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Promotion of Palmar Sweating with Oral Phosphatidylcholine

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Since acetylcholine is the main neurotransmitter of eccrine sweating, phosphatidylcholine ingestion might increase sweating. In 10 adults mid-palmar sweating was measured 12 hours after ingestion of a high and a low phosphatidylcholine supper. In a double blind, crossover study, mid-palmar sweating was measured in 11 consenting adults 12 hours after a low phosphatidylcholine supper taken with either lecithin or placebo. Five minutes after cleaning the palm and drying, sweat was captured in a quick-drying plastic film. The film was removed with cellophane tape and placed on a glass slide. Mean "droplet" diameter was measured by averaging the greatest diameter of 25 "droplets." Ten of 10 subjects (100%) produced more sweat with a high phosphatidylcholine meal than with a low one. Compared to placebo, 10 of 11 subjects (91%) given lecithin had significantly increased sweat secretion ($p<0.01$). It remains to be confirmed that this phosphatidylcholine-induced sweating increase is clinically significant. *Key words: Sweat, Lecithin.* (Received March 1, 1984.)

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Acetylcholine is generally considered to be the major neurotransmitter responsible for the stimulation of eccrine sweating when the sympathetic secretory innervation of eccrine sweat glands is activated. This eccrine sweat secretory response can be blocked with atropine and augmented by cholinesterase inhibitors. Moreover, Clubley et al. (1) neatly quantitated the stimulatory effect of intradermal injection of acetylcholine on sweat production by the method of Thomson & Sutarman (2), using a quick drying plastic impression taken by painting a suspension containing polyvinyl formal, butylphthalate, ethylene dichloride, and graphite on the skin and removing it in entirety after about 30 sec.

Hirsh et al. reported that the oral ingestion of lecithin more effectively elevates serum free choline, and brain choline than does ingestion of choline directly (3). Such increased choline levels appear to elevate brain acetylcholine (4, 5). Moreover, there is evidence suggesting that choline administration enhances acetylcholine release from nerve endings in the brain (3). We have, however, not found any literature on whether oral ingestion of lecithin can affect peripheral nervous system function.

Lecithin is a common dietary constituent whose concentration is high in eggs, liver, meats, peanuts, and many grains and quite low in most vegetables and fruits (6). The term "lecithin" compasses a variety of naturally occurring phosphoglycerides which contain choline called phosphatidylcholines (7). Because it was considered likely that oral phosphatidylcholine can elevate acetylcholine levels and promote its release throughout the nervous system we undertook this study to determine whether such lecithin ingestion can increase sweating.

MATERIALS AND METHODS

Eleven adults, ten white and one oriental, were studied. The research was carried according to the principles of the Declaration of Helsinki. The proposed study was fully explained to each subject and written consent was obtained. This study was approved by the Clinical Investigations Committee of the University of Chicago Hospitals and Clinics. There were eight males ranging in age from 24 to 65 years with a mean of 39.2 years. The three women were ages 34, 42 and 49 years with a mean of 41.6 years. Two subjects had an atopic diathesis without significant cutaneous involvement. One had mild psoriasis covering less than 3% of his body surface. No patients were using any topical therapy at the time of the study. No dosage of any medication taken was changed during the study. Written informed consent was obtained from each subject after the nature of the study procedures had been fully explained.

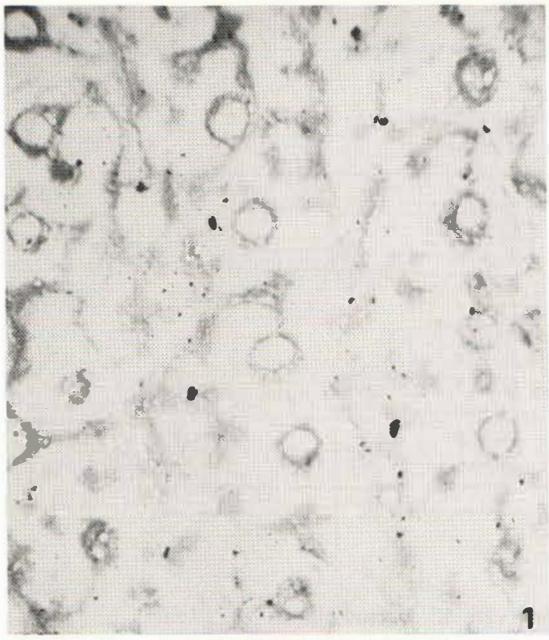
On four different days each subject was told to eat the same size lunch (containing approximately 500 mg of phosphatidylcholine (6)) consisting of a sandwich with no more than one-quarter pound of meat with optional vegetable (no cauliflower, kale, or peanuts were permitted) and/or potato plus no more than one glass of milk. Unlimited juice or soft drinks were permitted but no liquor. The supper the same day was to be taken at sometime between 8 and 11 p.m., though at roughly the same time on each test day. Three suppers consisted of no more than one-quarter pound of meat or fish with optional vegetable (again no cauliflower, kale or peanuts) and/or single potato plus no more than one glass of milk. Unlimited amounts of fruit juice or soft drinks were permitted but no beer. These suppers also contained approximately 500 mg of phosphatidylcholine. In addition, two of the suppers for each subject included 30 cc of substances labeled "A" or "B" prepared by a party not directly involved with the experiment. These substances were prepared to have approximately the same taste, color, and consistency. Substance A consisted of: starch 118 g, carboxymethyl cellulose 2 g, ethanol (95%) 40 ml, sterile water 72 ml, cherry syrup 120 ml, multivitamin syrup (for color) few drops/360 ml. Substance B consisted of powdered Lecithin, 95% pure containing 35–40% phosphatidylcholine (Gides-Nu-life, Inc., Long Beach, Calif.) in a concentration of 5.8 g/30 ml mixed as follows: Lecithin (120 ml) 70 g, carboxymethyl cellulose 2 g, ethanol (95%) 48 ml, Sterile Water 72 ml, cherry syrup 120 ml/360 ml. The fourth supper consisted of ½ to ¾ pounds of steak or hamburger and two to three eggs with a glass of beer. This meal was supplemented with an additional vegetable and starch as desired and contained at least 3 g of phosphatidylcholine. The four test suppers were ingested in a randomized order. No snacking was permitted.

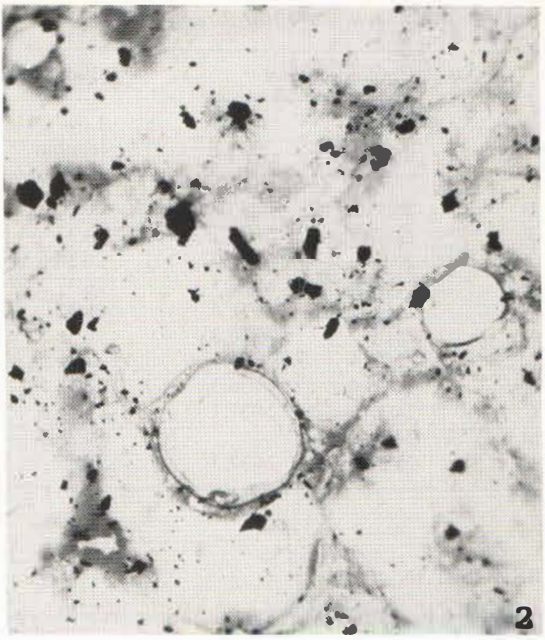
The morning after each test meal the subjects were placed in windowless rooms at a predetermined time, between 8 and 10 a. m. (about 12 hours after the meal was ingested). The subjects were seated in the same location each time and room temperature maintained as constant as possible for all the test periods. Oral temperatures were taken. Next, each subject's palm was cleansed with 70% alcohol and dried with gauze or cotton. Five minutes later (modifying the method of Thomson & Sutarman (2)) holes produced by sweat droplets were captured in a quick drying plastic film obtained by painting a 1×1 inch section of palmar skin with a formulation containing 3 g Polyvinyl Formal (Aldrich Chemical Co.), 1 g of Butyl Phthalate (Fisher Scientific), and a small quantity of a suspension made from graphite powder (Grade no. 38, Fisher Scientific) in ethylene dichloride (Fisher Scientific). The above mixture was diluted with additional ethylene dichloride to 100 ml. When dry, the film was removed with a clean piece of cellophane tape which in turn was pressed onto a glass slide.

Twenty-five droplets on each slide were measured microscopically using a calibrated eye piece and the 10× objective lens. Care was taken to measure only round or oval spots that were regularly spaced on the ridges of skin markings so as to lessen the likelihood that air bubbles and other artifacts were being measured (Figs. 1, 2 and 3). The mean hole diameter was calculated for each slide. Five 10× fields on each slide were viewed, the number of holes per field was counted and the mean number of droplets per field was calculated. All of these procedures were performed before the code was broken.

RESULTS

As seen in Table I, during the course of the study, the temperature of the room used for each patient remained relatively constant and each subject's oral temperature did not change. Table II compares sweat droplet size following meals of known high and low phosphatidylcholine content. Table III compares droplet size after meals whose phosphatidylcholine content was unknown both to subject and to investigator. Where the phosphatidylcholine content was known, sweating was greater in 10 of 10 subjects studied after the





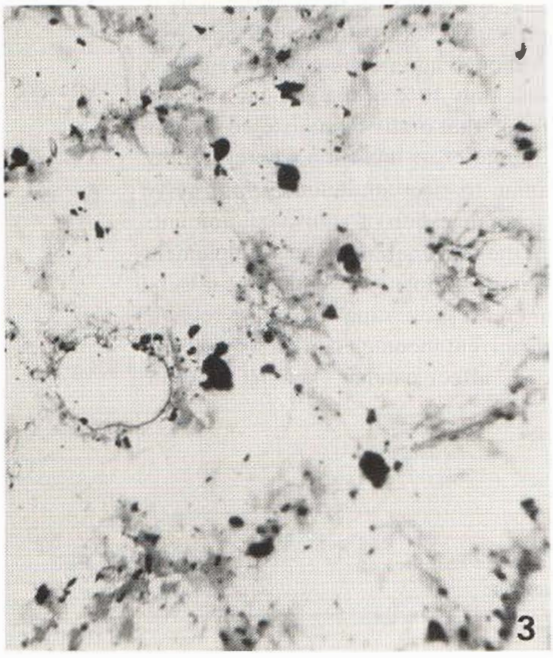


Fig. 1. Holes made by sweat droplets regularly spaced on the ridges of skin markings (×40).
Fig. 2. Holes made by sweat droplets in plastic film after high lecithin meal (×100).
Fig. 3. Holes made by sweat droplets in plastic film after low lecithin meal (×100).

high phosphatidylcholine containing meal than after the low phosphatidylcholine meal (one patient did not eat the high phosphatidylcholine meal). More significant was that in the double blind study, sweating was greater in 10 of 11 subjects after high phosphatidylcholine intake than after low ($p<0.01$ (Wilcoxon signed rank test for pair difference)). Table IV compares the numbers of holes found per 10× field. In the double blind crossover study the $p>0.05$.

Table I. *Room temp. (°C)/oral temp. (°C)*

Patient	Unblinded meal		Blinded meal	
	Low lecithin	High lecithin	Low lecithin	High lecithin
RD	20/35.8	20/35.8	20/36.5	20/36.5
BT	22/37	24/37	24/37	24/36.7
DA	26/35.9	26/36.7	26/36.6	26/36.6
RS	24/36.9	24/36.7	26/37.2	23/36.9
YJ	24/36.7	24/36.8	26/37	23/37.1
PA	26/36	26/36.3	26/36.3	26/36.3
RM	21/36.4	21/36.5	21/36.5	21/36.4
PS	17/36.4	18/36.3	18/36.5	17/36.5
CC	24/37.6	24/37.1	24/36.8	24/36.9
PM	24/36.7	–	24/36.7	24/37.6
RE	24/37.0	24/37.5	24/37	24/36.6

DISCUSSION

Although postganglionic sympathetic nerve fibers innervate all eccrine glands (8), sweating on the palms and soles is mainly stress-related while sweating over most of the body is primarily stimulated by heat (8, 9, 10) (temperatures <10°C and >46°C abolish stress-related sweating even on the palms and soles (11)). Although adrenergic mediators have a clear effect on sweat secretion they quantitatively cause only 10% of the amount of sweat stimulated by acetylcholine (9). Hirsch et al. (1978) found that orally administered choline chloride causes a peak rise in serum free choline 30 min after its ingestion whereas orally administered phosphatidylcholine causes serum choline to rise continuously for twelve hours to levels higher than the maximums obtained from ingestion of equivalent amounts of choline (3). Thus, if diet can affect sweat secretion, the most potent dietary supplement providing a source for cholinergic sweating through neural stimulation would appear to be phophatidylcholine. If phosphatidylcholine indeed increases sweating, the most reliable time to measure short term sweating as gathered from current incomplete data would be at twelve hours after its ingestion (5). Temperature does affect palmar sweating to some

Table II. *Droplet diameter in unblinded study*

Patient	After low lecithin meal (mm)	After low lecithin meal (mm)	% increase
RD	0.646	1.286	99.1
BT	0.672	0.960	42.9
DA	0.648	0.952	46.9
RS	0.614	0.794	29.3
YJ	0.728	0.814	11.8
PA	0.798	1.396	74.9
RM	0.722	1.086	50.4
PS	0.814	1.128	38.6
PM	0.799	–	–
RE	0.636	0.956	50.3

Table III. *Mean droplet diameter in blinded crossover study*[a]

Patient	After low lecithin meal (mm)	After low lecithin meal (mm)	% increase
RD	0.806	1.144	41.9
BT	1.128	1.258	11.5
DA	0.906	0.858	-5.3
RS	0.8872	1.140	30.7
YJ	0.836	0.906	8.4
PA	1.668	2.288	37.2
RM	1.518	1.808	19.1
PS	1.004	1.196	19.1
CC	0.830	0.946	14.0
PM	1.004	1.010	0.6
RE	0.936	1.032	10.3

[a] Wilcoxon test (for pair difference). $N=11$, $p<0.01$. Two-sided test.

degree (9), and so as best as possible was kept at a constant for each patient. Several rooms were used for this experiment and over the temperature range studied (17°C to 26°C) phosphatidylcholine continued to promote sweating.

Women generally sweat less than men (9). Subcutaneous acetylcholine injection produces a weaker response in women than in men (9). Therefore, it is not surprising that the subjects in whom lecithin promoted the least sweating were women although we note that the third female subject showed an above average increase for the group tested.

Phosphatidylcholine in this study caused no noticeable increase in the number of active sweat glands whereas acetylcholine injection has previously been shown to do so but such studies were performed on skin which dominantly has heat and not stress controlled eccrine secretion (1, 11). Temperature induced sweating on most body areas increases first by maximizing the number of active sweat glands (1, 2, 10). With further rises in temperature sweat production from each gland increases (1, 10). In contrast, sweat production on the palms and soles is continuous by all glands so increasing stimulation

Table IV. *Mean number of sweat droplets per 10×hpf (5 fields measured)*

	Unblinded study		Blinded study	
Patient	Control	Lecithin	Contol	lecithin
RD	9.2	16.8	10.6	15.4
BT	6.4	9.4	11.8	14.2
DA	12.2	14	16.2	14.8
RS	10	8.8	9	8.2
YJ	11	10	11	10
PA	12.2	9.6	11.2	9.2
RM	12	12.6	14.8	10.2
PS	13.4	12.4	14.6	13.6
CC	10	10.8	11	10
PM	9	–	9	10.5
RE	10	8.8	8.4	9.4

[a] $N=11$, $p>0.05$ for blinded study. (Wilcoxon test for pair difference).

from whatever source merely increases the sweat produced by each gland with the number of active glands remaining constant (8, 11).

Our results suggest that orally administered phosphatidylcholine administered in a pharmacologic preparation or by diretary means does increase palmar sweat production. According to the rule of Cannon, denervated tissues have increased responsiveness to local injections of neurotransmitter. Denervated eccrine glands, however, show a decreased responsiveness. This has been explained by the presence of a hypothetical substimulatory tonus or priming tonus of acetylcholine supplied to the sweat glands by innervation. According to this hypothesis, denervation abolishes this tonus level leaving eccrine glands less sensitive to neurotransmitter substance and thereby increasing the level of acetylcholine required to stimulate sweating. If this type of substimulatory tonus exists, then the accessible amount of acetylcholine present in an eccrine nerve ending might be rate limiting during a low or possibly even a basal level of palmar sweating, if indeed the latter is a valid concept (12). Palmar sweating is primarily emotional sweating and being so it changes drastically from moment to moment. We recognize that the holes we measured reflect only 10 to 20 sec of actual sweating. This brief period of study, however, is valid because both experiments which we performed were carefully controlled and one was also double blind. To minimize the effect of emotional variation we studied eleven subjects, each of whom was measured in precisely the same manner during each test day and that measurement was taken after a period of a least five minutes of physical rest with the subject concentrating on keeping one hand immobile. Of course, the holes measured in this study cannot be used to accurately quantify changes in sweat production, nevertheless, the method is adequate to confirm that such changes have occurred. More refined technology will be needed to show whether oral phosphatidylcholine can increase sweating over a clinically significant period.

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