



The Schellong test: detecting orthostatic blood pressure and heart rate changes in German-speaking countries

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Received: 20 June 2019 / Accepted: 22 June 2019 / Published online: 4 July 2019
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Keywords Schellong test · Standing test · Orthostatic hypotension · Head-up tilt test · Syncope

“Schellong test” is the eponym used in German-speaking countries to refer to the active standing test for measuring blood pressure and heart rate changes under gravitational stress. The test is named after Fritz Schellong, a European pioneer of cardiovascular autonomic neuroscience.

Schellong, who was born 10 September 1891 in Königsberg (at that time part of Prussia) and died 18 January 1953 in Münster (Germany), became Professor of Internal Medicine in Prague and Münster and a prominent member of the German Society for Circulation Research (*Deutsche Gesellschaft für Kreislaufforschung*, nowadays known as *Deutsche Gesellschaft für Kardiologie–Herz-und Kreislaufforschung*, i.e. the German Society for Cardiology, Heart and Circulation Research). Schellong dedicated his scientific career to the understanding of blood pressure regulation, which he summarized in his small monograph *Regulationsprüfung des Kreislaufs* (Evaluation of the circulatory regulation), published in 1938. In his 133-page book, Schellong described specific tests to evaluate circulatory function with emphasis on blood pressure and heart rate. The monograph included many case examples of these responses, profusely illustrated with 92 graphs (Fig. 1). The original Schellong protocol consisted of three consecutive tests:

1. Blood pressure and heart rate measurements in the supine position, at 1-min intervals after standing up, and at 1-min intervals after lying down again

2. Blood pressure and heart rate measurements immediately after climbing up a staircase and at 1-min intervals afterwards
3. Measurement of the QRS complex duration on an ECG tracing prior to climbing the stairs in part (2), immediately afterwards, and at 1-min intervals afterwards

Schellong considered the responses in part (1) to depend on neurogenic regulation of peripheral blood vessels, part (2) on both neurogenic control of blood vessels and cardio-circulatory regulation, and part (3) on cardiac regulation only.

After studying the orthostatic blood pressure responses in 92 healthy subjects, he concluded: “As far as the responses in the upright position is concerned, we came to the conclusion that the systolic blood pressure behaves somewhat differently: it can rise a little or remain the same, or sink a little. A decrease of 5 or 10 mmHg is meaningless, but a decrease of 15 mm is the ‘borderline case’...the diastolic blood pressure usually increases by a few millimetres (5–10 mmHg), sometimes it remains the same, only in a few cases it drops slightly, but increases again while standing. The pulse rate shows an increase of 10–20, even 40 beats per minute. In young people the increase is greater than in older people; in the latter the frequency can also remain the same” [17].

By applying the simple methodology described above, Schellong already understood that orthostatic systolic blood pressure reductions greater than 20 mmHg are abnormal in the clinical setting [10], that diastolic blood pressure probably contributes to a lesser extent to orthostatic blood pressure regulation and its disorders [7], and that, above all, aging significantly affects baroreflex function [2, 13].

Nowadays there are much more sophisticated ways to examine both cardiac intrinsic and baroreflex function, but a simplified version of the Schellong, or standing test, i.e. the evaluation of heart rate and blood pressure changes

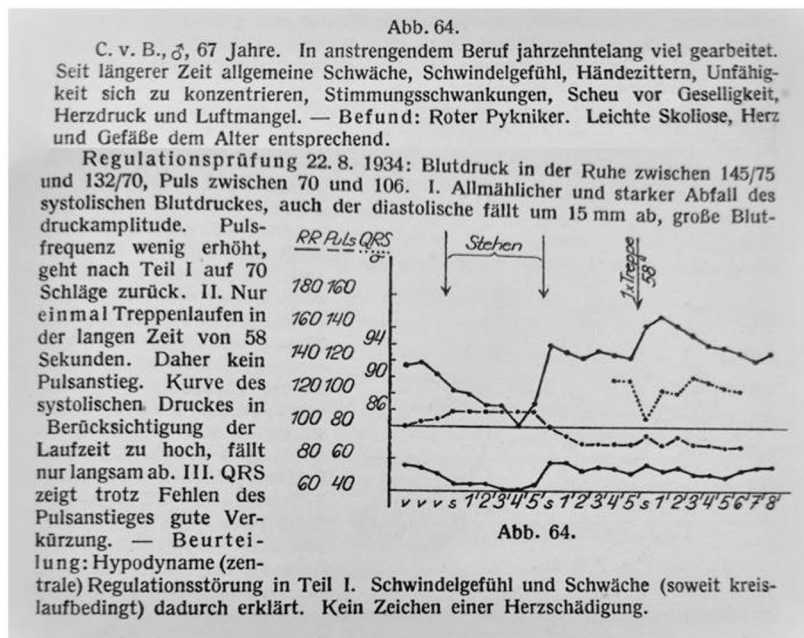
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Fig. 1 Left panel: Fritz Schellong in 1950, family archive. Source: Wiki Commons. https://commons.wikimedia.org/wiki/File:Fritz_Schellong_1950.jpg?uselang=de. Right panel: Example of a Schellong test in a patient presumably affected by parkinsonism and neurogenic orthostatic hypotension: “C.v.B., male, 67 years old. Worked for years under stressful conditions. For a long time now, general weakness, dizziness, hand tremor, inability to concentrate, mood fluctuations, reluctance to social life, angina and dyspnea. Findings: red endomorph. Slight scoliosis, normal heart and blood vessels. Regulation test 22.08.1934: Blood pressure at rest between 145/75 and 132/70, pulse between 70 and 106. Part I. Progressive and severe



decrease of systolic blood pressure, also diastolic blood pressure drops by 15 mmHg, large blood pressure amplitude. Pulse frequency slightly increased, afterwards back to 70 beats. Part II. Only one stair case in the long time of 58 s. Therefore no pulse increase. Systolic blood pressure curve too high in consideration of the exercise time, delayed return to baseline. Part III. QRS shows a good shortening despite the lack of pulse increase. Interpretation: hypodynamic (central) regulatory disorder in part I. This explains dizziness and weakness (as far as circulation is their cause). No sign of heart damage.” First published in F. Schellong “Regulationsprüfung des Kreislauf”, Theodor Steinkopff Verlag (Dresden, Leipzig) 1938; C, 2d: 100–101

from the supine to upright position, is still recommended as a bedside screening measure in patients with suspected cardiovascular autonomic dysfunction, including syncope, whenever the patient’s clinical condition allows it [3, 18].

There is no universal standardized protocol for performing a standing test, although this usually consists of a supine phase of 5–10 min, followed by an active standing phase of at least 3 min, ideally 5–10 min. Blood pressure and heart rate are measured at the end of the supine phase and at 1-min intervals during the orthostatic challenge. If the patient is unable to stand up from the supine position, a sitting-to-standing protocol is acceptable [11], although less sensitive than the supine-to-standing one [4].

For screening purposes and when no other technologies are available, heart rate can be measured manually or with a pulse oximeter, while blood pressure can be obtained with an arm cuff [3].

A sustained blood pressure fall of at least 20 mmHg in systolic or at least 10 mmHg in diastolic or an absolute systolic blood pressure below 90 mmHg after 3 min standing qualifies for orthostatic hypotension [3, 10].

Orthostatic hypotension may be symptomatic, i.e., causing symptoms of organ hypoperfusion such as dizziness, cognitive slowness, blurred vision, or shoulder or neck pain; or asymptomatic, mostly depending on the lowest blood pressure value when standing [15]. In the clinical setting, the most frequent causes of orthostatic hypotension are non-neurogenic, i.e., volume depletion (dehydration, blood loss) and medication side effects. In non-neurogenic orthostatic hypotension, baroreflex function is preserved, and the fall in blood pressure is compensated by a marked rise in heart rate. In contrast, when orthostatic hypotension is caused by neurodegenerative, metabolic, autoimmune, or genetic disorders affecting afferent or efferent autonomic pathways, baroreflex dysfunction is evident, and the orthostatic heart rate response to hypotension is reduced or absent [14]. Evaluating the supine-to-standing heart rate changes may thus provide invaluable information about the cause of the orthostatic hypotension, and inform treatment.

Blood pressure measurements in the supine position may also detect supine hypertension [6], defined as blood pressure $\geq 140/90$ mmHg at the end of a supine phase of at least 5 min in patients with neurogenic orthostatic hypotension.

Neurogenic supine hypertension affects about 50% of patients with neurogenic orthostatic hypotension [5] and, if present, has major therapeutic and prognostic implications.

The active standing test may also detect delayed orthostatic hypotension, i.e., occurring beyond 3 min of orthostatic challenge [3], although prolonging the test to 10 min or more may be uncomfortable for geriatric patients. In this case a tilt-table test may be preferable.

There is conflicting evidence in the literature as to whether a standing or a head-up tilt test, i.e. an active or passive orthostatic challenge, is more sensitive for detecting orthostatic hypotension [1, 12]: these tests are eventually to be considered of complementary value in the diagnostic workup of orthostatic hypotension.

Continuous heart rate and blood pressure monitoring during a standing test may also identify transient orthostatic blood pressure changes, such as initial orthostatic hypotension (i.e. a BP fall > 40/20 mmHg within the first 15 s upon standing, with recovery within 30 s) or delayed blood pressure recovery (i.e. a BP fall > 20/10 mmHg persisting 30 s after standing) [9], which have recently been acknowledged as possible causes of falls and syncope in the aging population [8, 16].

A standing test may be also used to screen for postural tachycardia syndrome (POTS). In case of suspected vasovagal syncope extended continuous heart rate and blood pressure monitoring for up to 45 min at 60-degrees head-up tilt is often necessary, in order to diagnose and classify syncope [3]. The sensitivity is indeed higher during a head-up tilt examination, thanks to the exclusion of the muscular leg pump, to the possibility of prolonging the test beyond 10 min or adding provocations like sublingual nitro-glycerine or isoproterenol [3].

Bernard of Chartres, a twelfth-century philosopher, said that “we, the Moderns, are like dwarves perched on the shoulders of giants, the Ancients, and thus we are able to see more and farther than the latter. And this is not at all because of the acuteness of our sight or the stature of our body, but because we are carried aloft and elevated by the magnitude of the giants.” Thanks to advanced technology, modern clinical autonomic medicine is nowadays able to diagnose, quantify, and monitor over time a wide range of cardiovascular autonomic disorders. More than 80 years ago, however, Schellong already understood the key point of cardiovascular autonomic testing: to stress the baroreflex by standing up.

Funding None

Compliance with ethical standards

Conflict of interest The authors declare no conflicts of interest.

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