

Important observations prior to the description of the Hoover sign

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Abstract—Objective: To study the context in which Hoover described his sign for differentiating hysterical and organic hemiplegia. **Background:** At the turn of the 20th century, many physicians were looking for signs to distinguish organic from hysterical hemiparesis. In 1908, Hoover described his sign of “complementary opposition.” Other signs based on associated movements of the upper extremities, lower extremities, and trunk were also described during and before this period and might have contributed to Hoover’s understanding of complementary opposition. **Methods:** A complete literature review of the original relevant articles by Babinski, Bychowski, Grasset and Gaussel, and Hoover was performed. **Results:** Several similar maneuvers were described before the Hoover sign. Babinski described the trunk-thigh test in 1897. Bychowski in Warsaw (performed since 1902, published in 1907) and Grasset and Gaussel in Paris (1905) independently described a phenomenon in which the separate elevation of each leg was performed more easily than simultaneous elevation. Moreover, Bychowski, although not emphasizing it as a sign, described what became known as Hoover sign. Hoover sign (1908) has been considered a further elaboration of these previous observations. Interestingly, Hoover had studied in Europe, and although no direct relationship between his discovery and these observations has been elucidated, the authors postulate that he was influenced by Babinski, Bychowski, and Grasset and Gaussel. **Conclusion:** Although Babinski, Bychowski, and Grasset and Gaussel described similar signs, only Hoover sign is still in wide use by practitioners.

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Near the end of the 19th century and beginning of the 20th century medical practitioners were searching for neurologic examination signs to discern organic paralysis from psychogenic or sometimes called hysterical paralysis. Babinski, one of the well-known neurologists of this period, described several signs, including the extensor plantar response (1896), that were useful in this regard. However, there remained a need for better tests to distinguish organic from hysterical or psychogenic paralysis. Babinski then went on to describe the “trunk-thigh test,” which was based largely on “associated movements.” When a healthy recumbent person was asked to sit up without using his or her arms, Babinski observed that the sacrolumbar muscles contracted to stabilize the pelvis and that the leg muscles extended and pushed against the surface of the bed. He also observed that when an organic hemiparetic patient was asked to sit up from a reclining position with his or arms held crossed on the chest, the hemiparetic leg flexed upward at the hip (figure 1). In hysterical (or psychogenic) hemiparesis, however, Babinski noted that the patient did not appropriately flex at the hips or would alternatively claim to be unable to perform the request. Babinski also observed in some cases

that this type of patient might make various movements (e.g., only the good leg will go up) that were different from the movement of “flexion combinée de la cuisse et du tronc” [combined flexion of the thigh and trunk].^{1,2}

During the first decade of the 20th century, practitioners attempted to describe these “associated movement” phenomena. In this article, we will discuss the original articles in which these types of signs were described (by Bychowski, Grasset and Gaussel, and Hoover), and we will place emphasis on whether there was a relationship between each of these descriptions.

A contribution from Warsaw: Bychowski’s “Ersatzphenomän” (1902/1907). Zygmunt Bychowski (1865 to 1934), a neuropsychiatrist who investigated traumatic epilepsy and multiple sclerosis, worked at the Jewish Praga hospital in Warsaw, Poland.³ In 1907, he described an important phenomenon that he had observed in hemiplegic persons.

If a person suffering from hemiplegia or hemiparesis of cerebral origin, while in recumbent position, is able to elevate the extended good leg, up to H cm and the

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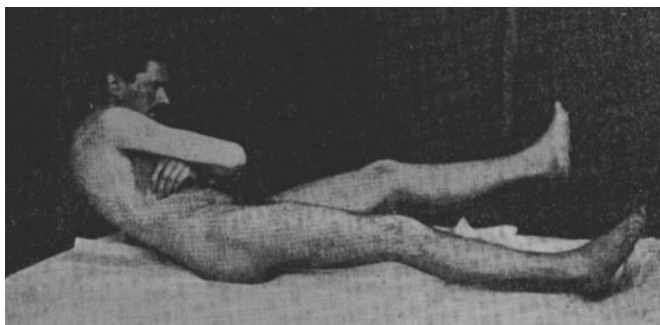


Figure 1. Babinski's trunk-thigh test (from Babinski²).

affected leg not at all or only H' cm ($H > H'$), he will only rarely reach the height (H or H'), when requested to elevate the extended legs simultaneously . . . Thus, the good leg remains on the ground almost completely despite several observable muscle contractions. Healthy persons are easily able to elevate both legs simultaneously as high as either leg separately [translation from German by P.K.].^{4,5}

Bychowski also observed that patients with spinal cord disease and polyneuritis were able to perform as well as healthy persons. The phenomenon was best seen in persons after recent hemiplegia. He did not examine patients with hysterical hemiplegia. In a footnote, he stated that although the paper was sent to the editor in July 1906, he had demonstrated the sign several times while working in the department of his previous chief, Dr. Zielinski (Warsaw), and these observations predated his submission by at least 4 years. The delay in submission was because of a stay in Manchuria (in the present northeastern China) in 1905. Because Poland was a part of the Russian empire at the time, Bychowski probably had to serve in Manchuria during the Russo-Japanese War of 1904 to 1905. After he returned to Poland, he read Grasset and Gaussel's 1905 article in the *Revue Neurologique* on a sign similar to his own. In his German article (1907), Bychowski explained his observation as one of central substitution (i.e., that the normal cerebral hemisphere replaces part of the function of the damaged one): "the less individualized a synergy, the earlier it originated in phylogenetic regard, the faster it will be replaced by the undamaged hemisphere."⁴ Therefore, the leg was supposed to recover sooner than the arm. In October 1907, Bychowski published an article in the *Revue Neurologique* in which he repeated the fact that Grasset and Gaussel observed the same phenomenon independently.⁶ He also noted that Grasset, although labeling it "ingenious," had rejected his central replacement theory.

It was a great pleasure to learn that the phenomenon had also been observed by a person of such high authority; but with regard to the explanation of the phenomenon presented by professor Grasset, I find, to my regret, that it is little convincing and not compatible with facts from experience [translation from French by P.K.].⁶

Grasset's theory was that to allow for movement in a certain joint, there should be stabilization of neighboring joints. Bychowski criticized Grasset's theory, pointing to inconsistencies and describing it as too simple. Bychowski believed that by this explanation, the sign would not be specifically useful for hemiplegic patients. He thought the intact hemisphere controlling the (ipsilateral) affected leg should explain this phenomenon.

Quand on ne souleve qu'une jambe, c'est bien l'autre qui sert, entre autres, de point d'appui, on peut s'en convaincre facilement en interposant la jambe immobile entre la main et le lit; car on a la sensation nette d'une pression notable sur la main, dès que le sujet souleve l'autre jambe.

[When a person elevates only one leg, it is the other that, among others, serves as a point of support; one is easily able to convince oneself by interposing the immobile leg between the hand and the bed; because one has the clear sensation of a notable pressing on the hand, as soon as the person elevates the other leg; translation from French by PK].⁶

This is an important section of the article. In arguing against the theory of Grasset and Gaussel, Bychowski almost described what was later known as Hoover sign. However, he made a mistake in his description (the hand should be placed between the leg and the bed) and never emphasized this as an important phenomenon to distinguish between organic and hysterical paralysis.

Another interesting point in Bychowski's description is the name he imparted on it. In his German text,⁴ he called the phenomenon "Ersatzphenomän" (substitution phenomenon). Reading Babinski's 1897 article, we find the term "Ersatzbewegungen" (substitution movements). The international understanding of these movements, although flawed, provided a basis for the exploration of their use as clinical examination signs. In explaining the phenomenon of associated movements, Babinski referred to explanations offered by German physicians, including Hitzig, Senator, Sander, and Koenig, who hypothesized the action of anatomic centers in the cerebral peduncles or spinal cord as responsible for associated movements by combining cerebral excitations. Interestingly, examining these coincident ("Mitbewegungen") and substitution movements ("Ersatzbewegungen"), the Germans mentioned reflex movements appearing after pinpricking the sole of the foot (!).⁷ They had a notion of the anatomic wiring in the brainstem and spinal cord resulting in fixed movement patterns coordinating agonist and antagonist muscles. Therefore, the increased efforts to move a paretic limb could easily result in coincident and substitution movements.⁷⁻⁹ Babinski did not completely agree with these explanations, but these were the important international hypotheses of the time that led these investigators to describe their signs.¹ Although Bychowski did not refer to Babinski's, Hitzig's, or Senator's articles on the subject, the central explanation of his sign indicates that he most probably was aware of these ideas.



Figure 2. Joseph Grasset (1849 to 1918; courtesy Bibliothèque Interuniversitaire de Montpellier, Section Médecine).

The work of Grasset and Gausssel in France.

Joseph Grasset (1849 to 1918; figure 2) from Montpellier, France and his pupil A. Gausssel (1871 to 1937) described the phenomenon of complementary opposition in a unilateral pyramidal lesion (1905), a finding Bychowski applied a few years previously.¹⁰ They began their article stating:

Several signs indicate that in hemiplegics, the movements in the affected leg are easier when they are associated and bilateral than when they are dissociated and effectuated by that leg in isolation. . . . Involuntary movements provoked in the paralytic leg by voluntary contraction of the muscles of the opposite side, voluntary movements of that limb that are turned more energetically under the same influence [translation from French by P.K.].

However, the authors pointed out an exception to this rule, as observed in four of their hemiplegic patients.

. . . indeed, the patients of Mr. Grasset and Mr. Gausssel could elevate their two lower limbs *separately, but not simultaneously* [italics by the author].

Grasset and Gausssel explained that to check for the sign, the patient is asked to lie on the bed with his or her arms crossed and a space between the legs. The patient should then elevate each leg separately and subsequently both together. The patient will execute the first two movements but is unable to perform the third. It will even be clearer if the para-

lyzed leg is elevated; as soon as the good leg is elevated, the paralyzed leg will fall down. Two conditions should apply to carry out the test: 1) the hemiparesis should not be complete (which is obvious); and 2) the paresis should involve certain muscles that play a role in the stabilization in a sufficient way.

Grasset and Gausssel also explained that the study of the difference between the two actions would reveal that when one leg is elevated, the stabilized part that serves as a point of support (abutment) is effectuated by the trunk and the other inferior limb, in the second case by the trunk only, so that it is the muscles of the lumbosacral mass that should take care of the stabilization of the pelvis. A healthy person, lifting 15 kg with one leg, would only be able to lift 10 kg when simultaneously lifting the other leg. The author/reporter opined that the Grasset–Gausssel phenomenon deserves a place for the diagnosis of the motor disturbances in the organic hemiplegic patient, along with the sign of Babinski (the way by which the patient, recumbent on his or her back, tries to sit without the help of his arms). “. . . it is particularly for the differential diagnosis between the organic paralyzes and the neurotic paralyses” (the term “névrose” at the time still had another meaning than neurotic. . .). The stabilization constitutes a purely automatic process, which is distinguishable from voluntary acts. “. . . the hysterical patient will not elevate the paralyzed leg separately nor simultaneously with the other leg, or he elevates it in both circumstances.”¹⁰ The author added that what has been said for organic hemiplegia is also true for paraplegia.

Charles Franklin Hoover: the Hoover sign.

Charles Franklin Hoover (1865 to 1927; figure 3) had traveled extensively in Europe when he described his sign in 1908. He visited several clinicians, including Charcot’s former pupil Pierre Marie (1853 to 1940) in Paris (1905 to 1906).¹¹ It is unknown whether Marie and Hoover spoke about the Babinski trunk-thigh sign or other associated movements. Hoover might have heard or read about it because this was the period in which Grasset and Gausssel published their article. Hoover would later remark about the shortcomings of Babinski sign. He was aware of Babinski’s findings and their importance to his sign as he demonstrated by reading, “the Significance of Coordinated Reflexes in Differentiating between Functional and Anatomic Diseases of the Nervous System,” before the Academy of Medicine of Cleveland, March 19, 1909. “If paresis of one lower extremity is due to an interruption of the crossed pyramidal path we expect with confidence to find the knee jerk exaggerated and the dorsal flexion of the great toe to follow irritation of the plantar surface in the method described by Babinski.”¹² Hoover described his sign in 1908 after having observed it in many hemiparetic patients for 2 years. He found it lacking in two malingering and two hysterical cases.



Figure 3. Charles Franklin Hoover (1865 to 1927; courtesy Wesleyan University).

I feel justified in attaching great importance to the sign because it is dependent on a normal function, which I find always exhibited in healthy persons and invariably present in the sound leg of patients suffering from hemiplegia or paresis of one leg due to some pathologic lesion. If a normal person, lying on a couch in the dorsal position, be asked to lift the right foot off the couch with the leg extended, the left heel will be observed to dig into the couch as the right leg and thigh are elevated.¹³

He noted that the force by which the leg is pushed down, when holding the hand underneath the Achilles tendon, is related to the force by which the other leg is elevated. "This will always occur if the healthy person makes a free and uninhibited effort to lift the right leg." The reverse order can also be tested by asking the patient to press the leg against the surface, in which there will be "a counter-lifting force exhibited in the left leg." He had observed a similar sign in the arm but not consistently. Hoover observed that the leg sign was lacking in two cases in which paresis of a leg was claimed in suits for personal injuries. "Furthermore, in both of these cases, when the patient was asked to lift the normal leg off the couch, the leg which was alleged to be paretic was opposed strongly against the surface when resistance was offered to lifting the normal leg." When

asked to lift the affected leg, the examiner did not notice the slightest opposition of the normal leg on the surface of the couch. In a genuine paretic leg, "the sound leg would have been firmly opposed against the surface of the couch. . ."¹³ Hoover had also observed the lack of complementary opposition in a case of hysterical hemiplegia. He thought the sign was important because it depended on the function of the normal leg. Furthermore, he was still uncertain whether the lack of the sign would always be found in malingerers and hysterical patients and therefore recommended further research. At the end of the article, Hoover compares his sign with that of Babinski, stating that the latter is dependent on the affected side.

I have found Babinski's sign unsatisfactory. The fact that this sign of complementary opposition is always present in normal subjects and in genuine paresis of the lower extremity, and the fact that it depends on an invariable function of the normal side gives it a very broad application.¹³

Not long after Hoover's publication, Philip Zenner, working at the Medical College of Ohio, Cincinnati, was able to confirm his findings.¹⁴ The importance of the sign was recognized in France in 1908, for example, by Jean Lhermitte (1877 to 1959),¹⁵ who called it "le phénomène de Hoover" [Hoover's phenomenon].

Hoover's test in recent years. Hoover sign is based on associated movements in the opposite leg. When a person flexes a hip, the contralateral hip is extended. It is assumed that this is a result of the crossed extensor reflex described by Sherrington. The reflex is active in normal walking and can also be demonstrated in decorticate animals.^{16,17}

Although only limited data on its reliability are available, Hoover sign has survived throughout the years. In the 1960s, Hoover sign was evaluated using EMG and clinical scales. The sign was deemed "invaluable in the differential diagnosis in many patients who had real or functional pain or weakness in the back or lower extremities."¹⁸ However, other investigators found the method less consistent and pointed to the variable responses that could be expected, resulting from spasticity, pain, weakness, accompanying sensory abnormalities, and an incomplete understanding of the instructions. These perhaps more cautious investigators advised that the sign should be considered in the context of the complete examination.¹⁹ A new study recently was performed that quantified Hoover sign. A significant difference was discovered in maximal involuntary/voluntary force ratio between the "paretic" limbs in "non-organic" patients when compared with control subjects and/or organic patients.²⁰ It recently has been suggested that with respect to the examination of functional weakness, it is important to look for evidence of inconsistency and that Hoover sign is "the most useful test for functional weakness."¹⁶

References

1. Babinski J. De quelques mouvements associés du membre inférieur paralysé dans l'hémiplégie organique. *Bulletins et Mémoires de la Société médicale des Hôpitaux de Paris* 1897;14:1098–1103.
2. Babinski J. Diagnostic différentiel de l'hémiplégie organique et de l'hémiplégie hystérique. *Gazette des Hôpitaux* 1900;73:521–527, 533–537.
3. Landman I, ed. *Encyclopaedia judaica*, vol II. New York: Jewish Encyclopaedia Co., 1943:1203.
4. Bychowski Z. Zur Phänomenologie der cerebralen Hemiplegie. *Neurol Centr Bl* 1907;15 February:154–157.
5. Bychowski Z. Contribution à la symptomatologie de l'hémiplégie cérébrale. *Sem Méd* 1907:282.
6. Bychowski Z. Pourquoi certains hémiplégiques ne peuvent-ils pas soulever simultanément les deux jambes? *Rev Neurol* 1907;30 October: 1070–1072.
7. Senator H. Ueber Mitbewegungen und Ersatzbewegungen bei Gelähmten. *Berlin klin Wschr* 1892;29:1–4, 32–33.
8. Nothnagel H. Ueber centrale Irradiation des Willenimpulses. *Arch f Psychiatrie* 1872;3:214–218.
9. Hitzig E. Ueber die Auffassung einiger Anomalien der Muskelinnervation. *Arch f Psychiatrie* 1872;3:312–329, 601–617.
10. Grasset J, Gaussel A. Un signe de paralysie organique du membre inférieur: possibilité de soulever isolément le membre paralysé avec impossibilité de soulever simultanément les deux membres inférieurs. *Sem Méd* 1905:554–555. Abstracted from *Rev Neurol* 1905, 15 September.
11. Thwing C. *Friends of mine*. New York: The MacMillan Company, 1933.
12. Hoover CF. The significance of coordinated reflexes in differentiating between functional and anatomical diseases of the nervous system. *Academy of Medicine Cleveland* (read before the Academy) 1909;March 19:317–327.
13. Hoover CF. A new sign for detection of malingering and functional paresis of the lower extremities. *JAMA* 1908;51:746–747.
14. Zenner P. A new sign for the detection of malingering and functional paresis of the lower extremities. *JAMA* 1908;51:1309–1310.
15. Lhermitte J. De la valeur du phénomène de l'opposition complémentaire comme moyen de diagnostic entre les hémiplégies organiques et les hémiplégies fonctionnelles. *Sem Méd* 1908:565–567.
16. Stone J, Zeman A, Sharpe M. Functional weakness and sensory disturbance. *J Neurol Neurosurg Psychiatry* 2002;73:241–245.
17. Sherrington CS. Flexion-reflex of the limb, crossed extension reflex, and reflex stepping and standing. *J Physiol (Lond)* 1910;40:28–121.
18. Arieff AJ, Tigay EL, Kurtz JF, Larmon WA. The Hoover sign. An objective sign of pain and/or weakness in the back or lower extremities. *Arch Neurol* 1961;5:109–114.
19. Archibald KC, Wiechec F. A reappraisal of Hoover's test. *Arch Phys Med Rehabil* 1970;51:234–238.
20. Ziv I, Djaldetti R, Zoldan Y, et al. Diagnosis of "non-organic" limb paresis by a novel objective motor assessment: the quantitative Hoover's test. *J Neurol* 1998;245:797–802.

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