidence of neuromuscular disease. In all these patients, the curvature of the spine was greater than 40° and paraspinal and gluteus muscle specimens were obtained during the surgical correction of scoliosis.

The paravertebral muscles at the apex of the curve on either side of curvature (i.e. concave and convex) were

selected for the study. Great care was taken to see that the tendon area of the muscle was not included in the study. Specimens taken from the gluteus maximus muscle of each patient were also included in the study to evaluate the lower limb girdle muscle. This muscle was not available in two cases.

Quadriceps muscle biopsies from eight (non-scoliotic) patients which appeared normal in histochemistry and electron microscopy (EM) were included for EM morphometry for the comparative studies. Since similar data on normal paraspinal muscle was not available, the quadriceps muscle profile was used for comparison.

Histochemistry and electron microscopy

The muscle biopsies were divided into two segments. One part was quickly frozen in isopentane and liquid nitrogen for histochemical studies. Frozen serial sections of 8–10 micron thickness were treated for the detection of ATPase (pH 9.4, 4.4), NADH, glycogen (PAS) and fats (Oil Red O and Sudan Black) besides the routine Haematoxylin and Eosin and Trichrome stains (Sahgal et al. 1976). Another portion of the biopsy was processed in a routine manner for electron microscopic studies (Sahgal & Sahgal 1977).

Histometry

The percentage of each fiber type was calculated by counting the proportion of two fiber types in several fascicles in each biopsy.

The diameter of the transverse sections of both fibers stained for ATPase (pH 9.4) reaction was measured using the microprocessor based image analyzer (MOP-3 system). One hundred fibers of each type were measured to get the mean fiber diameter in each biopsy. Histogram analysis was done by plotting the fiber diameter against the number of fibers. The biopsy material from one case was unsatisfactory for histometric study.

EM morphometry

Sampling procedure. It was apparent in the beginning of the study that cellular distribution varied selectively with reference to different areas in a muscle fiber. Nuclei, mitochondrial proliferation, glycogen granules and lipid vacuoles were more frequently found under the plasma membrane than the central area of the fibers. The central area of the muscle fibers of these biopsies could still give a normal appearance when viewed separately. Therefore, the subsarcolemmal region of the fibers was selected for the quantitative determination.

For each biopsy, 3–4 longitudinally embedded blocks were randomly selected and thin-sectioned for electron microscopy. Three grids with serial sections from each block were examined and photographed for the quantitative measurements. Whenever possible, the fiber

was photographed nearest the corners of the grid square which again was closest to the center of the supporting grid. Usually 2–3 electronmicrographs from each grid and, consequently, about 20–24 electronmicrographs per biopsy were quantitated. Both normal and atrophic fibers were included for the measurements. This exercise was done to guard against a bias in fiber type selection.

Measurements. In the present study, a microprocessor based image analyzer system MOP-3 (Carl Zeiss, Inc.) was employed. Unlike the point sampling technique, this system gives the results in terms of the relative percentages of the subcellular organelles in a muscle fiber considering the area measured as 100 percent. It was not possible to keep a constant magnification at all times due to the varied size of the fibers. The final print magnification ranged from 16 to 24 000. The relative percentages of mitochondria, glycogen, lipid and Z band material were determined for each print and finally the mean values of each of these organelles were arrived at after computing all the electronmicrographs studied for that particular biopsy. Biopsy material from six cases was not satisfactory for the quantitative study of its electronmicrographs.

RESULTS

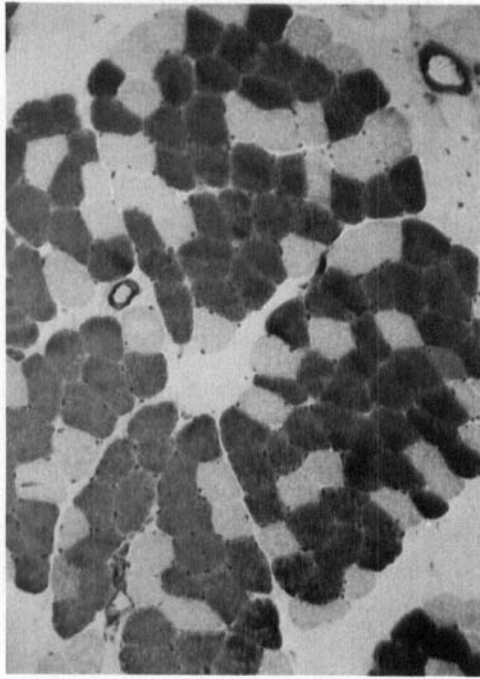
Light microscopy

Paraspinal muscles. The specimens showed a variation in fiber size, central nuclei, splitting and hyalinization of fibers. These changes were observed on the concave as well as the convex side of the scoliotic curve. There was also an increase in interfascicular connective tissue. The chains of nuclei were frequently seen.

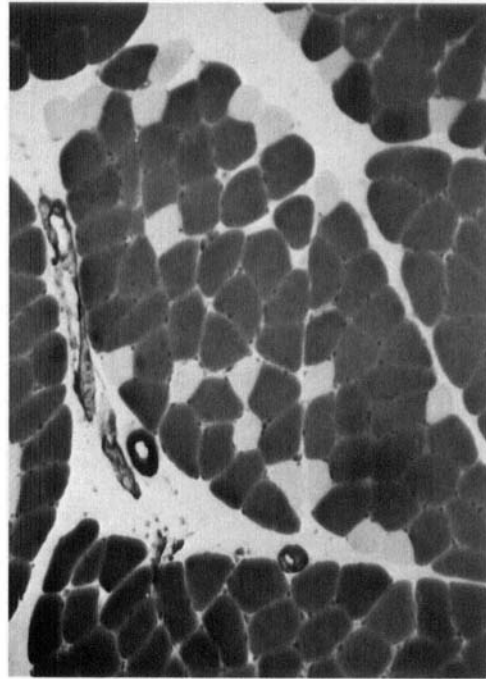
The DPNH reaction showed type I fibers as dark and type II as light fibers while the ATPase (pH 9.4) reaction exhibited type I as light and type II as dark fibers. By these histochemical stains, five cases (nos. 1, 3, 9, 10 & 12) showed fiber type grouping on both sides of the curve (Fig. 1a & b). In the rest of the cases there was a preponderance of type I fibers on both sides of the apex.

Gluteus maximus muscle. Myopathic changes such as variation in fiber size, central nuclei, splitting and hyalinization of fibers were also seen in the gluteus muscle of all cases.

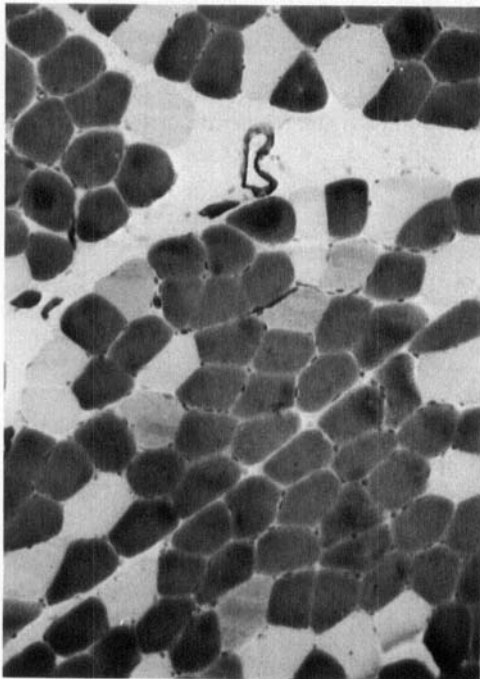
Histochemical reactions showed fiber type grouping in three cases, viz. 1, 3 & 10 (Fig. 1c).



a



b



c

Figure 1. Transverse sections of paraspinal and gluteus muscle biopsies from idiopathic scoliosis patient (case no. 10) show grouping of dark type I fibers (adenosine triphosphatase reaction pH 4.4) $\times 120$. a – concave side of the apex. b – convex side of the apex. c – gluteus maximus.

The rest of the cases showed fiber type I predominance.

Histometry

Table 1 represents the percentages of type I and type II fibers in the paraspinal as well as the gluteus muscles of idiopathic scoliosis. The ratio of the type I 'slow' oxidative fibers to type II 'fast' anaerobic fibers was also calculated. The normal ratio of type I to type II fibers has been reported to be approximately 1:2 in skeletal muscle (Dubowitz & Brooke 1973). Considering both sexes, the ratio was considered normal in a range of 0.45 to 0.65.

Paraspinal muscles. Concave side – The concave side of the apex showed a very low percentage of

Table 1. Percentages and fiber type ratios of Type I and Type II fibers in paraspinal and gluteus muscle of idiopathic scoliosis

Case no.	Concave apex			Convex apex			Gluteus		
	Type I	Type II	Ratio of Type I/Type II	Type I	Type II	Ratio of Type I/Type II	Type I	Type II	Ratio of Type I/Type II
1	64	36	1.78	62	38	1.63	71	29	2.45
2	67	33	2.03	69	31	2.23	61	39	1.56
3	70	30	2.33	79	21	3.76	77	23	3.35
4	63	37	1.70	65	35	1.86	66	34	1.94
5	78	22	3.55	59	41	1.44	82	18	4.56
6	44	56	0.79	71	29	2.45	48	52	0.92
7	45	55	0.82	61	39	1.56	64	36	1.78
8	57	43	1.33	59	41	1.44	69	31	2.23
9	66	34	1.94	57	43	1.33	63	37	1.70
10	63	37	1.70	68	32	2.13	53	47	1.13
11	73	27	2.70	48	52	0.92	70	30	2.33
12	65	35	1.86	79	21	3.76	70	30	2.33
13	28	72	0.39	36	64	0.56	*	*	*
14	53	47	1.13	59	41	1.44	*	*	*

* Biopsy not available.

Sign tests

Muscle	Total		Probability
Concave apex	11+	3-	0.057
Convex apex	12+	2-	0.013
Gluteus	11+	-	0.0031

type II fibers (from 22 to 37 percent) in nine cases which consequently had type I/type II ratio ranging from 1.70 to 3.55 – higher than the normal range. Four cases (namely 6, 7, 8 and 14) did not exhibit significant differences between the percentage of two fiber types. Here the fiber type I/type II ratio varied from 0.79 to 1.13. However, it was interesting to note that the case no. 13 showed 28 percent of type I and 72 percent of type II fibers, which resulted in a low fiber type ratio of 0.39.

Convex side – Eight cases on the convex side of the apex also showed a very low percentage of type II fibers (from 21 to 39 percent) with type I/type II ratio ranging from 1.56 to 3.76. The difference between the percentage of two fiber types was not significant in five cases (nos. 5, 8, 9, 11 and 14) which had the fiber ratio values from

0.92 to 1.44. However, the same case (no. 13) that showed significantly high percentage of type II fibers and a low fiber type ratio on the concave side showed 64 percent of type II fibers and a fiber type ratio of 0.56.

Gluteus muscle. Ten out of 12 cases of gluteus muscle showed a low percentage of type II fibers (from 18 to 39 percent) with a fiber type ratio ranging from 1.56 to 4.56. The difference in the proportion of two fiber types was not remarkable in the remaining two cases (no. 6 and 10) whose fiber type ratio was 0.92 and 1.13 respectively.

The data were statistically analyzed to determine the significance of the above percentage differences (Table 1, Sign tests). A simple 't' test was not appropriate as type I and type II data, being the percentages, are perfectly (negatively) correlated. Hence, the Binomial Probability Theorem was used. It is assumed here that the 'true' probability is 0.50 for each fiber kind. A + sign was assigned to each case in which type I fibers were greater in number than type II and – sign where type II fibers were more in number than type I fibers. With this calculation, sign total was 11+ and 3– for concave, 12+ and 2– for

Table 2. Mean fiber diameter (in microns) of paraspinal and gluteus muscles of idiopathic scoliosis

Case No.	Concave apex		Convex apex		Gluteus	
	Type I	Type II	Type I	Type II	Type I	Type II
1	55	39	50	40	40	52
2	67	68	59	75	59	66
3	40	40	49	33	46	50
4	56	50	55	48	56	49
5	53	51	47	50	59	65
6	57	43	60	61	55	47
7	65	49	71	55	64	36
8	42	28	42	37	43	35
9	44	39	56	48	46	43
10	56	40	65	75	45	66
11	66	59	70	48	59	64
12	43	41	43	35	42	49
13	39	36	30	31	*	*
14	52	48	51	45	*	*
Mean	52.51	45.05	53.45	48.62	51.16	51.83
Standard deviation	9.62	10.08	11.34	14.05	8.27	11.19

* Biopsy not available.

"t" tests

Muscle	"t" value	Degree of freedom	Probability (P)
Concave apex	4.38	13	0.001
Convex apex	1.76	13	0.103
Gluteus	0.18	11	0.857

convex and 11+ and 1- for the gluteus muscle. The sign test was then performed where the probability of getting the sign total was computed when the available possibility is 0.50. The sign test indicated that the lower percentage of type II fibers was statistically significant on the concave and convex sides of the apex as well as the gluteus muscle.

Table 2 shows the mean fiber diameter of type I and type II fibers in paraspinal and gluteus muscles of idiopathic scoliosis.

Paraspinal muscles. Concave side – The concave side of the apex showed type II fibers smaller by 14 to 16 microns than type I in five cases, viz. 1, 6, 7, 8 and 10. However, this difference was not significant in seven cases (nos. 4, 5, 9, 11 and 14)

where type II fibers were smaller than type I by only 2 to 7 microns. Two cases (no. 2 and 3) showed almost equal size of the two fiber types.

Convex side – On the convex side, only three cases (nos. 3, 7 and 11) showed type II fibers to be smaller by 16–22 microns than type I. In six cases, type II fibers were smaller than type I by 5 to 10 microns. However, two cases (nos. 2 and 10) showed type II fibers to be larger than type I by 15–16 microns. The remaining three cases (nos. 5, 6 and 13) did not show much difference between the two fiber types.

Gluteus muscle. The gluteus muscle showed type II fibers to be smaller than type I by 28 microns in only one case (no. 7). Four cases (4, 6, 8 and 9) had type II fibers smaller than type I by only 3 to

Table 3. Histogram analysis in terms of left shift of fibers in paraspinal and gluteus muscle biopsies of idiopathic scoliosis

Case No.	Concave apex	Convex apex	Gluteus
1	+	+	—
2	same	—	same
3	same	+	same
4	same	+	same
5	same	—	same
6	+	same	+
7	+	+	+
8	+	same	+
9	same	+	same
10	+	—	—
11	same	+	—
12	same	+	—
13	same	same	*
14	same	same	*

+: Left shift of Type II fibers.

(More Type II fibers with smaller diameter than Type I)

—: Left shift of Type I fibers.

(More Type I fibers with smaller diameter than Type II)

Same: More or less overlapping distribution of both fiber types.

* Biopsy not available.

8 microns. However, the rest of the seven cases had type II fibers larger than type I by 4–21 microns.

The overall mean fiber diameter of type II fibers in the convex apex and gluteus muscle group was not significantly lower than type I fibers. However, the concave apex group did show greater difference (>7 microns) between the mean fiber diameter of the two fiber types.

Statistical analysis using the 't' test also indicated that type II fibers were significantly smaller than type I fibers in the concave apex region at the *P* value of 0.001 but was not so in the case of convex apex and the gluteus muscle (Table 2, 't' tests). It showed that the type II atrophy was more evident in the concave region than the convex or the gluteus.

Table 3 depicts the histogram analyses in terms of the left shift (smaller size) of either type I or type II fibers.

Paraspinal muscles. Concave side – The concave side of the apex showed left shift of type II fibers in five cases (viz. 1, 6, 7, 8 and 10) while the remaining nine cases exhibited an overlapping pattern of two fiber types.

Convex side – On the convex side, seven cases (1, 3, 4, 7, 9, 11 & 12) showed left shift of type II fibers and four cases showed an overlapping pattern. However, left shift of type I fibers was seen in the remaining three cases (2, 5 and 10).

Gluteus muscle. The gluteus muscle exhibited a left shift of type II fibers only in three (nos. 6, 7 and 8) out of 12 cases. Five cases showed an overlapping distribution of two fiber types while four (nos. 1, 10, 11 and 12) exhibited a left shift of type I fibers.

Electron microscopy

At the subcellular level, a variety of pathological changes were observed in all the 15 biopsies. These changes were seen on both the concave and convex sides of the apex as well as the gluteus muscle. The basement membrane was wavy and irregular in contour. Nuclei were mostly seen peripherally. However, central nuclei were occasionally seen. They frequently showed indented margins with clumps of heterochromatin along the nuclear membrane.

Some muscle fibers showed localized destruction of the normal striated pattern and thickening and/or streaming of Z line (Fig. 2). In four biopsies, presence of nemaline "rods" due to breakdown and accumulation of Z band material was noticed. Most biopsies showed subsarcolemmal accumulation of small, various-shaped mitochondria, lipid vacuoles and lipofuscin material. Accumulation of glycogen granules in the perinuclear as well as intermyofibrillar areas was striking in nine cases. Dystrophic changes and immature muscle fibers were also frequently seen on both sides of the apex but not gluteus in four of our cases (Fig. 3).

EM morphometry. Nine out of 15 cases could be studied quantitatively with respect to their subsarcolemmal distribution of lipid vacuoles,



Figure 2. Electronmicrograph of a muscle fiber shows streaming and thickening of dense Z band material in this area. (Biopsy of the concave side of the apex of case no. 2) $\times 8800$.

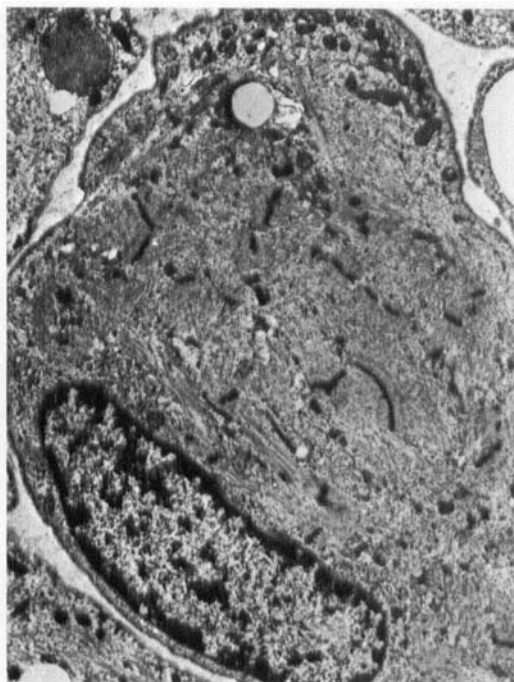


Figure 3. Electronmicrograph of a myofiber shows disrupted myofibrillary architecture. (Biopsy of the convex side of the apex of case no. 8) $\times 10200$.

glycogen, mitochondria, and Z band using the MOP-3 system. Biopsy material for gluteus was not available for two of these cases. Eight cases of normal subjects were also studied in a similar manner. Table 4 represents these results in terms of mean percentages of these organelles in muscle fibers of normal subjects (A), concave apex (B), convex apex (C) and gluteus muscle (D) of scoliosis patients. Large variation in the subsarcolemmal distribution of mitochondria, glycogen and lipid vacuoles was seen in individual cases as well as their mean values.

Paraspinal muscles. Concave side (Table 4B) – One case (no. 9) showed strikingly high percentages of lipid and glycogen and two other cases (nos. 12 and 14) also showed relatively high contents of lipid and glycogen. The overall mean value for lipid was higher on the concave side than the convex or the gluteus. The comparison of mean values of each of these organelles with

their normal counterparts (Table 4A) showed that the high glycogen and Z band values were statistically significant on this side of the curvature.

Convex side (Table 4C) – Two cases (nos. 7 and 12) showed higher percentage of lipid. The rest of the cases showed nearly normal lipid content. However, the mean value of the lipid for the entire group was higher than the normal and nearly the same as the gluteus but lower than the concave side. Most cases exhibited high glycogen content. Four cases (no. 8, 10, 12 and 13) showed high concentration of mitochondria. The mean value of mitochondria for the entire convex side also was higher than the normal. The statistical analysis brought out significantly high percentages of glycogen and mitochondria when compared to the normal.

Gluteus (Table 4D). Two cases (nos. 12 and 15) showed high lipid as well as mitochondrial per-

Table 4A. Mean percentages of subcellular organelles in quadriceps muscle of normal subjects

Serial No.	Lipid	Glycogen	Mito-chondria	Z-band
1	0.2	7.0	1.6	3.5
2	0.1	4.0	3.5	2.7
3	1.2	6.4	3.5	2.8
4	3.8	7.3	3.0	3.2
5	3.5	4.8	4.4	3.6
6	—	3.9	1.8	1.6
7	0.5	1.8	4.1	3.2
8	2.1	2.7	4.7	1.9
Mean	1.42	4.74	3.33	2.81
Standard deviation	1.54	2.02	1.14	0.73
Standard error	0.54	0.71	0.40	0.26

Table 4B. Mean percentages of subcellular organelles in paraspinal muscle (concave side) biopsies of idiopathic scoliosis

Case No.	Lipid	Glycogen	Mito-chondria	Z-band
7	—	2.7	4.7	3.5
8	3.3	13.8	7.2	1.0
9	16.7	16.8	3.0	3.8
10	3.2	23.0	2.7	5.4
11	0.8	11.5	1.5	4.6
12	6.1	5.2	4.8	3.2
13	2.3	9.5	4.7	6.3
14	8.2	15.3	3.7	4.9
15	4.5	11.2	5.0	3.5
Mean	5.01	12.11	4.14	4.02
Standard deviation	5.06	6.10	1.65	1.53
Standard error	1.69	2.03	0.55	0.51
't' test	-2.02	-3.42	-1.20	-2.12
Degree of freedom	9.64	9.92	14.23	11.75
Probability (P)	0.070	0.007	0.249	0.055

centages while the remaining showed nearly normal amounts of lipid and mitochondria. Three cases (nos. 7, 8 and 10) showed higher glycogen content. The overall mean for lipid was nearly the same as the convex side but higher than the nor-

Table 4C. Mean percentages of subcellular organelles in paraspinal muscle (convex side) biopsies of idiopathic scoliosis

Case No.	Lipid	Glycogen	Mito-chondria	Z-band
7	7.4	8.3	7.6	6.9
8	1.3	4.9	10.3	—
9	1.2	13.2	2.9	3.9
10	1.8	38.6	11.5	5.0
11	3.3	21.8	2.5	4.7
12	9.1	16.4	11.1	3.8
13	—	10.6	22.4	—
14	2.0	18.3	3.1	6.8
15	2.7	9.6	8.0	2.3
Mean	3.20	15.74	8.82	3.71
Standard deviation	3.04	10.06	6.21	2.55
Standard error	1.01	3.35	2.07	0.85
't' test	-1.54	-3.21	-2.61	-1.01
Degree of freedom	12.13	8.72	8.60	9.45
Probability (P)	0.149	0.011	0.028	0.338

Table 4D. Mean percentages of subcellular organelles in gluteus muscle biopsies of idiopathic scoliosis

Case No.	Lipid	Glycogen	Mito-chondria	Z-band
7	1.2	12.4	12.3	3.1
8	1.2	29.6	—	—
9	2.4	9.8	8.6	3.4
10	0.4	25.5	5.6	6.0
11	1.0	9.0	8.0	5.0
12	10.2	4.1	12.0	2.9
15	10.2	6.9	12.2	2.3
Mean	3.80	13.90	8.39	3.24
Standard deviation	4.41	9.74	4.49	1.93
Standard error	1.67	3.68	1.70	0.73
't' test	-1.35	-2.44	-2.90	-0.56
Degree of freedom	7.28	6.45	6.68	7.49
Probability (P)	0.218	0.050	0.023	0.595

mal. The mean glycogen content was also as high as the concave and the convex side and much higher than the normal. The mitochondrial mean

was nearly the same as that of the convex side but higher than the normal value. Like the convex side, higher glycogen and mitochondrial percentages were statistically significant when compared to the normal.

DISCUSSION

Histological studies showed myopathic changes such as variation in fiber size, internal nuclei and splitting of fibers on both the concave and the convex sides of the apex. These findings have also been described by others (Tsairis 1974, Spencer & Zorab 1976). Yarom & Robin (1979a) suggested that the concave side muscles were severely affected and that it was possible to diagnose the direction of the curve from histologic slides while working 'blindly'. However, we did not see the differences on either side of the curvature to the extent of identifying the side.

Similar but milder changes were also found in the gluteus muscle. This was also observed by Yarom & Robin (1979a,b). The myopathic changes in this muscle indicate involvement of non-paraspinal muscle in the disease process.

Fiber type grouping in five cases by histochemical staining was indicative of a neurogenic process. Three of these five cases also showed similar changes in the gluteus muscle. It may be viewed as a secondary change due to nerve involvement. Neurogenic involvement in idiopathic scoliosis was suggested by EMG studies (Kaplan et al. 1980). The neuromuscular basis for scoliosis was also suggested by Robin (1975) and Yarom & Robin (1979b). Though non-specific changes of mixed neurogenic and myopathic type have been described by several workers (Fidler et al. 1974, Hoppenfeld 1974, Spencer 1974, Tsairis 1974, Spencer & Eccles 1976, Spencer & Zorab 1976), it is not clear at this stage whether it is primarily a myopathic process followed by secondary nerve involvement.

The distribution of fiber types showed the preponderance of type I fibers on both the concave and convex sides of the curve as well as the gluteus muscles of most cases (Table 1). However, preponderance of type II fibers was observed in a case (no. 13) on both sides of its

curvature. The reason for this is not clear. Abnormalities in fiber type distribution with a general decrease in the number of type II fibers were also observed by Spencer & Eccles (1976) as well as Yarom & Robin (1979b). Preponderance of type I fibers in all three muscle samples of most cases may be suggestive of a congenital muscle problem (Brooke 1973).

Type II atrophy is a non-specific change and although most cases did not exhibit significant differences in the diameter of two fiber types, the 't' test showed type II atrophy preferentially on the concave side but not the convex and the gluteus (Table 2). Yarom & Robin (1979a,b) however, reported preferential type I atrophy in paraspinal and deltoid muscles of the concave side.

The ultrastructural study confirmed the myopathic changes observed in light microscopy. Subcellular changes such as general increase in glycogen and lipid contents, derangement of myofilaments and Z band seen in the present study have been also reported by Wong et al. (1977) in their study of two adolescent scoliotic patients. Dystrophic changes were observed in four of our cases on both sides of the curvatures. However, these changes were reported only on the concave side of the curve by Tokarowski (1965). Other studies on the spinal muscles in scoliosis have shown indications of atrophy, degeneration and denervation (Hirano 1972, Spencer & Zorab 1976). The present study indicates primarily myopathic changes and preponderance of type I fibers in most cases and secondary denervation, changes in five cases by fiber type grouping.

EM quantitative data on paraspinal and gluteus muscles in scoliosis have not been reported so far. In the present study the mean lipid content was not significantly higher than the normal in either paraspinal or the gluteus muscle. However, individual cases in all three muscle samples (nos. 9, 12 & 14 on concave, no. 7 & 12 on convex and nos. 12 & 15 of gluteus) did exhibit significant increase in their lipid contents which could be due to individual variation. All three kinds of muscle showed statistically significant glycogen content while mitochondria were significantly higher on the convex side and in the gluteus but not on the

concave side of the apex which exhibited significantly high Z band value. High percentage of Z band material is reflective of Z band spreading and nemaline-like rods. These data do indicate the involvement of gluteus muscle but definitive conclusions regarding the quantitative increase in cellular organelles and their relationships with the concave or convex side of the curvature await results on a larger number of scoliosis cases.

CONCLUSION

The results obtained from histochemistry, histometric and ultrastructural studies indicated that both sides of the apex region of the curve as well as the gluteus muscle were affected to different extents in idiopathic scoliosis. This gave the impression that the disease was not focal but diffuse in nature. Changes observed in the gluteus maximus suggested the involvement of pelvic girdle muscle in this pathological condition. Generalized myopathic changes in the paraspinal and gluteus muscle specimens suggest that idiopathic scoliosis may be a primary muscle disorder.

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