

ABSTRACT: Q-Sweat, a commercial quantitative sweat measurement system, is modeled on quantitative sudomotor axon reflex testing (QSART). This study investigated the sweat response using Q-Sweat and Mayo-QSART recordings under identical conditions in healthy normal controls. Ninety-four participants were recruited for this study. All participants underwent randomized bilateral QSART recordings over the four standard recording regions. For both men and women, Wilcoxon signed rank tests of paired differences showed significantly lower volumes at each of the four sites for Q-Sweat vs. Mayo-QSART. Linear regression analysis was used to estimate the relationship between Q-Sweat and Mayo-QSART volume measurements separately for men and women. Although there was variability about the regression lines, these fitted models can be used to estimate the expected Mayo-QSART volume given an observed Q-Sweat volume, although it is preferable to use the Q-Sweat normative database directly. We hypothesize that the constant-current generator used in conjunction with Q-Sweat provides a less efficient iontophoresis of acetylcholine than the Mayo-constructed constant-current stimulator and results in lower volumes.

Muscle Nerve 000: 000–000, 2009

RELATIONSHIP OF Q-SWEAT TO QUANTITATIVE SUDOMOTOR AXON REFLEX TEST (QSART) VOLUMES

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Accepted 1 June 2009

The quantitative sudomotor axon reflex test (QSART) has been a routine postganglionic sudomotor function (HCEFA 95923) clinical laboratory test at the Mayo Clinic since 1983. QSART is a test designed to evaluate the integrity of the postganglionic sympathetic axons.¹ At regional test sites, multicompartmental sweat cells are attached to the limbs.¹ Axon terminals are stimulated by the iontophoresis of acetylcholine (ACh) to one compartment, and the sweat response is recorded from a separate compartment. Typically, four regions are

studied (one on the forearm and three on the leg). In a previous study, a comparison of the difference between the right and left side showed no overall significant side-to-side difference.²

The Q-Sweat (Quantitative Sweat Measurement System; WR Medical Electronics Co., Stillwater, Minnesota) is a patented commercially available version of the autonomic lab first described by Low et al. in 1983.¹ It was approved by the Food and Drug Administration (FDA) in 2001 and introduced into the marketplace shortly afterward; it is now widely used in the United States. New technologies, described in more detail in the Methods section, used in the Q-Sweat device were intended to make the device more reliable, reproducible, and easier to use, operate, and maintain.

A large normative database of 376 participants of both genders, 10–83 years of age, has been reported² and has been relied upon by clinicians and researchers for the interpretation of Q-Sweat responses. Since the introduction of the Q-Sweat device, researchers have reported lower sweat volumes in normal participants when compared with

Abbreviations: ACh, acetylcholine; BMI, body mass index; FDA, Food and Drug Administration; HCCM, heteroskedasticity consistent covariance matrix; ICC, intraclass correlation coefficient; IQR, interquartile range; QSART, quantitative sudomotor axon reflex test; Q-Sweat, quantitative sweat measurement system; RMSE, root mean square error; VAS, visual analog scale (11-point)

Key words: autonomic function; autonomic testing; Q-Sweat; QSART; sudomotor

Additional Supporting Information may be found in the online version of this article.

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Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mus.21464

Table 1. Subject characteristics overall and by gender.

Characteristic	Overall	Men	Women
Number of participants	94	44	50
Age at time of Q-Sweat (years)			
Median (IQR)	34 (21, 54)	48 (22, 62)	28 (21, 44)
Range	18 to 78	19 to 78	18 to 65
Height (cm)			
Median (IQR)	171 (163, 180)	180 (174, 185)	163 (159, 170)
Range	147 to 198	156 to 198	147 to 180
Weight (kg)			
Median (IQR)	73 (61, 84)	82 (75, 91)	62 (56, 68)
Range	50 to 118	63 to 118	50 to 93
BMI (kg/m ²)			
Median (IQR)	24 (22, 27)	25 (24, 29)	23 (21, 26)
Range	17 to 41	20 to 41	17 to 38
Ethnicity			
Hispanic or Latino	2	1	1
Non-Hispanic nor Latino	87	40	47
Unknown/missing	5	3	2
Race			
White	88	41	47
Black	3	0	3
Asian	1	1	0
American Indian	1	1	0
More than 2 races	0	0	0
Unknown/missing	1	1	0

IQR, interquartile range; BMI, body mass index.

the current QSART normal database.¹⁻³ The reason for the disagreement is not certain, because Q-Sweat devices must pass calibration verification at 1, 3, and 5 μ l of distilled water before leaving the factory for field use.

This study was designed to give a formal comparison evaluating whether Q-Sweat records sweat volume with fidelity and is quantitatively the same as Mayo-QSART.

METHODS

Participants. With the approval of the Mayo Foundation Institutional Review Board, we investigated 94 healthy volunteers (44 men, 50 women) free of autonomic disorders and not taking medications; exceptions were made for those taking daily vitamins and oral contraceptives. All participants were recruited from the Autonomic Disorders Center database of healthy volunteers; all medical records were screened and found to be free of neurological diseases or injuries that may affect the post-ganglionic sudomotor system. In addition, all participants had to have a normal autonomic reflex screen (within 2 years) prior to being enrolled in this study. Median age at the time of Q-Sweat was 48 years (range 19–78 years) for men and 28 years

(range 18–65) for women. Participants were asked to provide ethnicity and race information on a volunteer basis. Values are reported in Table 1. All participants received reimbursement for their time and participation.

Materials and Procedures. All studies were completed in the Autonomic Disorders Center, Mayo Clinic, Rochester, Minnesota, with the participant supine. Room temperature and humidity were controlled at 23°C and 25–35%, respectively. Participants were randomized by side tested (right vs. left). All recordings for each device were performed on the same side of the body (i.e., one device went on the left side and the other device on the right side). Participants underwent bilateral routine Mayo-QSART and Q-Sweat recordings using the standard regional sites (forearm, proximal leg, distal leg, and foot). All regional test sites utilized the previously described cleaning procedure¹ of acetone, alcohol, and water, followed by thorough drying. Recordings were done consecutively on the same day in 88 of 94 participants and within 20 days in the remaining 6 participants (median time between testing was 9.5 days, range 3–20 days). The testing order was randomized to cancel out carry-over and order effects. When regional limb temperatures were <30.0°C, limbs

were warmed with a servo-controlled heat lamp to no more than 33.5°C to ensure adequate blood flow while simultaneously remaining below limb sweating threshold.^{4,5} Skin temperature measurements were recorded using a digital infrared temperature scanner (Model OS91; Omega Engineering, Inc., Stamford, Connecticut). ACh solution (10% w/v) was used as the reagent to evoke the QSART response. All participants were asked to rate their perceived level of discomfort to the constant-current stimulation (2 mA for 5 min) using an 11-point visual analog scale (VAS), where 0 = no pain or discomfort and 10 = most severe pain or discomfort, for both sets of recordings.

Mayo-QSART Recordings. A full description of the device setup to measure QSART has been published.^{1,3,5} Briefly, nitrogen gas is channeled through the sudorometer then into the multicompartmental sweat cell, where the thermal mass of the gas is changed as sweating occurs. The nitrogen is then channeled back into the sudorometer where the thermal changes are calculated, compared, and displayed on a computer screen. The constant-current generator used was designed and developed by the Section of Bioengineering, Mayo Clinic, Rochester, Minnesota.

Q-Sweat Recordings. A full description of the Q-Sweat device (WR Medical Electronics Co.) can be obtained from the manufacturer. Briefly, the Q-Sweat device uses a dessicant pack (#5190; WR Medical Electronics Co., Stillwater, Minnesota) as its dry air source. Room air is drawn in through an intake pump and channeled through a serpentine of drierite (W.A. Hammond Co., Xenia, Ohio). This air is then passed through a set of sensors (Honeywell International, Inc., Morristown, New Jersey), which controls the flow rate, preset to 60 standard cubic centimeters per minute. The sensors evaluate the temperature and percent relative humidity. Finally, the dried air is delivered to the capsule assembly (known as the multicompartmental sweat cell) applied to the regional skin site. Moisture released from the human eccrine sweat gland is picked up by the dried room air and returned to the main unit of the device via Teflon-lined Tygon tubing. Once again, sensors evaluate the temperature and percent relative humidity along with flow rate. These values are compared against baseline (initial) values and integrated using the vapor pressure calculation for water between 0° and 50°C.⁶ Sweat rate, expressed as

nanoliters per minute, is then displayed using Test-Works software (WR Medical Electronics Co., Stillwater, Minnesota). Life-Tech, Inc. (Stafford, Texas) provided an FDA-approved commercial constant-current stimulator, the Iontophor II (Model 6111PM/DX), commonly used in conjunction with the Q-Sweat device.

Multicompartmental Sweat Cells. The multicompartmental sweat cells used for sweat collection in Q-Sweat and Mayo-QSART are identical in area, measuring 0.119 × 0.119 in. Minor differences in other size calculations within the sweat cells were found, but none would contribute to the magnitude difference found within the recordings. Further evaluation found all differences to be within manufacturing tolerance for the specific measurement.

Analysis of QSART Recordings. Recordings of both volume and latency for the Mayo-QSART and Q-Sweat obtained followed a standard procedure. All latency measurements were obtained by finding the time from the “on” of the stimulators until a noticeable sweat rate change occurred; the time is expressed in minutes. Volume measurements were made by integrating 10 minutes of the recording. The initial marker used for the volume measurement was the same one used to mark the start of the latency response. The second marker was placed 10 minutes afterward, and the area was integrated to give a volume measurement in microliters per 10 minutes.

Statistics. We performed all analyses separately for men and women due to expected gender differences in the nature of the sudomotor response. At each of the four sites, we evaluated whether there were systematic differences in temperature, latency, or volume using two-sided Wilcoxon signed-rank tests for the paired differences. These differences were expressed as the QSART value minus the Q-Sweat value. Discomfort was evaluated using a two-sided Wilcoxon signed-rank test based on the paired differences in discomfort levels for each device. We estimated agreement for temperature, latency, and volume at each site by calculating the intraclass correlation coefficient (ICC), using a one-way random-effects model based on the rank-transformed data. With this model, total variability in the rank ordering of the participants can be partitioned into participant-to-participant variability and device variability. The ICC can

therefore be interpreted as the proportion of total variability in rank ordering of the subjects that is due to participant-to-participant variability. When the ICC is near 1, most of the variability in the data is due to differences among participants; however, when the ICC is near 0, most of the variability is due to differences in the devices.

We estimated the relationship between Mayo-QSART and Q-Sweat at each site with a linear regression model utilizing the HC4-type heteroskedasticity consistent covariance matrix (HCCM), which adjusts standard errors to account for increasing variability at higher measurements.⁷ In order to assess whether prediction of QSART vol-

umes could be improved by taking into account other variables, we modeled the expected Mayo-QSART volume as a function of Q-Sweat volume, age, body mass index (BMI), temperature at the site, and latency at the site. To obtain a parsimonious model, we used backward stepwise elimination with criteria for retention set at $P = 0.10$ using the HCCM. No adjustments for multiple comparisons were made.^{8,9}

We used the intraclass kappa statistic to assess agreement between the two methods in terms of classifying patients as normal or abnormal according to the published norms table.³ This method was used over simple percent agreement, because

Table 2. Mayo-QSART and Q-Sweat summary statistics represented as median (minimum, maximum).

Measurement	Mayo-QSART	Q-Sweat	Paired difference*	P^\dagger
Temperature (°C)				
Forearm				
Men	32.6 (30.3, 34.0)	32.5 (30.2, 34.2)	-0.2 (-1.5, 2.5)	0.57
Women	31.9 (30.4, 33.6)	31.9 (30.0, 34.0)	-0.1 (-1.2, 1.1)	0.30
Proximal leg				
Men	32.2 (30.5, 33.6)	32.2 (30.1, 33.7)	0.0 (-2.0, 1.9)	0.84
Women	31.7 (30.0, 33.3)	31.6 (29.7, 33.1)	0.1 (-1.4, 1.6)	0.27
Distal leg				
Men	31.5 (28.9, 33.5)	31.6 (29.5, 33.0)	0.0 (-1.7, 1.6)	0.45
Women	31.0 (28.3, 33.6)	31.3 (29.0, 33.5)	-0.1 (-2.0, 1.1)	0.013
Foot				
Men	31.8 (27.9, 33.3)	31.5 (27.9, 33.3)	0.1 (-1.3, 2.0)	0.38
Women	31.1 (29.5, 33.8)	31.4 (28.9, 34.1)	-0.2 (-2.0, 2.0)	0.20
Latency (min)				
Forearm				
Men	1.5 (0.8, 3.1)	1.7 (1.0, 3.0)	-0.3 (-1.2, 0.5)	<0.001
Women	1.7 (0.8, 3.3)	2.0 (0.2, 3.5)	-0.3 (-1.3, 1.5)	<0.001
Proximal leg				
Men	1.2 (0.2, 2.6)	1.5 (0.7, 3.1)	-0.1 (-2.2, 0.8)	0.034
Women	1.4 (0.2, 2.4)	1.7 (0.2, 3.6)	-0.2 (-1.3, 1.4)	<0.001
Distal leg				
Men	1.4 (0.4, 3.1)	1.4 (0.4, 2.5)	0.0 (-1.6, 1.4)	0.97
Women	1.7 (0.2, 4.0)	1.7 (0.4, 3.6)	0.0 (-1.2, 0.9)	0.78
Foot				
Men	1.9 (0.2, 5.1)	2.5 (0.4, 5.2)	-0.4 (-2.7, 1.7)	0.013
Women	2.3 (0.2, 5.2)	2.8 (0.2, 5.3)	-0.3 (-3.2, 2.6)	0.094
Volume (μl)				
Forearm				
Men	3.2 (0.3, 7.3)	1.3 (0.3, 3.9)	1.8 (0.1, 5.1)	<0.001
Women	0.9 (0.1, 4.4)	0.5 (0.1, 2.4)	0.5 (-0.4, 3.0)	<0.001
Proximal leg				
Men	2.4 (0.8, 6.5)	1.3 (0.4, 4.0)	1.0 (-0.6, 4.0)	<0.001
Women	1.4 (0.2, 5.1)	0.8 (0.1, 2.4)	0.7 (-0.5, 3.2)	<0.001
Distal leg				
Men	3.6 (0.4, 7.8)	1.9 (0.3, 3.9)	1.8 (-0.3, 4.6)	<0.001
Women	1.7 (0.2, 6.5)	1.0 (0.1, 3.5)	0.6 (-0.1, 3.0)	<0.001
Foot				
Men	1.6 (0.1, 5.1)	0.8 (0.2, 2.5)	0.8 (-0.3, 4.1)	<0.001
Women	0.8 (0.1, 4.2)	0.4 (0.0, 1.5)	0.5 (-0.1, 3.4)	<0.001

*Mayo-QSART value minus the Q-Sweat value.

†Based on one-sample signed rank test.

kappa takes into account the agreement that occurs by chance. All analyses were performed using R (version 2.8.1) software.¹⁰

RESULTS

Participant demographics are summarized in Table 1. Women in this study tended to be younger than men (median age 28 vs. 48 years, $P < 0.001$), although age ranges were comparable. Based on within-subject paired differences, skin temperatures differed significantly between Mayo-QSART and Q-Sweat only at the distal leg among women, although this median difference of 0.1°C was not considered clinically meaningful. For both men and women, latency was shorter for Mayo-QSART at all sites except for the distal leg. Median paired differences ranged from 0.1 to 0.4 minute shorter for Mayo-QSART. Volume was significantly greater with the Mayo-QSART for both men and women at all sites. Median differences ranged from 1.8 μl for men in the forearm to 0.5 μl for women at the same site (Table 2). The median paired difference in discomfort was 0.0 ($P = 0.28$); the median discomfort was 4.0 for Mayo-QSART and 3.0 for Q-Sweat. To quantify agreement between the devices, we estimated the ICC based on rank-transforming the data. These results are shown in Table 3 and indicate sometimes poor agreement, particularly in volume estimates.

On the other hand, there was a linear relationship between Mayo-QSART and Q-Sweat volumes at all sites for both men and women, as illustrated in Figure 1. Supplementary Figures S1 and S2

illustrate the relationship between the devices for temperature and latency. Table 4 provides the least-squares intercept and slope estimate, a 95% confidence interval for the slope, and the P -value for testing whether the slope differs from the identity line of perfect agreement for temperature, latency, and volume. Least-squares point estimates for temperature and latency were all <1 , indicating a tendency for reduced temperatures and longer latencies for the Q-Sweat device. However, the 95% confidence intervals for slope for temperature in the distal leg and foot among men, as well as the slope for latency in the distal leg among men and women, included the value 1.0, indicating that the data were nevertheless consistent with a 1:1 relationship at some sites. On the other hand, least-squares estimates for volume were >1.0 in the forearm, proximal leg, and distal leg. The slope was significantly >1.0 for the proximal leg among women ($P = 0.001$), and for the distal leg among men ($P = 0.02$) and women ($P < 0.001$). In the foot, the least-squares estimate was 1.1 among men and 1.5 among women, neither of which differed significantly from the line of agreement. In multivariate modeling, the participant's BMI, site temperature, and site latency were not significant predictors of Mayo-QSART volume at the 0.10 level after accounting for Q-Sweat volume. However, among women, age significantly improved the prediction model in the distal ($P = 0.09$) and proximal ($P = 0.07$) leg. Table 5 provides prediction equations for estimating QSART volume given a patient's Q-Sweat volume. Approximate 95% prediction intervals can be obtained by adding and subtracting twice the root mean square error (RMSE).

A cross-classification table (Table 6) summarizes the number of healthy participants who would be diagnosed as normal using Mayo-QSART and abnormal using Q-Sweat collection methods and vice-versa. The table estimates the discordance rate between measures at the four sites to be: 18% (forearm); 18% (proximal leg); 12% (distal leg); and 22% (foot). The κ value was found to be 0.27 (forearm), -0.04 (proximal leg), 0.24 (distal leg), and 0.38 (foot), suggesting no agreement ($\kappa < 0$) in the proximal leg and fair agreement ($\kappa = 0.21$ –0.40) in the forearm, distal leg, and foot.¹¹

Volume measurements collected using the Q-Sweat device were used in the regression equations presented previously to estimate the Mayo-QSART volume. The corrected volume measures were then compared with published norms³; all volumes were found to be within normal limits. This

Table 3. Agreement as indicated by intraclass correlation of rank-transformed values.*

Measurement	Men	Women
Temperature		
Forearm	0.60 (<0.001)	0.73 (<0.001)
Proximal leg	0.50 (<0.001)	0.67 (<0.001)
Distal leg	0.74 (<0.001)	0.73 (<0.001)
Foot	0.76 (<0.001)	0.66 (<0.001)
Latency		
Forearm	0.47 (0.0011)	0.55 (<0.001)
Proximal leg	0.44 (0.0023)	0.34 (0.013)
Distal leg	0.59 (<0.001)	0.53 (<0.001)
Foot	0.21 (0.18)	0.36 (0.012)
Volume		
Forearm	0.19 (0.20)	0.38 (0.0052)
Proximal leg	0.29 (0.052)	0.46 (<0.001)
Distal leg	0.15 (0.33)	0.70 (<0.001)
Foot	0.33 (0.026)	0.22 (0.13)

*Numbers in parentheses indicate P -value for test of zero correlation.

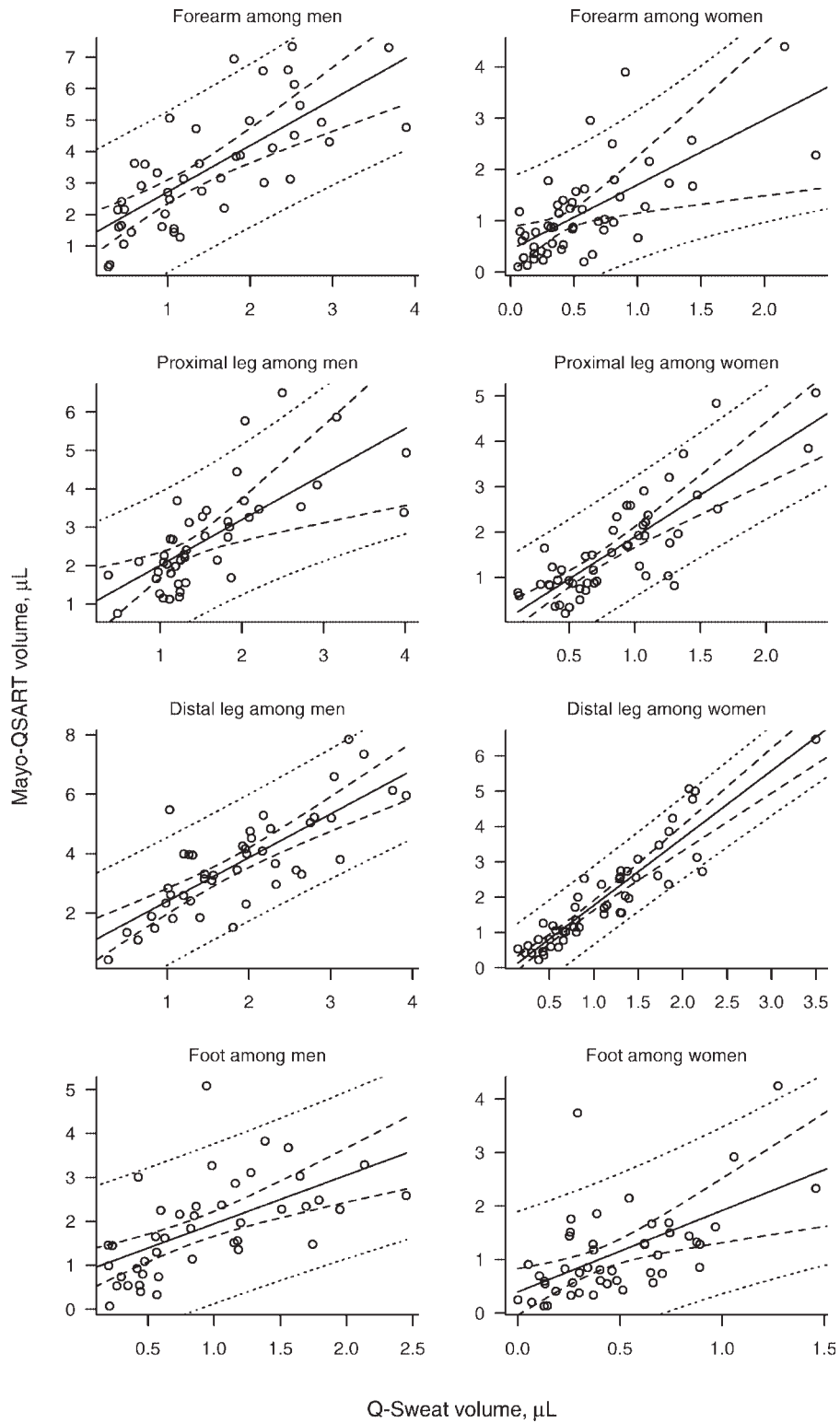


FIGURE 1. Mayo-QSART vs. Q-Sweat volumes (in microliters) for each regional site, separately for men and women. The least-squares regression line and 95% confidence intervals are indicated by solid and dashed lines, respectively. The dotted lines indicate a 95% prediction interval for the Mayo-QSART volume of an arbitrary patient given his/her Q-Sweat volume.

Table 4. Characterizing the linear relationships between Mayo-QSART and Q-Sweat separately for men and women.

Measurement	Intercept	Slope	95% confidence interval for slope	P*
Latency				
Forearm				
Men	0.408	0.589	0.26 to 0.92	0.02
Women	0.734	0.519	0.16 to 0.88	0.01
Proximal leg				
Men	0.541	0.526	0.064 to 0.99	0.04
Women	0.718	0.42	0.16 to 0.68	<0.001
Distal leg				
Men	0.489	0.65	0.2 to 1.1	0.10
Women	0.456	0.722	0.39 to 1.1	0.10
Foot				
Men	0.903	0.442	0.082 to 0.8	0.003
Women	1.41	0.395	0.072 to 0.72	<0.001
Volume				
Forearm				
Men	1.25	1.47	0.94 to 2	0.08
Women	0.435	1.27	0.32 to 2.2	0.60
Proximal leg				
Men	0.827	1.19	0.44 to 1.9	0.60
Women	0.0452	1.85	1.4 to 2.3	0.001
Distal leg				
Men	0.927	1.47	1.1 to 1.9	0.02
Women	-0.133	1.91	1.6 to 2.2	<0.001
Foot				
Men	0.841	1.11	0.63 to 1.6	0.70
Women	0.397	1.52	0.57 to 2.5	0.30

*Testing whether slope is significantly different from 1.0, the line of agreement.

would be expected, because the volume measures are being converted to the long-term average Mayo-QSART for all participants at a particular Q-Sweat volume, and prediction intervals around the regression are wide.

DISCUSSION

The main observation of this study is that there is a clear linear relationship between the volume estimates for the two devices as shown by the narrow confidence intervals about the mean (Fig. 1). This indicates that the Q-Sweat device faithfully measures the quantitative sudomotor axon reflex test sweat response. However, the slopes of these relationships were not consistently found to be near 1.0 for all sites. Instead, we found the estimated slopes to range from 1.1 to 1.9 across the four sites for both men and women, suggesting that Q-Sweat underestimates the QSART volume. We generated a formula that predicts Mayo-QSART from Q-Sweat. The regression is robust for all sites except the foot, where there will be a degree of

Table 5. Regression equations to predict QSART volume from Q-Sweat volume accounting for age when significant.

Endpoint	Regression equation	Model R ²	RMSE*
Forearm			
Men	1.25 + 1.47 × (Q-Sweat volume, in μL)	0.55	1.25
Women	0.435 + 1.27 × (Q-Sweat volume, in μL)	0.47	0.67
Distal leg			
Men	0.927 + 1.47 × (Q-Sweat volume, in μL)	0.62	1.04
Women	0.309 + 1.81 × (Q-Sweat vol, in μL) – 0.010 × (Age, in years)	0.86	0.54
Proximal leg			
Men	0.877 + 1.17 × (Q-Sweat volume, in μL)	0.51	0.92
Women	0.495 + 1.79 × (Q-Sweat volume in μL) – 0.012 × (Age, in years)	0.69	0.63
Foot			
Men	0.841 + 1.11 × (Q-Sweat volume, in μL)	0.35	0.89
Women	0.397 + 1.52 × (Q-Sweat volume, in μL)	0.33	0.71

*Root mean square error. Approximately 95% of QSART values can be expected to fall within 2 RMSEs of the regression line.

uncertainty when translating a Q-Sweat estimate to a Mayo-QSART volume for an individual patient as shown by the wide prediction intervals. The optimal approach for Q-Sweat users is to use the Q-Sweat-generated normative database directly.

There are a number of variables to be considered. The studies comparing these two devices were done on identical participants, and the design and results of the study exclude any confounding factor due to gender, age, or side tested. Tight control of room and limb temperatures excludes any potential effects that may contribute to temperature differences. Multicompartmental sweat cell design and ACh concentration are

Table 6. Agreement between Q-Sweat and Mayo-QSART on whether a sweat volume is abnormal.

Site	Q-Sweat result	Mayo-QSART result		Kappa
		Normal	Abnormal	
Forearm	Normal	73	0	0.27
	Abnormal	17	4	
Proximal leg	Normal	77	2	-0.04
	Abnormal	15	0	
Distal leg	Normal	80	0	0.24
	Abnormal	11	2	
Foot	Normal	61	0	0.38
	Abnormal	20	9	

identical. Both devices have been well-calibrated to accurately measure the volume of sweat response.

Because there is no difference due to capsule design, skin temperature, ACh concentration, and recording fidelity, the remaining variable is that of stimulator efficiency. Both stimulators are designed to deliver 2 mA. However, the actual current delivered and the efficiency of delivery depends on the characteristics of the stimulator, return electrodes, and the skin resistance of the participant. The longer latency and lower volumes of the sweat response generated using the typical Q-Sweat setup supports the notion that stimulation using Life-Tech current generators results in less efficient ion delivery. However, an argument against stimulus strength is the perception of the same degree of participant discomfort in response to Life-Tech and Mayo-built stimulators. Stimulus strength is a critical issue. A stimulus strength >20 mA will electrically evoke an axon reflex sweat response,¹² but it is quite painful. We chose a concentration of ACh and stimulus strength that is adequate but either not painful or only minimally painful. It is known that these stimulus conditions can result in a subthreshold stimulus in the occasional participant with high skin resistance, especially the female forearm site.³ The most parsimonious explanation is that there is a difference in the efficiency of ion delivery between the Mayo-built constant-current generator and the commercially available unit, and that carbonized rubber electrodes used in conjunction with Q-Sweat results in lower current delivery.¹³ Clearly the mechanism of difference is unknown at this time. Particularly, because of some uncertainty with estimates of lower volumes, it would be ideal for each laboratory to generate its own normative data set; however, knowing this may not be feasible, we provide a method to convert Q-Sweat to Mayo-QSART val-

ues. Common-sense judgment must be used when applying these equations to the data.

This research was supported by research funds from the NIH (NS3 2352, NS4 4233, NS4 3364, UL1 RR24150) and the Mayo Clinic. Dr. Low is a consultant to WR Medical.

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