Observations on the Function of the Clavicle*†

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THE function of the clavicle is usually dismissed with the observation that it acts as a sort of flexible outrigger which serves as a prop for the shoulder, thus establishing the conditions necessary for free action of the arm. But such a statement is far too general and provides little understanding of the essential mechanism to enable us to interpret certain clinical derangements or to develop rational methods of surgical correction.

The shoulder itself constitutes a complex mechanism in which no less than three joints participate, the sternoclavicular, the acromioclavicular, and glenohumeral, as well as the accessory motion of the scapula on the thoracic cage. So intimately related and yet so diverse are these individual functions that it is impossible to treat one of the constituents of the shoulder without at least touching upon the mechanism of the others. Therefore, in considering the function of the clavicle and in discussing such clinical problems as arise in association with dysfunction of this single member, it becomes necessary to touch, however briefly, on the range of movement occurring at the shoulder joint proper, so that we may follow some aspects of its sequence of motion in relationship to the other constituent bony levers.

The several joints which make up the shoulder complex, although capable of independent motion, all contribute their share to the total movement in a simultaneous but not successive manner. It is this simultaneity which results in that harmony of movement which Codman has so aptly called scapulo-humeral rhythm. It is of great clinical importance to recognize that any break in this harmony of rhythm is positive evidence of derangement in one or the other of the several components of the shoulder mechanism.

The most important movement for analysis is elevation of the arm, whether it be attained either through abduction or forward flexion. In these pathways there is little essential difference in mechanism except for minor details.

Elevation of the extremity, both in flexion and in abduction, at the glenhoumeral articulation is simultaneously accompanied by scapulothoracic movement, an arrangement which critically en-

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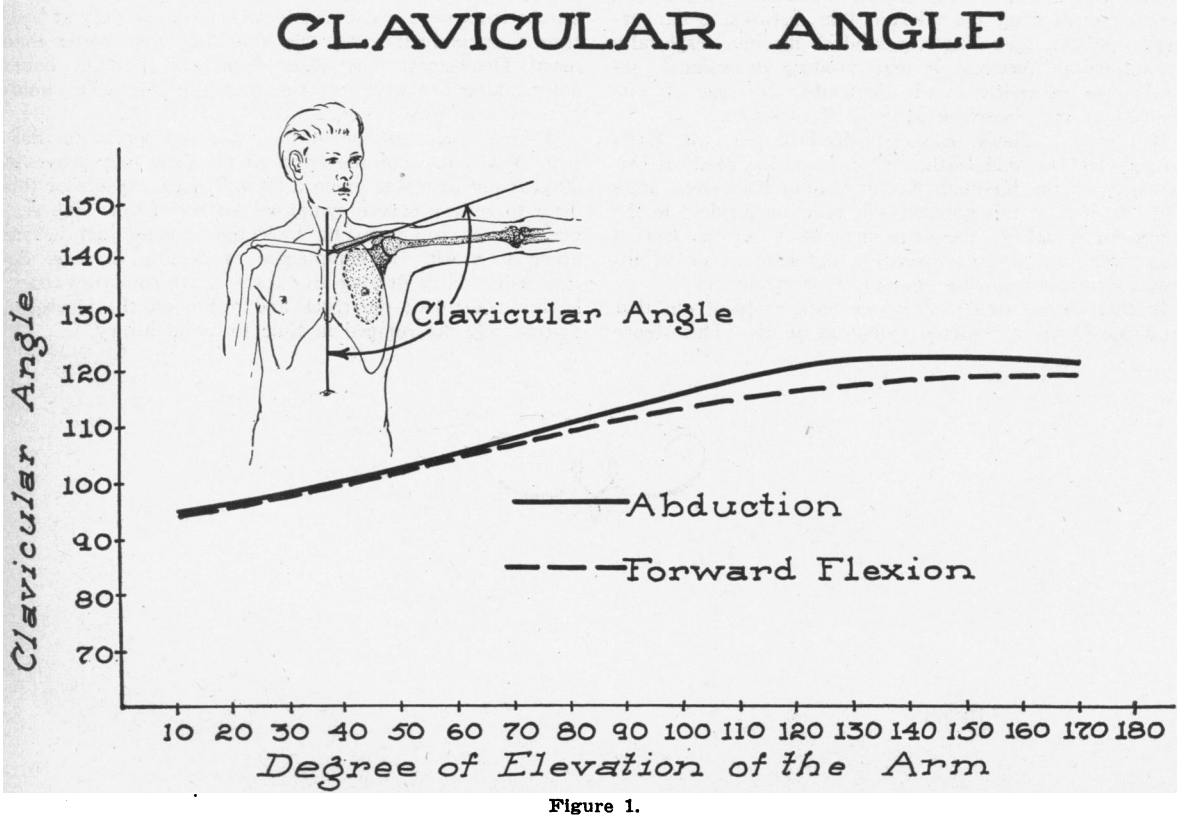


Figure 1.

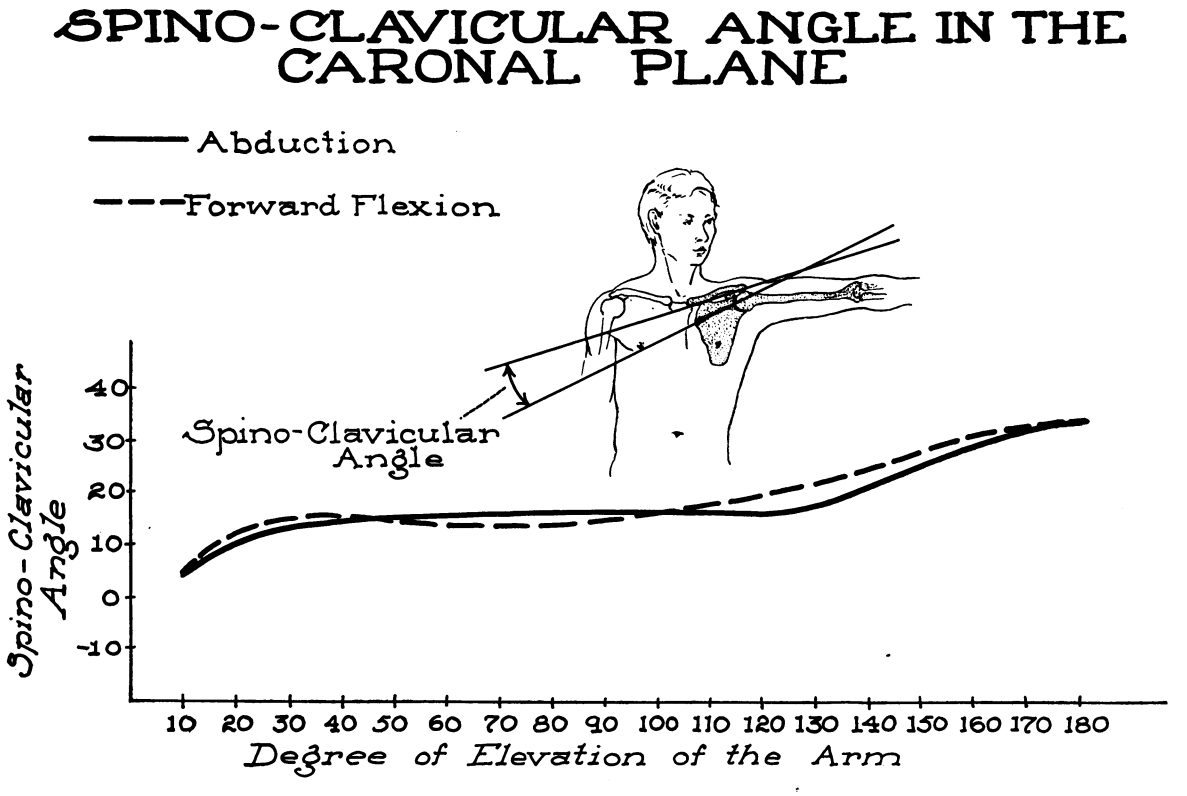


Figure 2.

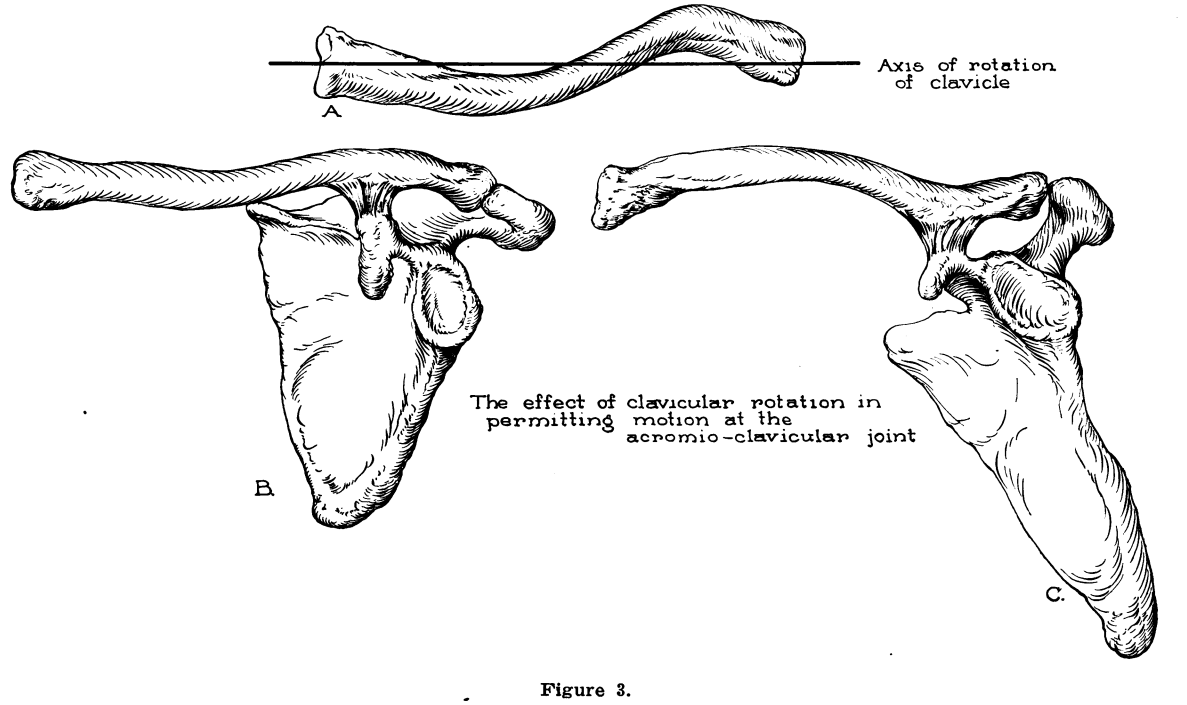
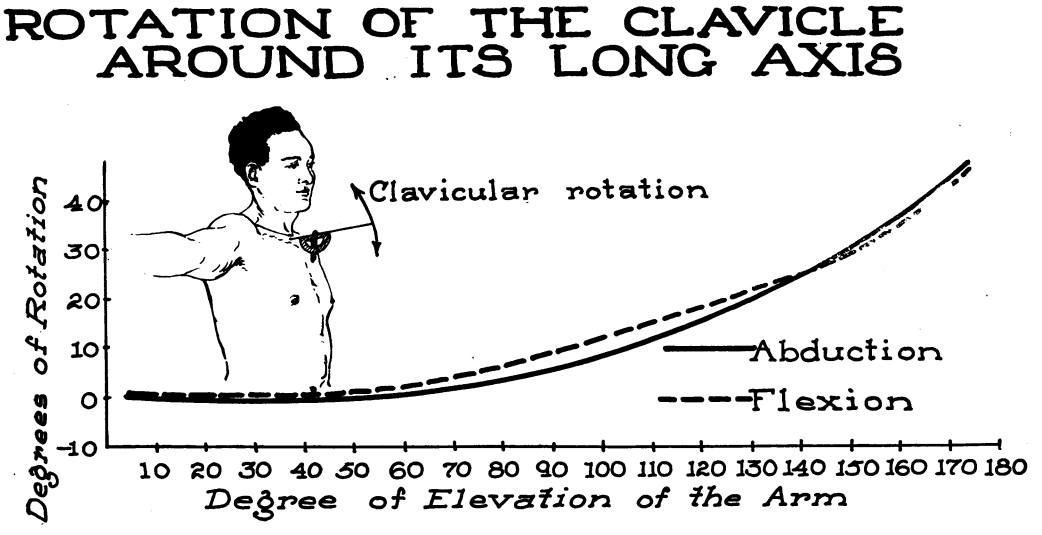


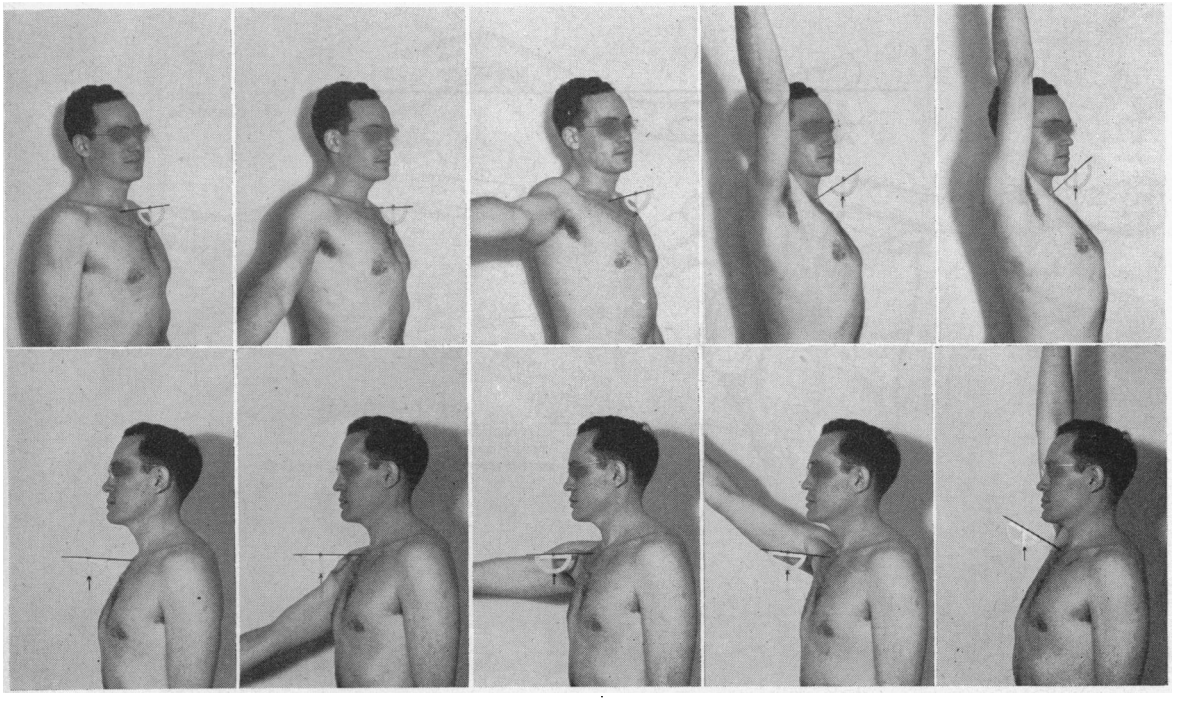
Figure 3.

hances the power of the attendant muscles. In the first 30 to 60 degrees of elevation, the scapula seeks, in relationship to the humerus, a precise position of stability, which it may obtain in one of several ways. Either the scapula remains fixed, motion occurring at the glenohumeral joint until the stable position is reached, or the scapula moves laterally or medially on the chest wall, or in rare instances oscillates until stabilization is attained. Hence the early phase of motion is highly irregular, and is characteristic for each individual. It would seem to depend upon the habitual position which the scapula occupies in the subject when at rest. This phase of motion is related to the setting action of the muscles, and we have, therefore, termed it "the setting phase."

Once 30 degrees of abduction, or 60 degrees of forward flexion has been reached, the relationship of scapular to humeral motion remains remarkably constant. Thereafter a ratio of two of humeral to one of scapular motion obtains; and thus, between 30 and 170 degrees of elevation, for every 15 degrees of motion, 10 degrees occurs at the glenohumeral joint, and 5 degrees by rotation of the scapula on the thorax.

Roentgenograph and examination of the living prove beyond a doubt that scapular and humeral motion are simultaneously continuous. As this





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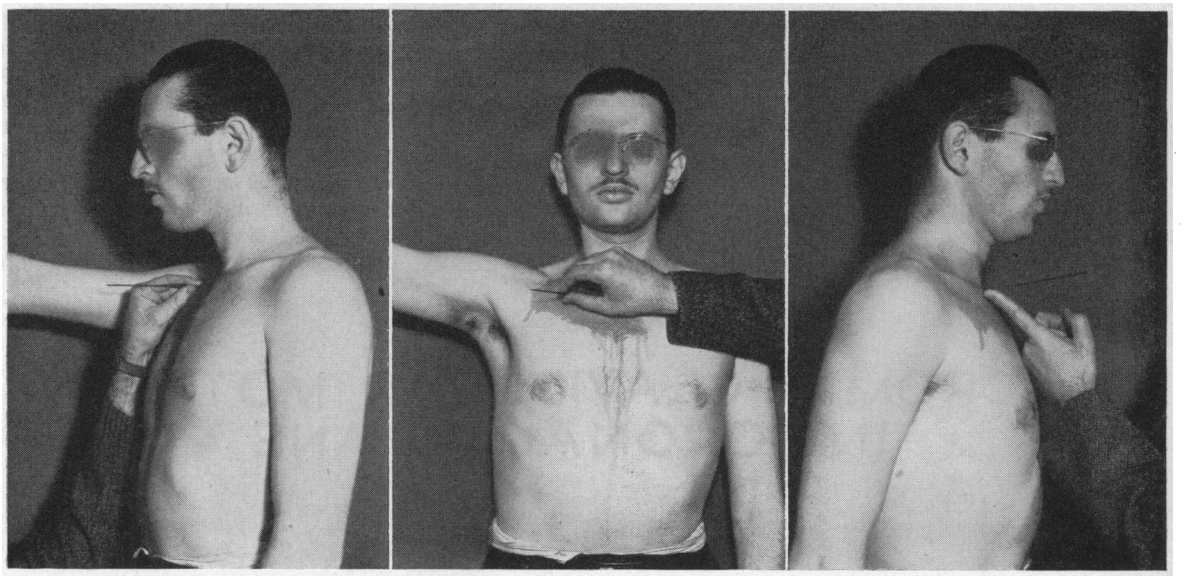


Figure 5.

ratio pertains, it is evident that the total range of scapular motion is not more than 60 degrees, nor that of the glenohumeral joint greater than 120 degrees. Under special and abnormal conditions, the motions of either one of these two joints can occur independently. For example, when the scapula is fixed, it is possible to raise the arm actively to the right angle and passively to 120 degrees.

Clavicular motion is more complicated than has been hitherto suspected. The continuous rotation of the scapula on the thoracic wall during elevation of the extremity is only possible because of the motion permitted at the two clavicular joints, and the phase and amount of movement is unequally distributed between them.

Elevation of the arm is accompanied by elevation of the clavicle at the sternoclavicular joint (Fig. 1). This movement begins early and is almost complete during the first 90 degrees, when for every 10 degrees of elevation of the arm, there are four degrees of elevation of the clavicle. Above 90 degrees, clavicular motion at this joint is almost negligible.

Motion at the acromioclavicular joint contrasts markedly with that found at the sternoclavicular joint (Fig. 2). The total range is approximately 30 degrees and occurs both early, in the first 30 degrees of abduction, and late, after 135 degrees of elevation of the arm. Between these two points there is almost no motion of this joint.

The sum of the movements at the sternoclavicular and acromio-clavicular joints is naturally equal to the range of movement permitted the scapula. Anatomically it is possible to envisage an adequate range of movement occurring at the sternoclavicular joint but it is difficult to understand how motion of such extent could occur at the acromioclavicular joint, in view of the fact that the clavicle is rigidly attached at its lateral extremity to the scapula through the medium of the coracoclavicular ligaments. For motion to occur at the acromioclavicular joint in the plane of elevation of the arm, elongation of this ligament would appear to be necessary, and on first sight this would seem to be impossible. Because of the marked curvature of the outer third of the clavicle, we could envisage a relative elongation of the coracoclavicular ligament, only by the clavicle rotating on its long axis, so as to allow this curvature to act as a crankshaft (Fig. 3).

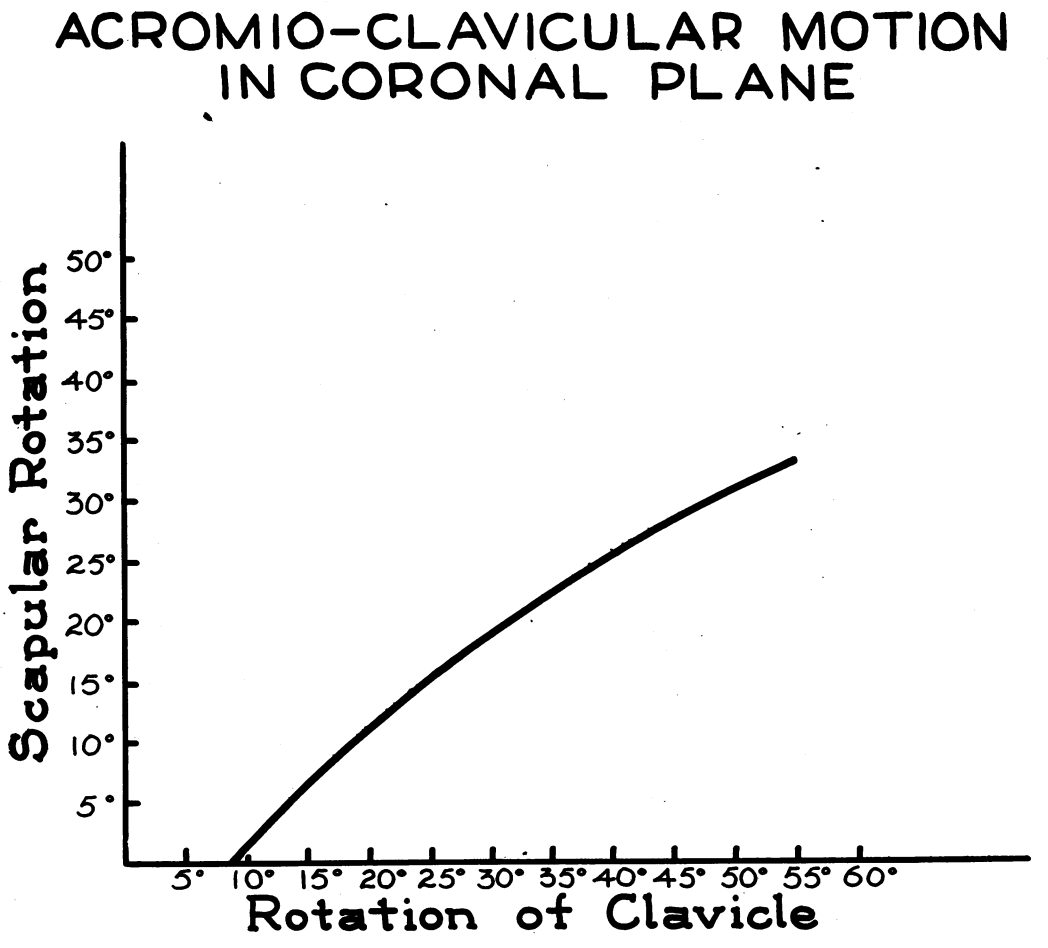
The existence of such clavicular rotation about its long axis was demonstrated experimentally in the living subject by the insertion of a steel pin into the bone and the measurement of its range of motion with elevation of the extremity. The degree of rotation proved to be very appreciable and amounted on the average to a movement of 50 degrees. (Fig. 4.) How necessary this rotation is for the free elevation of the extremity was shown experimentally by manual interference of the movement through the medium of the pin inserted into the clavicle. Under these conditions elevation is promptly limited to about 120 degrees (Fig. 5). The clinical significance of these findings will be discussed later.

The effect of clavicular rotation on the coracoclavicular ligaments is established by anatomical dissections. A direct relationship is found to exist between the line of attachment (trapezoid line and conoid tubercle) of these ligaments, the amount of clavicular rotation, the extent of relative lengthening of the ligaments and furtherance of scapular rotation. (Fig. 6.) Thus, of the total 60 degrees of scapular rotation, the first 30 are due to the elevation of the clavicle as a whole by movement at the sternoclavicular joint and the second 30 degrees permitted at the acromioclavicular joint by clavicular rotation and relative elongation of the coracoclavicular ligaments. Therefore, the lateral curvature of the clavicle is of the greatest

significance. It permits the clavicle to act as a crankshaft and thus mechanically allows of no less than half of the scapular movement.

In protrusion and retraction of the shoulders, no appreciable motion occurs at the acromioclavicular joint (Fig. 7), nor is there any great rotation of the clavicle (Fig. 8), the movement occurring predominantly at the sternoclavicular joint.

These observations mutually clarify clinical findings, and in turn are supported by them. The conception that the clavicle serves as a prop to the shoulder is not supported in those cases in which the bone is lacking or in which it has been excised. As is well known, the clavicle is absent or partially suppressed in that rare familiar disorder, craniocleido-dysostosis. In these cases the disposition of the shoulders in the resting position is not markedly disturbed, but their range of motion is greatly enhanced, protrusion and retraction



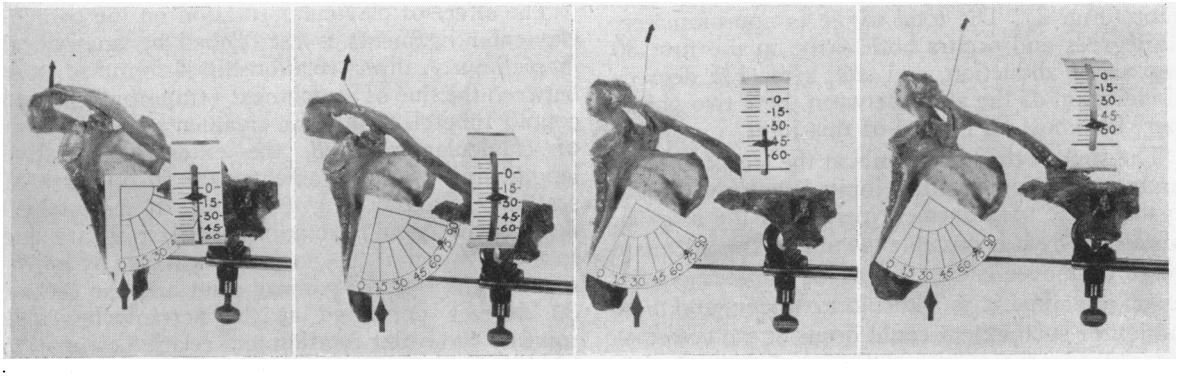


Figure 6.—Dissection of pectoral girdle mounted to demonstrate motion at the acromioclavicular joint. Goniometers are attached to scapula and clavicle to indicate simultaneous angular changes for construction of graph.

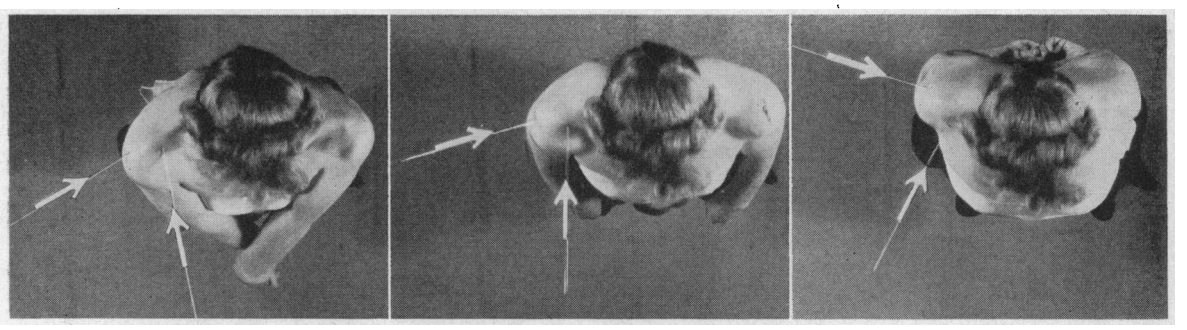


Figure 7.—Subject viewed from above. Pins inserted into acromion and lateral extremity of the clavicle. Note that there is little change in the angle between the pins during protrusion and retraction of the shoulders.

of the shoulder becoming very extensive and elevation being increased to beyond 180 degrees. (Figs. 9 and 10.) The lack of disability at the shoulder observed in this disorder has given us confidence in recommending excision of the clavicle in the presence of tumors and osteomyelitis of this bone. We have excised the entire clavicle in four patients. Diagnosis was a large expanding giant cell tumor, metastatic carcinoma of thyroid, Ewing's sarcoma and chronic osteomyelitis. The functional disturbance was negligible. The shoulder did not drop inwards and forwards as might be anticipated. The range of motion was increased and minor instability only occurred when a weight was supported over the head. On measurements there was no loss of muscle power and no complaint of dragging sensations in the arm. (Fig. 11 and Fig. 12.) These cases effectively dispose of the conception that the clavicle acts as a prop, but suggest that it contributes somewhat to stability in supreme elevation. Furthermore, our experience would lead us to recommend excision of the clavicle as an effective method of gaining an increase in the range of motion in arthrodesis of the glenohumeral joint.

As pointed out, clavicular rotation permits the final half of scapular rotation. With loss of this motion, abduction is limited to approximately 120 degrees. We have been able to demonstrate on several occasions the effects of this loss in the recently advocated method of treatment of acromioclavicular dislocation in which the clavicle is fixed to the caracoid by means of a metal screw, or in which the acromioclavicular joint is stabilized by the insertion of a metal pin. A single example will suffice to illustrate the unsatisfactory features of these methods of treatment.

CASE HISTORY

A 20-year-old student suffered an acute acromioclavicular dislocation of the right shoulder while playing football in September, 1943. Five days later the dislocation was reduced surgically and fixation achieved by the insertion of a metal screw through a drill hole in the clavicle into the base of the coracoid. (Fig. 13.) Following recovery from surgery the patient discovered that he was unable to elevate that arm above 110 degrees although no discomfort was felt. (Fig. 14.)

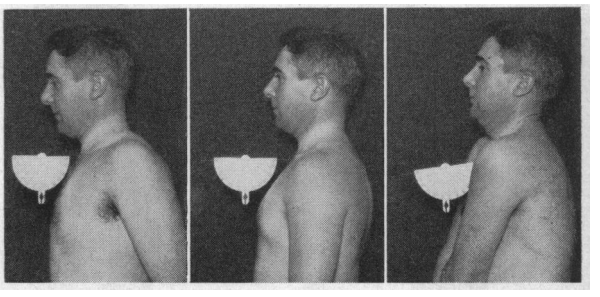


Figure 8.

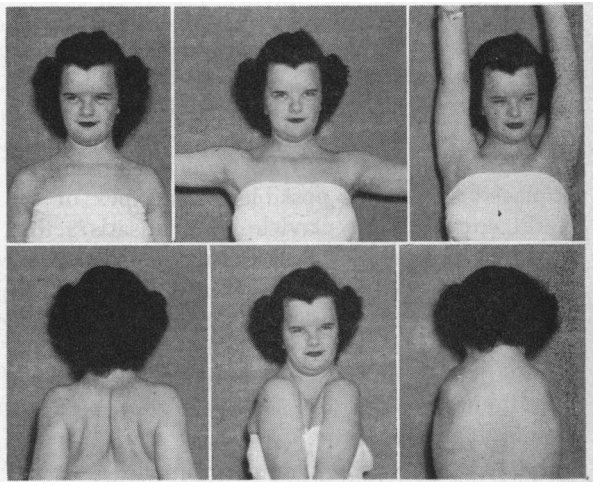


Figure 9.

In January, 1944, while runing, he slipped and fell, forcibly abducting the arm above his head. Over the tip of the shoulder he suffered immediate pain which subsided rapidly. Following this he found that he had regained a complete range of motion. X-rays revealed that the screw had been bent and avulsed from the coracoid, permitting the clavicle again to rotate freely. (Fig. 15.)

In the surgical treatment of acromioclavicular dislocation where, apart from conservative methods, it is desirable to maintain the full range of active motion, one has a choice of restoring the torn acromioclavicular ligaments or excising the lateral half of the clavicle. If the procedure of resection is adopted the clavicle should be removed to a point medial to the attachment of the liga-

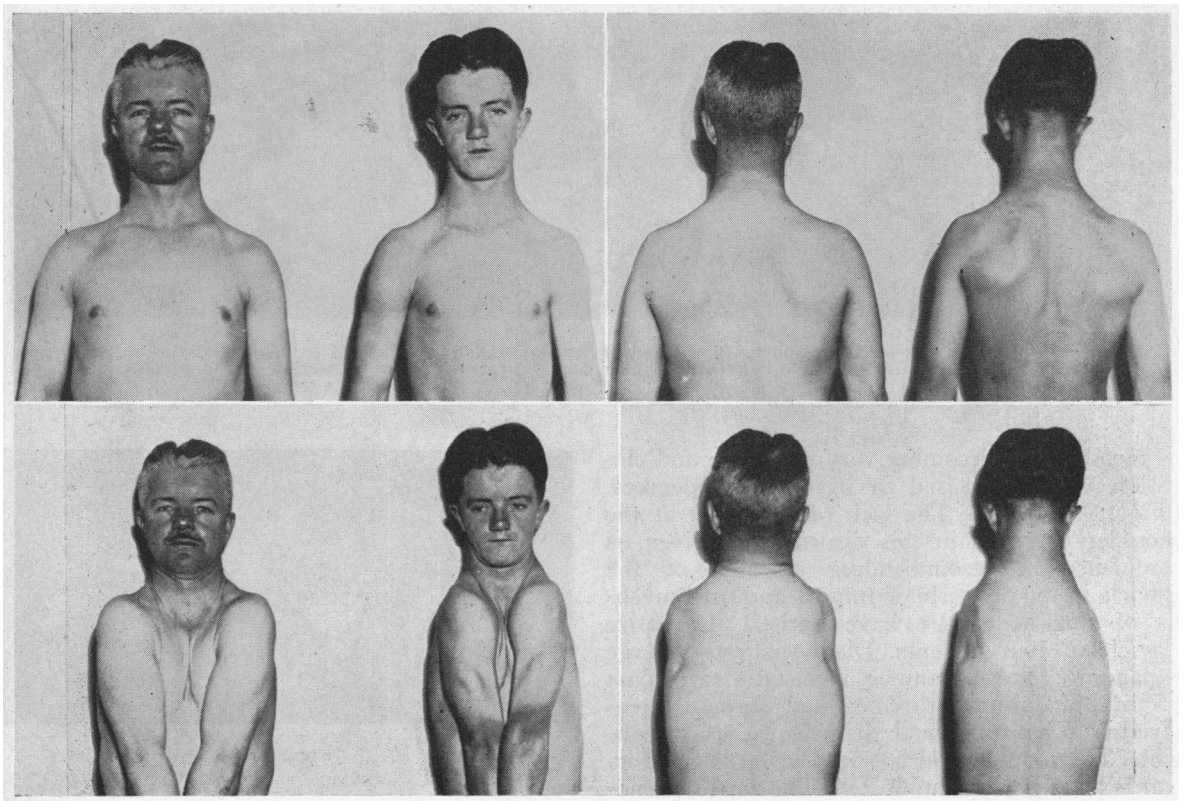


Figure 10.

ments. Otherwise, tension is still transmitted by these injured structures and pain will persist. If ligamentous restoration by fascia is chosen, it is important to insure that the clavicular attachment be placed as near as possible to the apex of the lateral curve of the clavicle. The unsatisfactory results from fascial reconstruction are often due to neglect of this point. Because of the cranklike action of the bone, it is necessary that the fascial suture follow, as closely as possible, the course of the normal ligaments. Otherwise there will be some limitation of movement and excessive stress thrown upon the repair.

Dysfunction at the shoulder sometimes occurs in association with fractures of the clavicle. Fortunately these complications are not common. An excessive exaggeration of the outer curve may interfere with the axis of clavicular rotation, resulting in displacement of its sternal extremity and pain at the related joint. We have recently seen examples of this type.

CASE HISTORY: CASE II

At the age of nine years the patient fell and fractured the right clavicle at the junction of the middle and inner thirds. The fracture was immobilized in a figure "8" of plaster. Healing occurred rapidly but with an increase in the medial curve and suppression of the lateral curve. No disability was experienced until several years later when increasing discomfort was noted at the sternoclavicular joint. When examined nine years after the original injury there was swelling over the right sternoclavicular joint. The right clavicle was more prominent than the left with a definite increase in its medial curve. There was marked instability of the right sternoclavicular joint as compared with the left. On elevation of the right arm the sternal end of the clavicle described an arc instead of rotating through an axis passing through the center of the articular surface of the joint.

Loss of the lateral curvature of the clavicle on the other hand immediately prohibits the full range of scapular rotation and interferes with complete elevation. The decrease in elevation is directly proportional to the degree of obliteration of this curve and is only noticeable above 120 degrees.

From these observations it is clear that apart from serving as a link in the pectoral girdle, the fundamental and most important function of the clavicle is related to the existence of its curvatures. It is these curves, especially the lateral, which bring this bone into relationship with the scapula and indeed are responsible for the necessary freedom which the scapula must possess to provide the niceties of rhythm which are so characteristic of shoulder movement. All other aspects of clavicular function are subsidiary to its rotation. Consequently, any condition which results in interference with this motion, or changes its relationship to other components of the complex, will result in limitation of movement. It can be said that the presence of the clavicle is not entirely necessary in man, and its absence in no way restricts, but in fact increases, the range of shoulder

movement with but slight loss in stability. Nature in her endless experiments has in many forms entirely suppressed this structure.

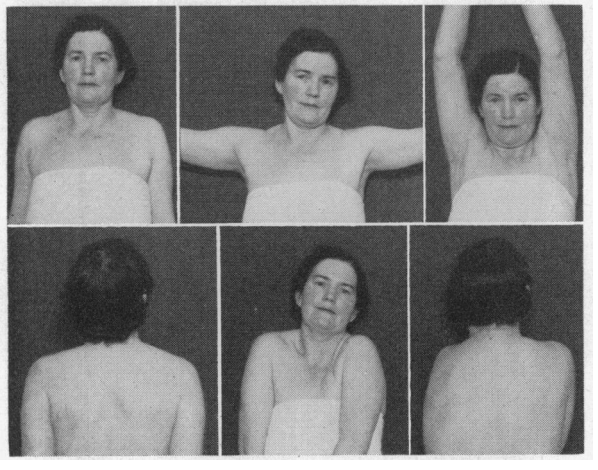


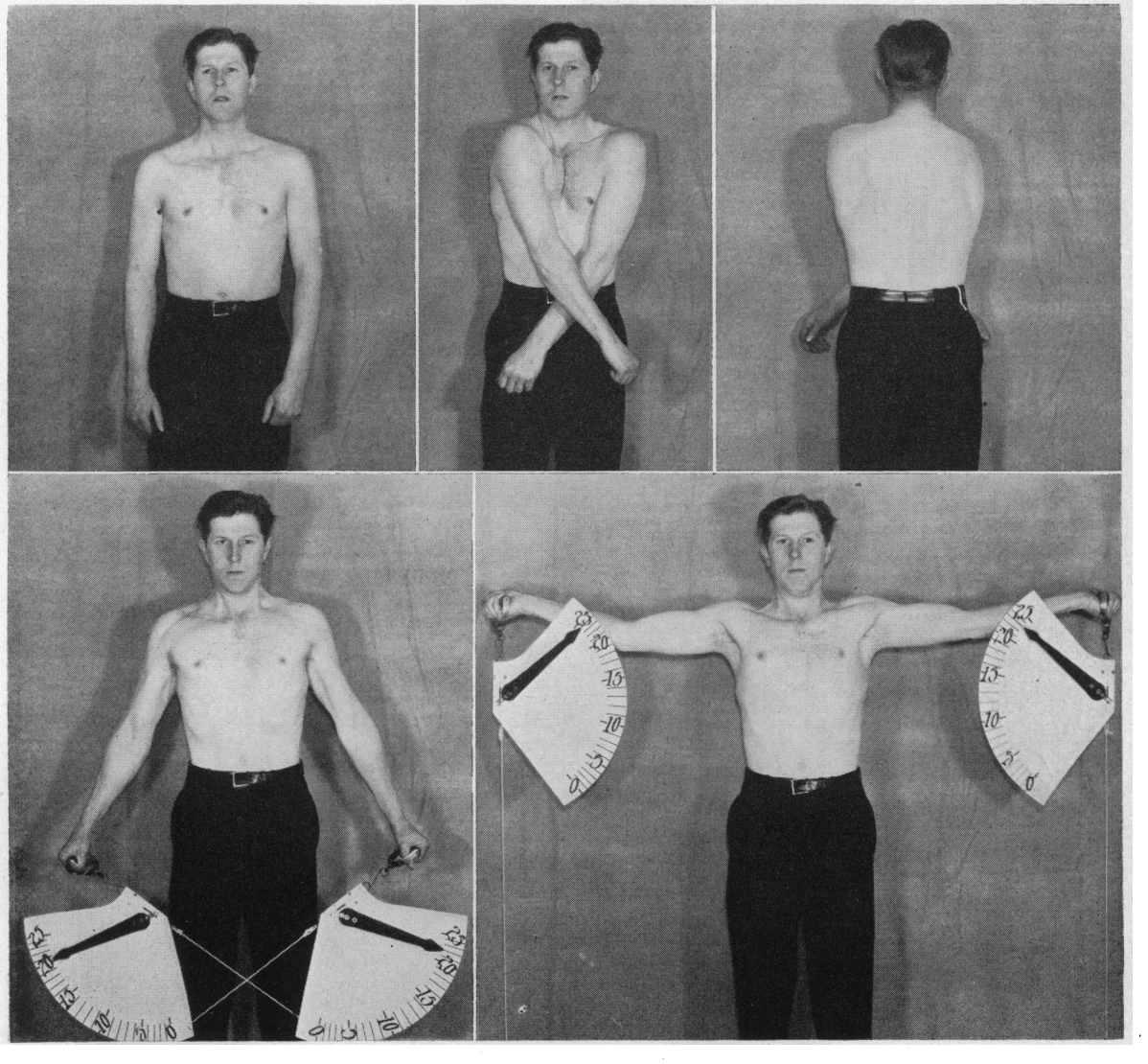
Figure 11.

SUMMARY

1. The function of the clavicle is closely integrated with the shoulder complex and any restriction of motion at either of its joints is promptly reflected in the total range of motion at the shoulder.

2. The traditional conception as it serves as a prop is of little or no consequence, and excision of the bone leaves no significant disability. It serves, however, to give some stability to the extremity under load in the extreme ranges of motion.

3. Rotation of the clavicle about its long axis and its action of its outer curve as a crankshaft is its most important function, since this motion allows of one-half the total range of rotatory excursion of the scapula. The remaining half of scapula excursion is the outcome of clavicular elevation at the sternoclavicular joint. Loss of clavicular rotation completely restricts elevation of the arm above 120 degrees which is a serious disability in certain occupations and athletic pursuits.



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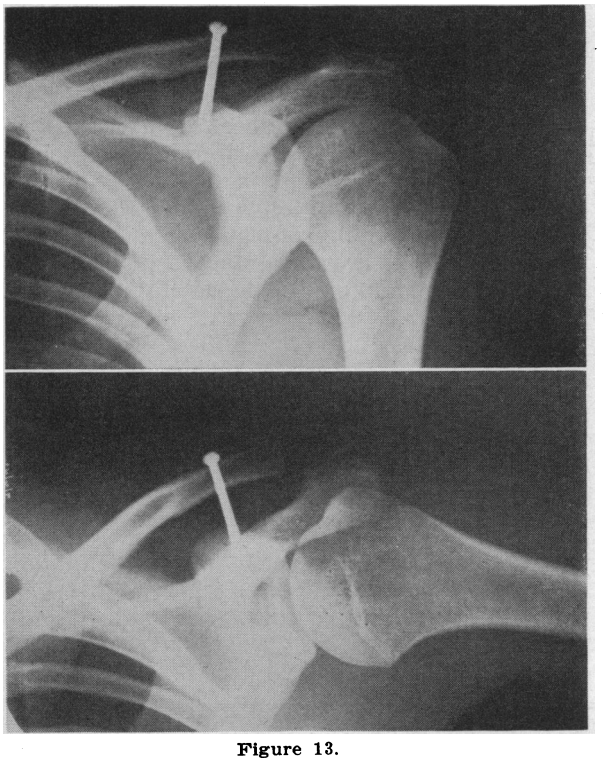

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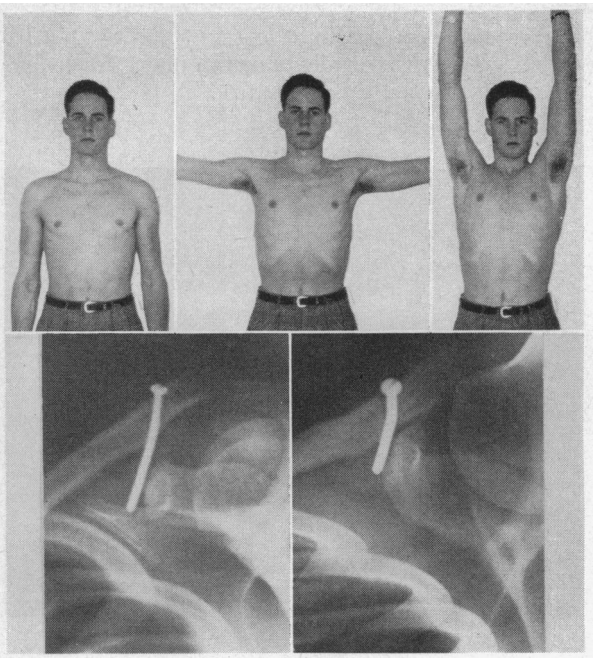

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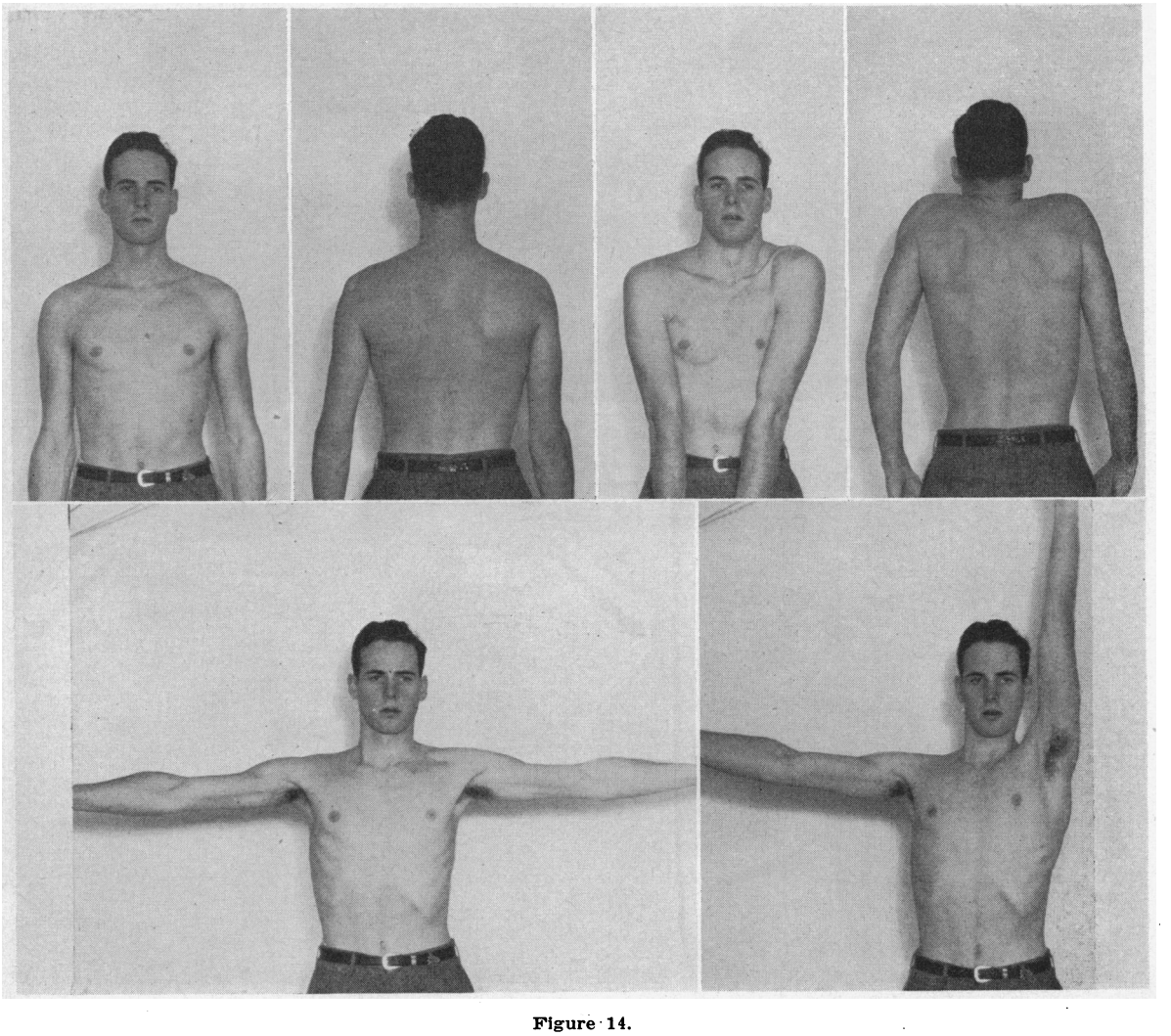

Figure 14.