The great beauty of Hoover’s sign is that it relies on the absence of a normal phenomenon found in most people and not the presence of an abnormal phenomenon such as the Babinski sign.

**BACKGROUND AND HISTORY**

It’s the middle of the clinic. Your next patient has a bulging set of case notes and struggles in to the room on two elbow crutches with a hand-written list of 15 somatic complaints. The worst symptom is progressive right leg weakness that has become so bad that any work has been impossible for six months. You have already noted some physical signs. The right leg is dragged like a sack of potatoes and when the patient climbs on the bed the leg is hauled on with both hands. On direct testing there is some 'collapsing weakness' even after you’ve cajoled and encouraged the patient. The reflexes are normal. How are you going to clinch the diagnosis of functional weakness? Can Hoover’s sign help you?

Time to get some definitions straight. In this article we will use the term functional weakness to refer to medically unexplained weakness of the type that was formerly labelled ‘hysterical’, i.e. the patient is unaware or largely unaware of any degree of control over the symptom. As we will comment later, Hoover’s sign does not help differentiate this type of weakness from deliberately simulated weakness, which in our experience is a much rarer problem outside medico-legal scenarios.

Dr Charles Franklin Hoover (1865–1927), a physician in Cleveland, Ohio, described his useful principle and two tests in the Journal of the American Medical Association in 1908 (Hoover 1908). According to Pryse-Phillips 1995, Hoover trained as a Methodist minister before medical studies at Harvard, Vienna and Strasbourg. He later became professor of medicine at Western Reserve University, Ohio specialising in pulmonary and hepatic disease. His neurological test should not be confused with a respiratory ‘Hoover test’, which relates to paradoxical movement of the rib cage in pericardial effusion. His article ‘A new sign for the detection of malingering and functional paresis of the lower extremities’ (Hoover 1908) was based on four patients seen in two years. Hoover’s sign, like the type of patient for whom it is intended, has not traditionally been popularised in neurological training or textbooks and yet it is one of the most useful and simple tests in this area.

**HOOVER’S SIGN**

Hoover’s two tests rely on the following principle—try it if you don’t believe us. If a healthy person, lying or sitting down, flexes their right hip, they will automatically extend their left hip. This also occurs in hemiparesis due to an upper motor neurone lesion—where hip extension is invariably well preserved—and in patients who have functional weakness.

This basic principle can be used to aid diagnosis in two main ways—both described by Hoover:
• For a patient with weakness of hip flexion: Ask the patient to flex their weak leg at the hip. In normal people and in patients with an organic hemiparesis you will feel downward pressure under the opposite heel. If you feel nothing it suggests a functional weakness, i.e. that effort is not being transmitted to either leg. This sign can be used even if both legs are weak but is probably less reliable than the next test.

• For a patient with weakness of hip extension: You have already found weakness of hip extension on direct voluntary testing. Ask the patient to flex their good leg against resistance while keeping your hand under the heel of the weak leg. If you feel downward pressure that was not there before you have palpable evidence of inconsistency in the examination. (Fig. 1).

The great beauty of Hoover's sign is firstly, that it relies on the absence of a normal phenomenon found in most people and not the presence of an abnormal phenomenon (such as the Babinski sign). Secondly, it is a clinical marker of internal inconsistency that can be repeated in a controlled way and does not rely on skilled surreptitious observation. Thirdly, and perhaps more controversially, it is a physical sign, which if carefully handled, can be used to demonstrate to the patient their own potential for recovery.

PHYSIOLOGY
Why does this phenomenon exist? A simple answer might be that for every action there is an equal and opposite reaction. Imagine you've just stepped on a pin. Because you have probably lifted and flexed your leg, it helps if the hamstrings of your other leg contract and keep you planted on the floor. Walking is more complicated but does rely on this basic response. Sherrington first described and named this the crossed extensor reflex (Sherrington 1910). He demonstrated its presence even in decerebrate and spinal cord animals. The pathway for this reflex involves excitatory spinal interneurones, which traverse multiple levels of the spinal cord before producing an antagonistic contraction in the opposite limb.

THREE IMPORTANT CAVEATS
Like any physical sign it is important not to get too carried away by Hoover's tests.
1 A positive Hoover test does not exclude dis-
Figure 2  A controlled study of Hoover's sign – figures adapted from Ziv et al. 1998. A unique discrepancy is observed in the affected weak limbs of patients with 'nonorganic' weakness, in contrast to their unaffected limb, normal controls and patients with 'organic' weakness (Error bars represent 95% confidence intervals).

We are aware of only four subsequent papers on Hoover's sign used to detect weakness. Arieff et al. 1961 examined the Hoover principle in several patients with functional weakness using EMG and what amounts to a set of bathroom scales but did not reach new conclusions. Archibald & Wiechec 1970 carried out a similar study in 12 normal patients, six organic hemiparetics, 11 patients with 'various neuromuscular disabilities' and two with functional weakness. The study is disappointing because they only provided data on one comparison between functional and organic weakness and only examined Hoover's test for weakness of hip flexion. They found retest and between-patient inconsistencies in the normal and organic groups ('a reliability coefficient of 0.56') when measuring downward heel pressure during contralateral leg raising. This variation is hardly surprising given the population being studied, but it doesn't help at all in validating the test in patients with functional weakness, for whom the test is intended.

More recently, Ziv et al. 1998 carried out a controlled study of Hoover's sign in nine patients with functional limb weakness, seven with organic causes for weakness, and in 10 healthy controls. They refined the test using computerized myometry - essentially a strain gauge measuring voluntary vs. involuntary hip extension as described above. They found this method could discriminate impressively between 'nonorganic' and 'organic' leg weakness when applied to a 'gold standard' of clinical diagnosis backed up with laboratory and imaging investigations (Fig. 2). Diukova et al. 2001 have recently replicated this finding in nine subjects using simple weighing scales. In this study, comparison groups with back pain, neurological weakness and healthy controls were significantly discriminated against. We must bear in mind though that neither of these studies were blinded and even weighing scales do not necessarily equate with busy clinicians using the sign in the real world. Clearly more work is needed.

HOOVER'S SIGN IN THE ARMS?
Hoover commented that the phenomenon of 'complementary opposition' is also present in the movements of shoulder abduction and adduction although admitted it is less reliably so. Ziv et al. 1998 investigated this with
their technique. They obtained similar results to those in the leg but it remains to be seen whether this result can be repeated or translated into clinical practice.

OTHER PHYSICAL SIGNS OF FUNCTIONAL WEAKNESS
How does Hoover’s sign measure up to other competing signs? In his original article, Hoover commented that he had ‘found Babinski’s sign unsatisfactory’ in relation to making a positive diagnosis of functional weakness (Hoover 1908). Babinski would have been the first to point out that his sign is absent in numerous organic causes of leg weakness, such as myopathy and radiculopathy, and therefore had good specificity but poor sensitivity for excluding functional weakness. Collapsing weakness has been investigated on a few occasions over the years in neurophysiological ways (McComas et al. 1983; Knutsson & Artensson 1985; van der Ploeg & Oosterhuis 1991), but not as a clinical sign. One of the very few studies to look at the frequency of collapsing weakness in neurological populations was carried out by Gould et al. 1986. In a salutary if crude paper, a third of 30 patients with acute organic neurological problems (mostly stroke) had collapsing weakness on admission – no doubt due to a variety of reasons such as pain, general illness and difficulty following instructions.

HOOVER’S SIGN AS A THERAPEUTIC PROCEDURE?
In the course of examining many patients with functional weakness we have recently found that some patients are interested to know precisely how we arrive at our diagnosis. In several patients, the demonstration of their own Hoover’s sign has allowed the patient to see that, under some circumstances, they are able to achieve greater power in their affected leg than they thought possible. Handled carefully, this seems to help their understanding of the problem, their belief that their leg can get better, and improves transparency and trust between doctor and patient. Handled badly, the patient may well interpret your explanation as ‘Gotcha!’: therein lies the challenge.

CONCLUSIONS
Hoover’s sign is an easy sign to learn and use. Once learned, it will not be long before you have an opportunity to try it out on someone – in the light of a thorough history of course. None of the physical signs of ‘functional’ weakness has much more to commend it than common sense. In our opinion Hoover’s sign is, despite all our caveats, the most useful.

REFERENCES

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Hoover’s Sign

Jon Stone and Michael Sharpe

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