



Opinion

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Water Immersion-Induced Skin Wrinkling: More Accurately Reflects Neurovascular Coupling rather than Just Neural Function

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Skin wrinkling (SW) is a normal response to water immersion (WI) that is impaired after peripheral nerve injury. The mechanism appears to involve passive diffusion of water across the stratum corneum into the sweat ducts. This alters electrolyte balance and increases sympathetic neural firing causing vasoconstriction. SW results from a decreased digital volume relative to surface area. WISW has been suggested to be a measure of peripheral sympathetic function, to reflect autonomic function and small fibre neural function. Since this response involves both neural and vascular responses, we propose WISW to more accurately reflect neurovascular coupling.

Keywords: Water induced skin wrinkling; Sympathetic function; Vasoconstriction; Neurovascular coupling

Opinion

Skin wrinkling (SW) of the fingertips is a normal response to water immersion (WI) [1]. WISW had long been attributed to passive exposure of skin to water until Lewis and Pickering noted that SW hadn't occurred in patients with upper limb paralysis resulting from conditions such as poliomyelitis more than 85 years ago [2]. Specifically, they noted skin innervated by palsied median nerve failed to wrinkle. Almost 40 years later, O'Riain, a plastic surgeon observed similar findings in that patients with peripheral nerve denervation did not exhibit SW in response to warm water [3]. He proposed WISW to be "a simple and objective test of innervation and regeneration of sensory nerves in the hand by immersion in warm water". Since then multiple studies have supported WISW to be dependent on intact peripheral sympathetic function [1,4-7]. WISW was observed to be blunted in diabetic patients and in patients after cervical sympathectomy [5,8]. Although the exact mechanism(s) has not been fully elucidated, WISW appears to involve passive diffusion of water across the stratum corneum into the sweat ducts. This alters electrolyte balance and increases sympathetic neural firing causing vasoconstriction. SW results from a decreased digital volume relative to surface area [1,9]. Accordingly, WISW has been proposed as a peripheral sympathetic function [10].

Bull and Henry observed WISW to occur in 2 patients with Raynaud's disease and hyperhidrosis before but not after unilateral upper thoracic sympathectomy. They further observed loss of WISW in 3 diabetic patients and evidence of autonomic failure but not peripheral neuropathy and in a patient with Guillain-Barre polyneuropathy [4]. These observations led them to conclude that the phenomenon of finger wrinkling may be used to identify autonomic neuropathy and more specifically reflects peripheral rather than cardiac sympathetic denervation evidenced by loss of sinus arrhythmia induced by Valsalva Maneuver. Another review of the literature also suggested WISW to more globally reflect sympathovagal balance. Our group previously reported that WISW responses correlated with indices of heart rate variability (HRV) in healthy subjects without known peripheral neuropathy [11]. HRV is the beat-to-beat variation in cardiac cycle length due to autonomic influences on the sinus node. Since decreased HRV is generally considered predictive of adverse cardiovascular events, it was suggested that WISW might be a useful prognostic indicator in patients with various cardiovascular diseases. In another study, our group found WISW responses to be less marked in patients with heart failure [12]. Since heart failure is associated with neuro-hormonal

and altered sympatho-vagal balance favoring vasoconstriction, blunted WISW might reflect more marked resting vascular tone as well as intravascular volume overload and decreased HRV. Further support for WISW reflecting general autonomic function was evidenced by the finding that blunted WISW was found predictive of abnormal response to tilt table testing [13].

In recent years, Wilder-Smith's group has contributed greatly to the understanding and significance of loss of WISW. This group showed WISW was accompanied by a significant reduction of blood velocity in the ulnar artery, digital artery and superficial skin vessels with the most marked reduction within the digital artery [9]. Moreover, WISW was similar to the effects obtained by topical administration of EMLA vasoconstrictor cream [14]. Therefore, a vascular response is required for WISW to manifest. It is well known that resting vascular tone is governed by a variety of vasoconstrictor and vasodilator influences acting on the vascular bed and it would stand to reason that the WI vasoconstrictor response would be less in subjects with a basal state of more marked vasoconstriction [15,16]. Therefore given the neural and vascular responses required for WISW, we propose WISW to more accurately reflect neurovascular coupling rather than serving as a test for sympathetic function or autonomic insufficiency. Neurovascular coupling refers to a complex of processes resulting in dynamic signaling between neurons and blood vessels [17]. The efficiency neurovascular coupling lessens with aging and altered coupling has been implicated in a variety of disease states ranging from premature births to dementia [18]. While a variety of sophisticated in-vivo imaging techniques have been used to assess neurovascular coupling with high sensitivity including laser Doppler flowmetry, laser speckle contrast imaging, intrinsic optical signal imaging, optical coherence tomography, and two-photon microscopy WISW would appear to be a crude but widely available technique. Moreover, it is recognized that neural and vascular abnormalities often coexist in chronic disease states such as HIV in which WISW has recently been employed to assess neuropathy [19]. Therefore it should be recognized that WISW represents an integrated assessment of both neural and vascular components of the response.

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Conflict of Interest

No conflict of interest.

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