

THE ACT OF STANDING

By

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Investigations of the mechanisms which temporarily stabilise the joints of the body during standing must be founded on a knowledge of the forces operating on each joint during that act. In one individual, these forces are variable; the magnitude and direction of the force acting on any joint varies with the orientation of the body, and its duration varies with the time for which the individual remains immobile.

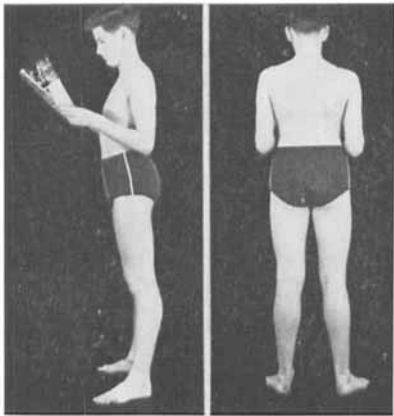
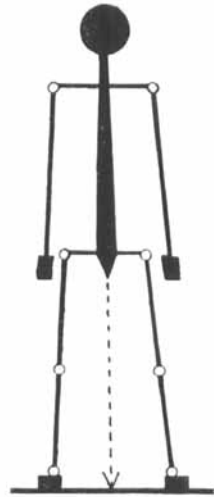
Throughout the act of standing, short periods of near immobility alternate with transient movements. During each static phase, the head, eyes and hands may move to a greater or lesser degree, but the trunk and lower limbs are practically motionless and the relationship of the centre of gravity of the body to the feet is consequently almost uniform. Although the attitude of the trunk and lower limbs is static during each immobile period, a number of different attitudes are adopted during a prolonged stance: one attitude may be succeeded after a brief movement by another of similar or one of different form.

In this investigation the forms and durations of the different immobile attitudes of standing were observed. The investigation was undertaken to provide data for a study which has been made of the supporting mechanism of the foot in standing.

MATERIAL

The form and periodicity of the attitudes adopted by a standing subject tend to change as soon as he is aware that he is being observed, particularly if he knows why he is being observed. Any investigation into the normal attitudes of standing, therefore, must be undertaken outside the laboratory, and the subjects must be completely unaware that they are being watched.

Even in such subjects, however, it is necessary to differentiate two forms of standing, and of these, the form adopted at any one time

*Fig. 1 a.**Fig. 1 b.**Fig. 1 c.**Fig. 1.*

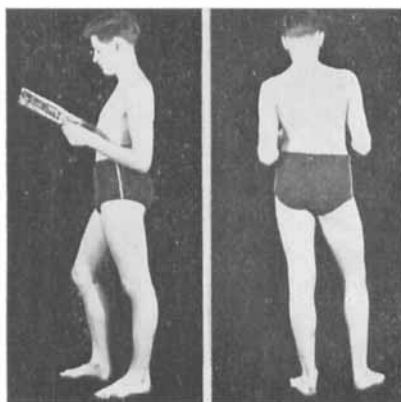
The symmetrical attitude.

(a) As seen in the clothed subject.

(b) As seen in the unclothed subject.

(c) Diagrammatic representation. The dotted line represents the line of the centre of gravity of the body.

depends on what can be called the “expected imminence of subsequent movement”. In other words, expectation of movement in the immediate future, even though it is not consciously formulated, is associated with one form of standing which might be called “dynamic standing”, whereas expectation of a period of immobility is associated with a

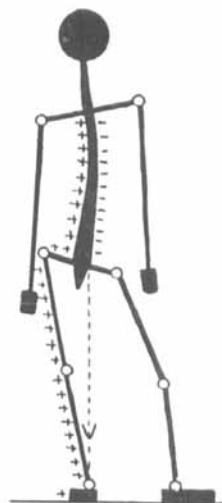
*Fig. 2 a.**Fig. 2 b.*

The asymmetrical attitude 2 L.

(a) As seen in the clothed subject.

(b) As seen in the unclothed subject.

(c) Diagrammatic representation. Regions subjected to compression and tension are indicated by the appropriate signs. The dotted line represents the line of the centre of gravity of the body.

*Fig. 2 c.*

different form which can be called "static standing". The former is essentially a part of, or a prelude to, locomotion and has not been considered; it is the attitudes that are normal to static standing which have been observed and analysed.

It comes to this then, that the subjects for such an investigation must fulfil two conditions. They must be unaware that they are being observed, and secondly, they must be standing in the manner just described as static. In this study people were observed in bus queues, on railway stations and in conversation in the street, and so that the second condition (*vide supra*) might be fulfilled as far as possible, none were included in the final figures unless they were observed standing continuously for over two minutes. Two hundred and fifty subjects were studied, and in this way one thousand eight hundred and ten separate attitudes were observed.

RESULTS

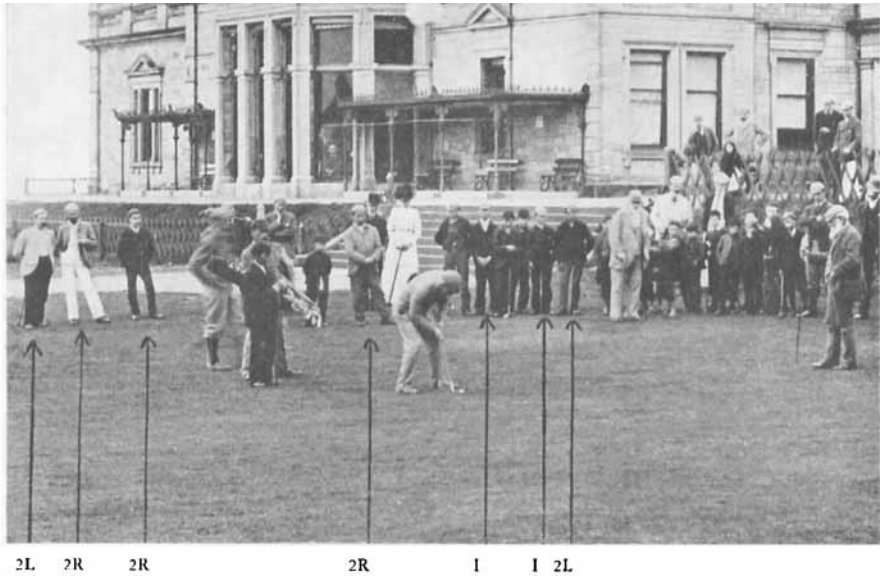
The Form of the Attitudes of Static Standing.

It was found that the attitudes which are usually adopted in static standing fall into two categories.

The first of these types is illustrated in Fig. 1. When a subject stands in this way it can be observed that the shoulders are level, that the knee joints are equally extended, and that the feet are level with one another in an antero-posterior direction and lie equidistant from the median plane. The distance by which the feet are separated varies, but does not usually approach either the minimum when the feet are together or the maximum when the weight of the body "turns the ankle". Because this investigation was carried out on fully clothed subjects, the orientations of such parts as the vertebral column and the pelvis could not be observed: they can, however, be deduced. Thus in this attitude, it can be surmised from the observed symmetry of the lower limbs and shoulders that the vertebral column and the pelvis are also symmetrically disposed about the median plane, and that the line of the centre of gravity of the body falls midway between the feet. Furthermore, if this attitude is imitated as closely as possible, it is found that, to be comfortable the knee and hip joints must both be a few degrees short of full extension.

The principal character of this attitude is symmetry and it will consequently be referred to as the symmetrical attitude or Attitude I. When a person adopts this attitude, each foot is affected by a force which is equal to half of body weight and which is transmitted to the foot in a downward or a downward and lateral direction (Fig. 1 c).

The main features of the second attitude are illustrated in Fig. 2. It is apparent, from the position of the body in relation to the feet, that body weight is carried almost entirely by one foot, through which the line of the centre of gravity must pass, whereas the other foot

*Fig. 3.*

Examples of symmetrical and asymmetrical attitudes.

carries very little weight and merely assists in maintaining balance. The weight may be carried by the right or the left foot: there are therefore two types of this second attitude which are mirror images of each other. These two attitudes will be called Attitude 2 R and Attitude 2 L, the letter indicating the weight bearing foot. The principal features of Attitude 2 L will be described.

It can be observed that the right or balancing foot is placed antero-lateral to the left or weight-bearing foot to a variable degree; that the extension of the left knee is more complete than that of the right, and that the left shoulder is lower than the right. From the relative positions of the feet and the relative extension of the knee joints, it follows that the pelvis is tilted in such a way that a line joining the anterior superior iliac spines passes downwards, forwards and to the right. Furthermore, from the relation of this deduced orientation of the pelvis to the observed position of the shoulder girdle, it can be assumed that the thoraco-lumbar region of the vertebral column is convex to the right. If this attitude is imitated, the position of the pelvis and the form of the vertebral column are confirmed (Fig. 2 b), and in addition, it is found that the left knee joint, although slightly more extended than in Attitude I, is still not completely extended. Thus, during asymmetrical standing the force that affects the supporting foot is much larger than, and its direction differs from, that affecting either foot in

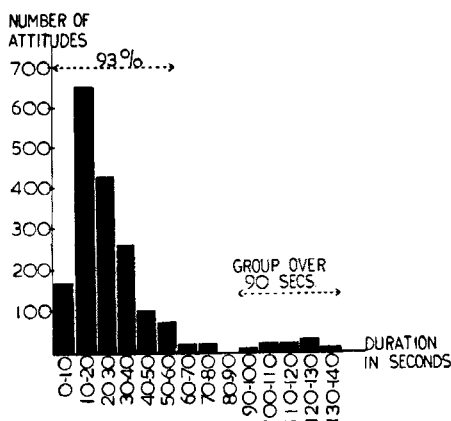


Fig. 4.

The duration of the immobile attitudes of standing.

symmetrical standing. The force is almost equal to body weight and is directed downwards and medially (Fig. 2 c).

It was found in the subjects observed, that one of the two asymmetrical attitudes occurred approximately four times as often as the symmetrical attitude, the actual figures being 1423:387. There was no significant difference in the frequency of the two asymmetrical attitudes either in single subjects, or in the group as a whole, in which the left-footed attitude occurred 679 times to the 744 times of the right-footed attitude.

Fig. 3 is an old photograph of a crowd of people and examples of symmetrical and asymmetrical attitudes are indicated by arrows.

The duration of the Attitudes of Static Standing.

The duration of each attitude observed during the course of the investigation was recorded, correct to the nearest five seconds. The results are shown in fig. 4.

The average duration of all attitudes was approximately thirty seconds and there was no significant difference in this respect between the symmetrical and the asymmetrical forms. A large majority, namely 93 %, of all attitudes were maintained for less than one minute.

The mean attitude duration varied in different subjects from fifteen seconds to eighty five seconds, and observation of subjects who were known to me gave me the impression that this mean was, to some extent, associated with the personality of the individual. The longer mean attitude durations were not due to one or two prolonged attitudes. Thus in the series under consideration the ninety three attitudes

which were observed to persist for longer than ninety seconds all occurred in a group of forty one subjects. Even if these ninety three prolonged attitudes are deleted, the average attitude duration in the whole parent group is forty eight seconds. It is believed therefore that in some individuals the attitudes of static standing are habitually prolonged, and that the duration of each successive stress on the foot is correspondingly increased.

DISCUSSION

The concept is now widely accepted that in static standing the body is maintained erect by the postural contraction of muscles and the passive support of skeletal and joint structures. It is postulated here that standing is performed in such a manner that these supporting tissues are subjected to—and therefore have to resist—a minimum mechanical stress.

The effect of stress on any tissue depends on two factors: one is the magnitude of the stress, and the other is the duration of its action. Thus, tissues which can sustain intermittent stresses of considerable magnitude may be injured by a prolonged stress of smaller magnitude.

In response to this common physical property, the activity of any tissue or any collection of tissues is normally punctuated by intervals of rest, and the resulting periodicity of function is apparent from the phasic activity of single cells to the alternate sleep and waking of the whole organism. *Ellis* (1889) recognised this property of tissues when, speaking of ligaments, he wrote—"They share the influence of a law, universal in all the tissues of the body, that constant pressure or constant tension causes wasting, while intermittent pressure or intermittent tension promotes growth and strength . . ."

During static standing the magnitude of the stress acting on any of the supporting tissues is constant. Therefore the effect of the stress is proportional to its duration, and can be reduced only by reducing this duration. It is in the light of this fact that the characteristics of static standing are to be interpreted.

If the act of static standing were continuously and totally immobile, then the supporting tissues of the body would be subjected to uninterrupted stress throughout the whole period of standing. If, on the other hand, standing were a continuous alternation of symmetrical attitudes with brief movements, the continuity of the stress affecting the tissues would be broken, but the stress would still affect the same tissues in each successive attitude, and the period of rest would be short.

It is by alteration between the two asymmetrical attitudes that the

period of rest is extended. Thus in one asymmetrical attitude (say Attitude 2 L), compression stresses act along the left side of the vertebral column, and through the pelvic strut, leg and foot of that side as indicated in Fig. 2 c. At the same time the right side of the vertebral column is subjected to tensile stresses and the pelvic strut, leg and foot of the right side are almost entirely free of any burden. When the weight is shifted on to the right foot, that is when Attitude 2 R is adopted, the distribution of stress is completely altered; those parts which were compressed are now rested or subjected to tensile stress and vice versa.

It becomes apparent then, that in the alternation of the body between immobility and movement, and in the alternation between attitudes of different form, there is a mechanism by which the continual force of gravity is rendered intermittent in its effects on the supporting tissues. Because the effect of a stress on the supporting tissues is proportional to the time for which it is maintained, prolongation of the stress beyond a certain duration must result in injury to the tissues. Furthermore, if such a prolongation is habitual then the injury will be progressive. It has been noted that the immobile periods of standing *are* habitually prolonged in certain individuals, and it is well known that some occupations demand, on occasion, a form of standing which is continuously immobile. It is suggested therefore that such prolongation of the attitudes of standing may have a causal relationship to a variety of postural disorders.

S U M M A R Y

1. Standing is made up of a series of relatively immobile attitudes separated by brief intervals of movement.
2. An attitude may be symmetrical in form. When this is so each foot is subjected to a force which is equal to one half of body weight and which is directed downwards, or downwards and laterally.
3. More commonly the attitude is asymmetrical, body weight being borne almost entirely by either the left or the right foot. In these circumstances the supporting foot is subjected to a force which is almost equal to body weight and which is directed downwards and medially.
4. The individual attitudes of standing do not persist for longer than one minute in the majority of cases, the average duration being about thirty seconds.
5. The alternation of the symmetrical attitude and the two asymmetrical attitudes is a means by which the continuous force of gravity

is rendered intermittent in its effects on the supporting tissues of the body during standing.

6. It is suggested that habitual prolongation of the immobile periods of standing may result in postural disorders.

RESUME

1. La position verticale est constituée par une série d'attitudes relativement immobiles, séparées par de brefs intervalles de mouvements.
2. Une attitude peut être symétrique dans sa forme. Lorsque c'est le cas, chaque pied supporte une force égale à la moitié du poids du corps et celle-ci est dirigée vers le bas, ou vers le bas et latéralement.
3. L'attitude est plus communément asymétrique, le poids du corps reposant presque entièrement soit sur le pied gauche, soit sur le pied droit. Dans ces circonstances, le pied qui supporte le poids est soumis à une force à peu près égale au poids du corps, celle-ci étant dirigée vers le bas et médialement.
4. Les différentes attitudes de la position verticale ne persistent pas plus d'une minute dans la majorité des cas, la moyenne de leur durée étant d'environ trente secondes.
5. En alternant l'attitude symétrique et les deux attitudes asymétriques, on rend intermittente la force de gravité continue dans ses effets sur les tissus du corps chargés de supporter son poids pendant la position verticale.
6. Il convient d'envisager qu'une prolongation répétée des périodes d'immobilité de la position verticale peut engendrer des troubles positionnels.

ZUSAMMENFASSUNG

1. Das Stehen ist von einer Reihe verhältnismässig unbeweglicher Haltungen, die von kurzen Bewegungsintervallen unterbrochen werden, zusammengesetzt.
2. Die Haltung kann eine symmetrische sein. Wenn dies der Fall ist, wird jeder Fuss der Wirkung einer Kraft unterworfen, die gleich dem halben Körpergewichte ist und die nach abwärts oder nach abwärts und lateral gerichtet ist.
3. Häufiger jedoch ist die Haltung asymmetrisch, so dass das Gewicht des Körpers fast gänzlich vom linken oder rechten Fuss getragen wird. Unter diesen Umständen wird der belastete Fuss einer Kraft unterworfen, die beinahe dem ganzen Körpergewicht entspricht und die nach abwärts und medial gerichtet ist.

4. Die einzelnen Stellungen beim Stehen werden in den meisten Fällen nicht länger als eine Minute festgehalten. Die Durchschnittsdauer beträgt ungefähr 30 Sekunden.
5. Die wechselweise Einnahme der symmetrischen und der beiden asymmetrischen Stellungen bietet die Möglichkeit die beständige Wirkung der Schwerkraft auf die Stützgewebe des Körpers während des Stehens in eine unterbrochene Wirkung umzuwandeln.
6. Man weist darauf hin, dass gewohnheitsmässige Verlängerung der unbeweglichen Zeitabschnitte beim Stehen zu Haltungsschäden führen kann.

REFERENCES

Ellis, T. S. (1889): *The Human Foot*. London. Churchill.

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