CHAPTER 20

Structural basics : Bones and muscles

Introductory

Traditionally the subject of anatomy is concerned almost exclusively with two interdependent systems. The first, the skeletal-system, is made of rigid components (bones) and the second, the muscle system, of flexible ones (muscles, tendons and ligaments). The complicating factor of a third system comprising the fatty tissue, is largely ignored in most texts. Presumably this is because it is so variable in its characteristics that little can be said about it except that its presence tends to obscure and distort information provided by the other two systems, thereby muddying what might otherwise be relatively clear waters. However, the fact that it renders analysis more difficult, does not make it less interesting Certainly, the fatty layers have a significant influence on appearances, not least with respect to the individual differences that artists strive to capture.

If the model is wearing clothes, these provide a fourth system. They obey their own laws and these reflect interactions between the properties of the materials, the way they are cut and joined together and the forces of gravity. Interactions between them and the three other systems have important repercussions on appearances.

In this chapter we start with two basic articulating principles relating to interactions between bones and muscles, before progressing to some invariant structural relationships within the skeletal system. In the next chapters we will move on to muscles, fatty tissue and clothing.

TWO BASIC ARTICULATING PRINCIPLES

The two basic articulating principles follow from the fact that the purpose of muscles is to move bones.

The first principle

Figure 1 illustrates a fundamental features of the relation between muscles and bones.[1] They may seem too obvious to be worthy of mention but, as Paul Klee asserted, their simple yet profound implications can hardly be overemphasised. Keeping them in mind while drawing can be very useful indeed.

The principles in question derive from the two basic functions of all muscles namely, on the one hand, to hold the different parts of the skeleton in position and, on the other, to enable control over limb movements. From this it follows that:

- Muscles are invariably attached to bones (by tendons and ligaments).
- The action of muscles always spans either a joint which links two bones (for example: knees elbows, hips, etc.) or the space which divides them (for example at the shoulder blades).

From these properties can be deduced two other invariants:

- The articulating junctions of the bones and the points of intersection of the muscle system **always overlap**.
- The the combination of muscle and tendon obscures many significant features of the skeletal system including, to a greater or lesser degree, *all the articulating points* (just as the fatty tissue and clothes can make it difficult or impossible to analyse the muscle structure that lies beneath them).

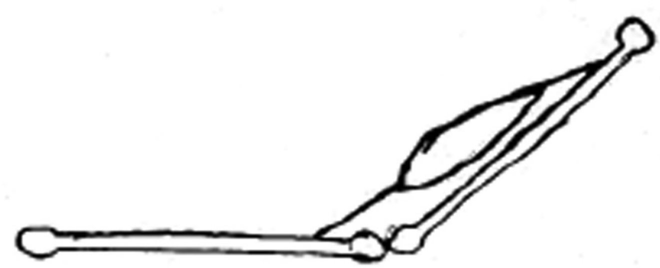

Figure 1 : Muscles overlay joints

This last point provides yet another reason why good figure-drawing requires especially careful looking. One of the main many advantages of studying

1 Based on one of the illustration by Paul Klee in : Paul Klee, 1961, *The Thinking Eye,* Lund Humphries

anatomy is that knowledge of it provides the eye/brain with a check-list of questions as to how a particular variable works out in the always unique situation being analysed.

The second principle

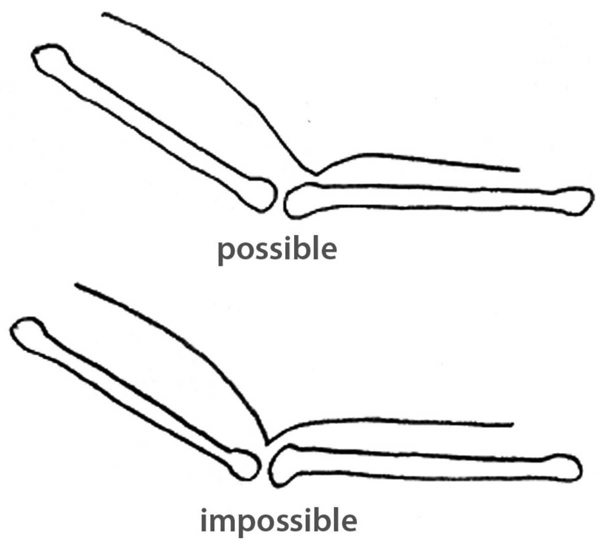

Figure 2 : An impossible but widespread tendency

The bottom drawing in *Figure 2* illustrates a widespread tendency which, though usually more obvious in the productions of beginners, is often to be found in those of more experienced draughtsmen. It shows the lines indicting the external contour of the muscle system homing in on the point at which the two bones meet. The implicit message provided by drawings that exhibit such a tendency is that the muscles are attached to the end knobs of the bones. However, this is clearly impossible. If they were so attached, they could not exercise the leverage which is their purpose. It follows that the bottom drawing represents a situation that could never happen. There must always be an overlap, as in the top drawing.

A plausible explanation for the widespread occurrence of such impossible drawings lies in the way we think about our own body. Our introspective *sense of our own body* is likely to be in terms of the articulating joints rather than of overlapping muscles. In as far as this sense influences line production, there will be a tendency for the contours describing muscles to dip in the direction of the articulating points as in the bottom drawing in *Figure 2*. And it will almost certainly do so unless attention is focussed on the relativities between the bone junctions and the specifics of how the muscles overlap them.

SOME INVARIANT STRUCTURAL RELATIONSHIPS

The next section of this chapter is dedicated to relating the two basic articulating principles just described to specific parts of the skeleton, each of which is given a separate section.

Pelvis, spine and rib cage

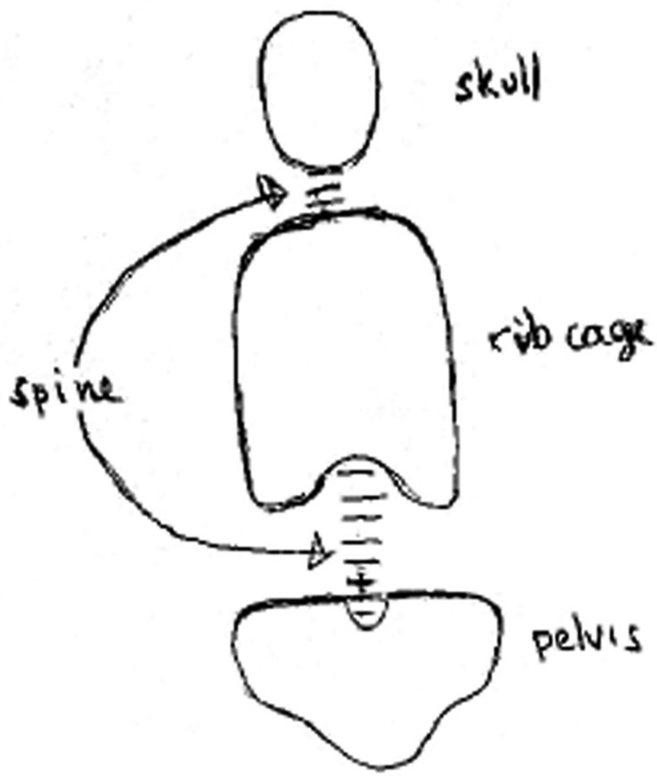

Figure 3 : Skull, pelvis, rib cage and spine

The skeleton consists of a number of bones joined together in a variety of ways. In general bones are *rigid* and *joined to other bone*s. Only the *spinal cord* (if considered as one unit)[2] and the ribs are to any degree flexible along their length, and only the *shoulder blades* enjoy the possibility of unjointed movement. *Figure 3* and *Figure 4* indicate some of the main consequences of this arrangement. Looking out for them in an actual model, is likely to draw attention to relationships, which my experience of teaching tells me, are only too frequently overlooked.

Figure 3 indicates important constraints on interactions between the *skull, rib cage* and *the pelvis*. Notice in particular that:

- Though capable of the degree of expansion and contraction necessary for breathing, the rib cage never distorts in such a way as to effect its general shape. In particular, it always has smoothly curving outline. Accordingly, if ever the contour of the upper part of the body suddenly changes direction, the reason can only be transformations of more superficial anatomy. The most likely causes of changes of direction of this kind will be either the raising or lowering of arms, which will cause displacements of breasts and shoulder blades (see *Figure 8*), or changes in the relationship between *pelvis* and *rib cage* (such as those described below), which will be reflected in distortions of the abdominal region.
- Since the bottom end of the *spine* is locked rigidly into the *pelvis*, changes in the orientation of the latter involve analogous displacements in the former. This means that whenever the *pelvis* is sloping and the *rib cage i*s in an upright position or visa versa, a certain amount of lateral displacement of the one relative to the other will have occurred (see *Figure 4*). It also means that the room for manoeuvre with respect to sideways movements of either *pelvis* or *rib cage* or pelvis without concomitant sloping is very limited indeed.

Bending a leg

Since, like nearly all other bones, the *thigh bone (femur)* and the *lower leg bone (tibia)* are rigid, when a leg is bent at the knee, the direct distance between foot and pelvis must be reduced. Thus, assuming that the foot of the bent leg remains on the ground and that the other leg remains straight, the *pelvis* will automatically slope down on its bent-leg side (as illustrated in *Figure 4)*. When it does so, the base of the *spine* will slope commensurately, causing the *rib* cage to be displaced (as just explained). A consequence of this will be a distortion of the area around the abdo-

2 A necessary qualification since the spine is made up of many inflexible segments.

men, with one side being stretched and the other squashed. The resulting pose will have much in common with that of the famous *Venus de Milo* (*Figure 9*, at end of chapter).

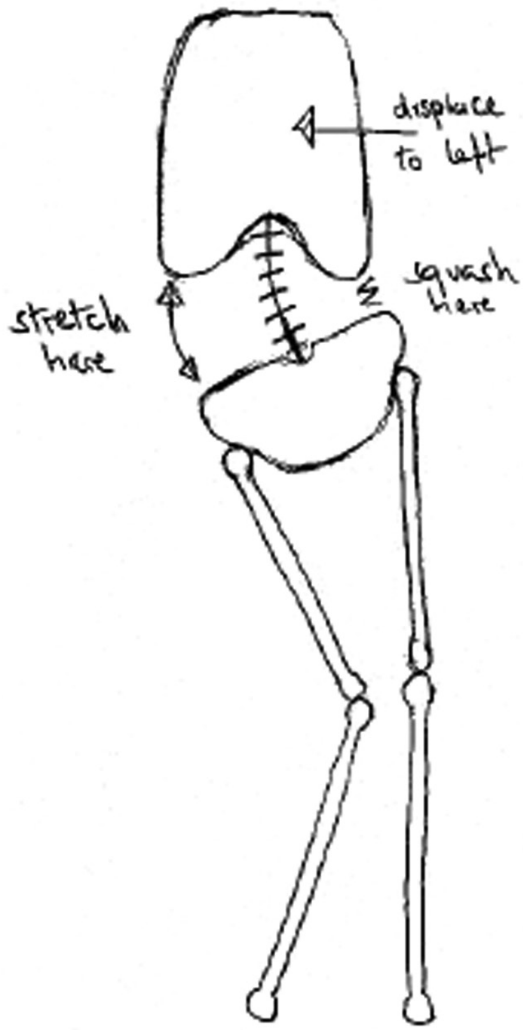

Figure 4 : Effects of bending a leg on both the slope of the pelvis and the position of the rib cage.

The need to call attention to these inescapable anatomical consequences of the rigidity of bones, is evidenced by the number of drawings in which they are not observed. Only too frequently, the *pelvis* is represented as being in the horizontal default position and the *rib cage* as too directly above it. In drawings of nude models, this outcome is common. In drawings of clothed models, it is rampant.

Leg bones: Pelvis and thigh bones

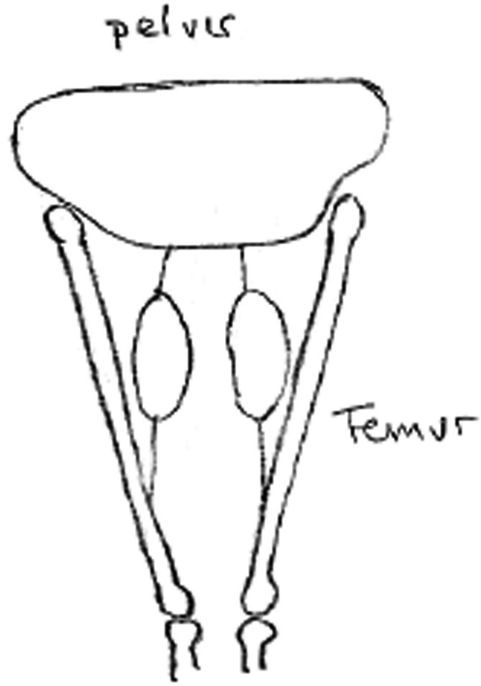

Figure 5: Pelvis and thigh bones

Figure 5 shows the *pelvis* and the two *thigh bones* of an erect figure standing with its knees together. Since the top ends of the latter insert into the outer extremities of the former, while their lower ends are virtually touching, it is inevitable that they slant diagonally inwards from the top downwards. As this alignment is not only difficult to sense introspectively (we think of our legs as going straight downwards) but also easy to overlook. The impediment to visibility is that a large bundle of thigh muscles (those which enable the legs to flex sideways) do not follow the line of the *thigh bone*. Rather, they are attached at the centre of the *pelvis* and descend from there, often giving the unwary draughtsman an impression of a more or less vertical, sausage-like musculature. The junction between the vertical and sloping muscle systems is much more evident when the leg under analysis in thin and skinny. However, even the fattest legs are likely to reveal some indication of a change in direction of contour about one third of the way up the inner thigh. If, for any reason, there is none (due to being obscured by fat), this should be considered as a significant feature, since it reveals an aspect of the individuality of the pose.

The forearm (ulna and radius)

One of the distinguishing characteristics of our species is the ability to use hands in ways which are beyond the possibilities of other animals. This highly functional capacity is largely due to having fingers capable of an astonishingly wide range of manipulations, but also depends importantly on being able to rotate the forearm. The rotation is possible because the arm contains two bones capable of a considerable degree of independent movement. They are called the *ulna* and the *radius* and the latter, as its name suggests, *rotates* around the former, which acts as a *pivot*. The upshot is illustrated in *Figure 6*, which shows that the two bones can either be roughly parallel to one another or crossed over (not to mention the range of in-between positions). In making drawings of *forearms*, it is always worth checking out how these simple facts are revealed. Once again, it is easier to see the anatomical facts described when the arms concerned are skinny than when they are fat.

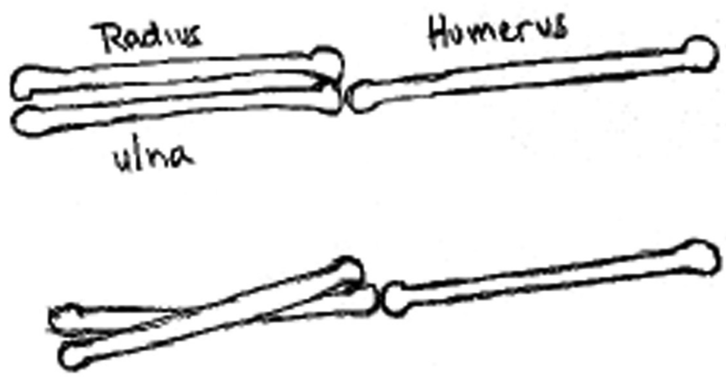

Figure 6 : Arm bones - The crossing of the ulna and the radius

Leg bones: Tibia, fibula and ankle

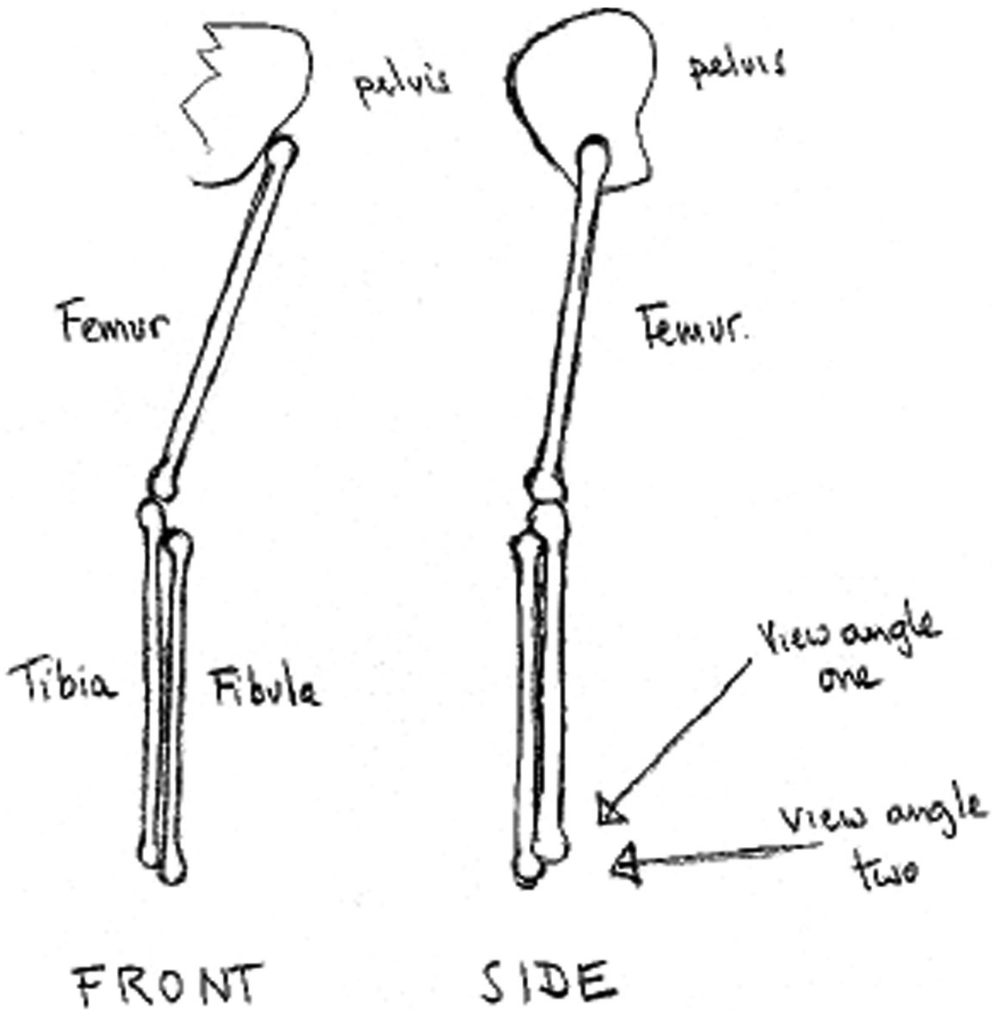

Figure 7: Leg bones - Tibia, fibula and ankle

Figure 7 illustrates the well-known fact that the lower leg contains two bones, the *tibia* and the *fibula*. The former is the main structural element. The hatter has two functions. It enables the leg to rotate (minimally as compared with the rotation of the forearm) and it offers it support when the weight is on the outside edge of the foot. Not surprisingly, the pressures produced in this circumstance causes the end knob of the fibula to protrude more than otherwise.

Another important feature is dependent on the fact that the top and bottom knobs of the fibula insert below the corresponding knobs of the tibia and are situated further away from the front of the leg. The relative heights of the knobs cause an often-overlooked asymmetry in the appearance of the ankle, while the setting back of the fibula means that this asymmetry varies with the spectator's viewpoint. For example, when the angle of vision is both near and high (or the leg is sloping forward in the direction of the viewer) the asymmetry can virtually disappear.

Shoulder-blades and breasts

Figure 8 shows the consequence on the positions of both the shoulder blades and breasts of raising an arm. Thus, assuming the trunk to be erect, a line joining any common feature (for example, the nipples) will slope upwards in the direction of the raised arm. The result can be a considerable change in appearances. However, as indicated above, no amount of raising or lowering of arms will affect the shape of the rib cage. It is for this reason that a good draughtsman will always look for the position of the rib cage before delineating the surface distortions. Vernon Blake makes a great deal of this point which he illustrates by reference to the drawings of Michelangelo.

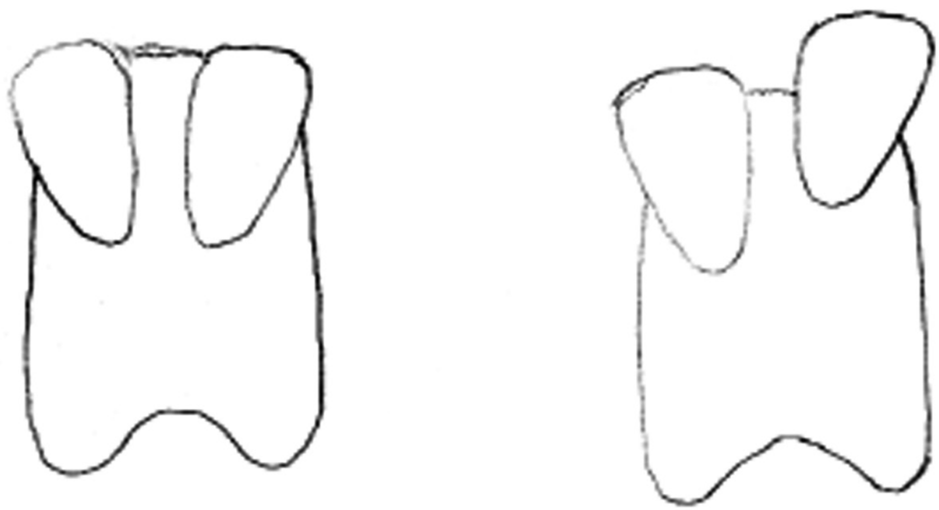

Figure 8 : Movement of shoulder-blades and breasts : Notice that the shape of the rib cage is unchanged.

Muscles do not always obscure bones

Except for the very general points made at the beginning of this chapter and except in relation to the thigh bone muscles and how they obscure the orientation of the femur, muscles have so far received little mention. In both those places the point being made is that the muscles overlay and, consequently, obscure bones, and this is a very important point to make. The truth is that it is often actually quite hard to find the evidence necessary to work out exactly where the bones are and consequently how they the different parts of the skeleton relate to each another. This is why it is well worth while to find the places where the bones have no muscles covering them and, accordingly, where it is possible to detect their presence. One easy to see example would be where the bulges corresponding to the heads of the radius and ulna are visible at the wrists. Another would be where the analogous bulges corresponding to the heads of the tibia and fibula are visible at the ankle. The complete list would include the knuckles, the elbows, the knee caps, the breast bone and a large proportion of the tips of the 33 spinal bones (vertebrae).

Figure 9 : Back view of nude woman with particularly evident sacral triangle (two dimples making a triangle with the sacrum)

More difficult to see is the evidence for the position of the pelvis, which only touches the surface in a very limited number of locations. However finding where it does so can be very helpful. This is why Vernon Blake and others place such emphasis on finding the "*sacral triangle*" (*Figure 9*). Notice that the two dimples at the top of it are slightly sloping up from left to right. This is visible proof that the woman's pelvis is sloping at the same angle. If you were drawing this woman from her front, you could go round the back to establish this fact.

Figure 9 : Back view of nude woman, with sacral triangle difficult to see

Implications

This chapter has listed a number of structural relationships that are always true with respect to any human figure. However, it is not always evident exactly how they effect appearances in any particular pose and trying establish to how they do so can be surprisingly time consuming. However, it is likely to be time well spent. As repeatedly emphasised in this series of books finding questions to ask is the most fundamental of the keys to being able to see in new ways and, therefore, to make progress with respect to drawing skills. This particular book concentrates on question generated by knowledge of invariant relationships and how they are manifested in appearances. In the next chapter we move on to the fatty tissue and clothes, both of which make it harder to see the underlying anatomical features.