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The Antiperspirative Effect of the Silicon Socket：A Qualitative Study

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In clinical prosthetic experience, profuse sweating was a major problem when conventional sockets or inserts were used. However, the newly developed silicon suction socket could prevent that. We doubted that these differences came from the different nature of the silicon, pelite and polyethylene. So using the starch iodine sweating test, the forearm skins of the twenty normal subjects were sealed with a piece of 2cm × 2cm × 0.3cm silicon, pelite or polyethylene respectively. Surprisingly, not only silicon but also pelite and polyethylene could inhibit sweating. This meant that decreased sweating of the silicon suction socket might not be due to the chemical property of the silicon, instead, due to the little amout of the dead space between the silicon socket and skin. In other word, the more intimate sealing existed between the socket and skin, the less sweating. This was the reason why conventional inserts, made of pelite or polyethylene, could not prevent sweating clinically though, they did decrease sweating under the experimental intimate sealed situations. In addition, the quantitative sweating test will be applied in the further related studies because the starch iodine sweating test is qualitative only. (J Rehab Med Assoc ROC 1998; 26(1): 29-33)

Key words: silicon suction socket, sweating, hidromeosis

INTRODUCTION

In hot and humid areas, patients with amputation suffer from excessive sweating which may produce a foul smelling over the skin of the stumps. Therefore good hygiene is especially important for them to prevent skin lesions . The commonly used sockets with or without soft inserts can not avoid profuse sweating. Therefore, amputees need to change their socks frequently, sometimes two or three times daily in a hot weather. However, a recently developed silicon suction socket (3S) [1,2] can provide good control of sweating and has perfect suspension. To our knowledge no research has provided evidences the reason why the stumps become anhidrosis when amputees wear the silicon suction sockets. The present study was designed to clarify the possible mechanism. Is it coming from the specific chemical

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property of the silicon or is it any other mechanical factor existed ?

SUBJECTS AND METHODS

Twenty healthy subjects, 9 males and 11 females, were included in this study. The mean age was 37±8.4 years old; the range, from 10 to 72 years old.

At room temperature 20-25°C, with a relative moisture of 60-80%, each subject received these following procedures: (1) To clean the skin of the extensor sides of both forearms with alcohol cotton; (2) To draw a rectangle 2cm × 8cm over the cleaned skin in each forearm, making one 2cm × 2cm block in the center of the rectangle; (3) To paint that skin with mixtures of glycerol and 2% iodine tincture (2:1 ratio), and allow to dry; (4) To put 2cm × 2cm × 0.3cm sized silicon and pelite over the center of the marked skin of the right and left forearms respectively, and sealing the application tightly with 3M tape (Fig. 1). (5) To induce perspiration via exercise, e.g. jogging or jumping for more than 10 minutes; (6) After sweating, remove the covering material from the skin and spray the corn starch powder evenly over the area. Then observe the color changes and record them with a camera; (7) Repeating all the above procedures again with other three sets of materials: (a) polyethylene and rubber (b) smooth and uneven silicon, (c) smooth and uneven polyethylene.

RESULTS

All subjects showed consistent features: decreased perspiration over the skin covered with silicon and, more surprisingly, also decreased sweating over the skin covered with pelite, polyethylene and rubber (Fig. 2). By naked eye, there were nonsignificant differences in perspiration among the decreased sweating areas which were covered with any of the four different materials. Furthermore in repeating the procedure with smooth and uneven silicon and polyethylene, intermingling patterns were found (Fig. 3, Fig. 4). That is, under the covered areas, some showed decreased sweating but others not, depending on the geographic feature and the degree of sealing intimacy of the contact interface.

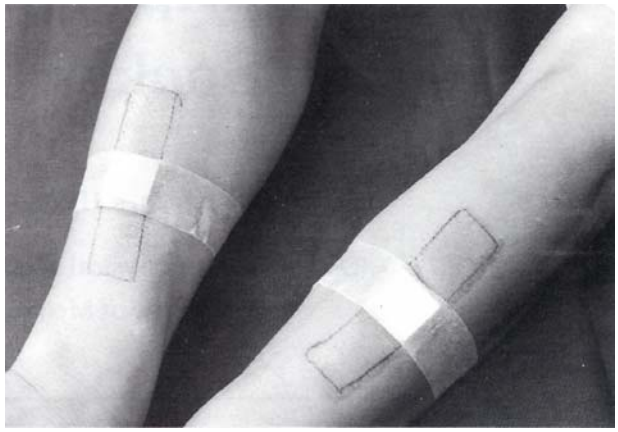

Fig. 1. Before exercise to induce sweating, placing a 2cm × 2cm × 0.3cm-sized silicon and pelite over the skin of right (silicon) and left (pelite) forearms respectively then sealing tightly with 3M tape.

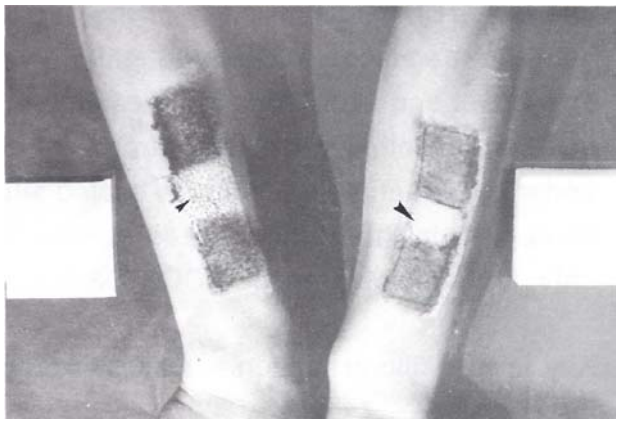

Fig. 2. Using starch iodine test, decreased sweating was noted over the right forearm skin (small arrow), which was covered with silicon. More surprisingly, decreased sweating was also found over the skin of the left forearm (big arrow), which was covered with pelite.

DISCUSSION

Generalized sweating is the normal response to exercise or thermal stress to control body temperature through evaporative heat loss [3]. The secretory functions: (1) secretion of an ultrafiltrate of a plasma- like choline

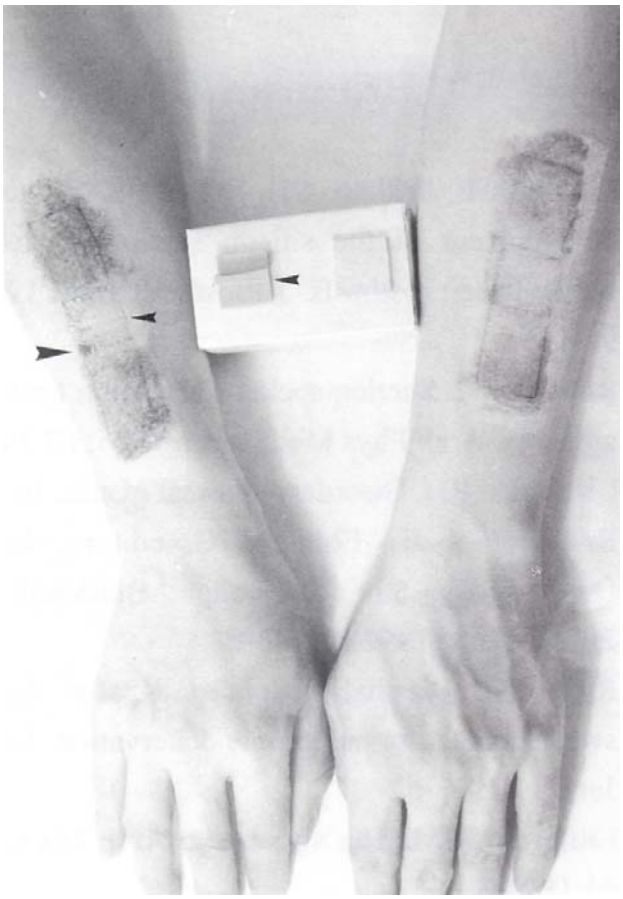

Fig. 3. Comparing the inhibiting effect on sweating between smooth and uneven silicon, intermingling pattern was noted over right forearm (small arrow, skin), which was covered with uneven silicon. Meanwhile, the intermingling pattern was correlated with the geographic feature of the uneven surface of the silicon (small arrow at silicon). In addition, sweating was also increased at the boundary of silicon and naked skin (big arrow), another evidence that uneven sealing could not inhibit sweating.

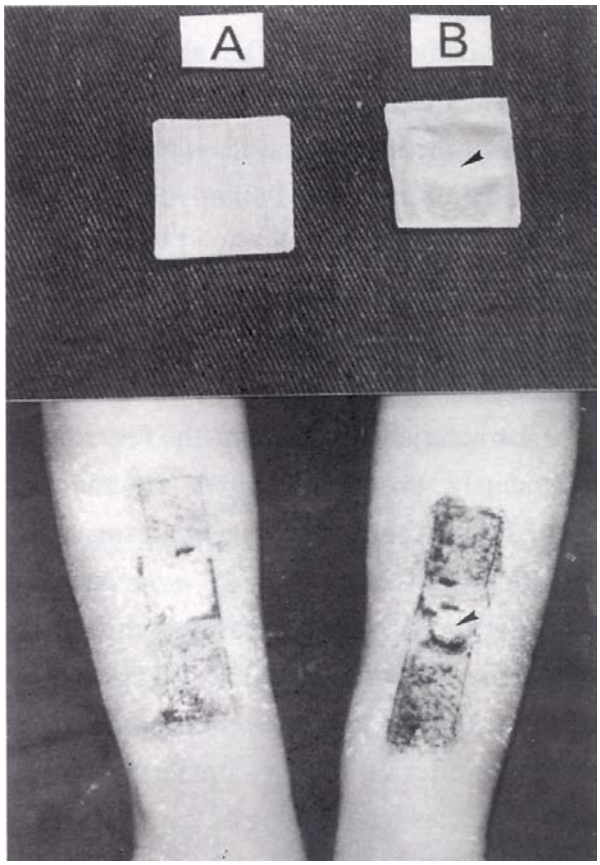

Fig. 4. Comparing the inhibiting effect on sweating between smooth (A) and uneven (B) polyethylene.
Note: intermingling pattern (lower arrow) was again correlated with the geographic feature of the uneven surface of the polyethylence (upper arrow).

released from the sympathetic nerve endings; (2) reabsorption of sodium in excess of water by the duct, thus producing a hypotonic skin surface sweat [3].

In hot and humid climates, profound sweating of the soles may create a foul odor. The same is true for stump-socket interface of amputees. It is not unusual for amputees to need to change socks many times per day. However, this can be avoided when the newly-developed silicon suction socket, which makes the skin dry, is used. The reasons are unknown. This may be the result of inbibition of the secretion of the plasma-like precursor fluid in the secretory coil, as it blocks the neurotransmitters such as acetylcholine [4], which initiates the sweating process, or it may block the outlet of the eccrine glands. The answer is uncertain.

There are many methods [3-7] to evaluate sweating, some are qualitative but some, quantitative. Starch iodine test is a long-used, simple qualitative method [3]. Some modified starch iodine tests were considered as the semiquantitative method [7].

The study results showed that sweating decreased not only over the skin covered with silicon, but also decreased over the skins sealed with pelite, rubber or polyethylene. Surprisingly this is quite different from the clinical features. If the skin was covered with unevenly

surfaced silicon or polyethylene, an intermingled sweat pattern could be demonstrated. The above results proved that mechanical block of the sweating gland outlet could be responsible for the decreased sweating when wearing the silicon suction sockets. Pelite, rubber, polyethylene can seal the skin completely by 3M tape in experiment; however, these materials can not keep persistent contact with skin clinically. That is why these materials could inhibit sweating experimentally, but not clinically.

Characteristically when the eccrine sweat gland continuously produce copious volumes of sweat for several hours, the rate of sweating progressively declines. Reduction of sweating may be associated with sustained wetting of the skin, since hydrating the stratum may result in reducing sweating, so called "hidromeosis" [8]. Randall and Peiss showed that a reversible anhidrosis occurred in the fingers after 30 minutes immersion in warm water [9]. So hidromeosis may be one of the reasons for obstruction of the eccrine sweat glands. There may be other inhibitory factors such as pressure, heat et cetera, but this needs further studies.

CONCLUSION

Clinically, when amputees wear a silicon suction socket, their stumps are dry. That may not be due to the silicon's effect, rather may come from a mechanical obstruction effect, because silicon has a property of persistently and completely sealing with the skin. Though decreased sweating is also found by use of other materials (pelite, polyethylene, rubber) under experimental conditions, they can not inhibit sweating clinically because the sockets or inserts made of such materials cannot always maintain tight contact with the skin.

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矽膠套筒抗流汗效應之定性研究

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傳統的義肢套筒及內套是由聚乙醚，聚乙烯，聚丙烯或特製海綿 (pelite) 等材料做成的，當患者穿戴著這些傳統義肢在走路或操作日常生活時，常常會因流汗而使殘肢味道難聞，但最近發明的以矽膠爲內套之矽膠吸入型套筒 (silicon suction socket) ，則反而可以減少殘肢的流汗。究竟是什麼因素使矽膠減少患者殘肢皮膚之流汗？是矽膠本身的化學特性使然，抑或是矽膠所產生之機械效應引起的？因此，本研究乃針對上述問題，找來二十位健康受試者，其中男性 9 位與女性 11 位，年齡從 10 歲到 72 歲，平均 37±8.4 歲。每位受試者的前臂都要塗上甘油碘酒 (2：1)混合液，然後分梯次用 3M 膠布貼上下列物質(每種物質的大小都是 2×2×0.3cm 的薄方塊)：(1)第一梯次：右前臂矽膠方塊，左前臂特製海綿方塊；(2)第二梯次：右前臂聚乙烯方塊，左前臂橡膠方塊；(3)第三梯次：右側平面矽膠方塊，左側凹凸面矽膠方塊；(4)第四梯次：右側平面聚乙烯方塊，左側凹凸面聚乙烯方塊。然後要受試者慢跑十到二十分鐘直到流汗爲止。接著取下上述物質，將澱粉平均灑在前臂上，立即觀察顏色變化情形，並拍照存證。

實驗結果顯示不但貼矽膠方塊的皮膚流汗減少，更令人意外的是連貼特製海綿、聚乙烯及橡膠的部份也會減少流汗。此外，平面方塊的止流汗效應遠比凹凸不平面方塊之止流汗效應爲佳，因此吾人的結論是止流汗效應與物質的物性無關，而與上述物質經緊密黏貼之後所產生的機械效應有關。

而臨床上爲何只有矽膠製成的義肢套筒才有止汗效果呢？主要是因爲矽膠製成之內套可與皮膚產生完全密合的機械效應，而其它物質如特製海綿、聚乙烯或聚丙烯等，則在實際的日常環境裡沒有辦法與皮膚維持無時無刻密合的效果，因此無法有效地阻止流汗。本研究的缺點則是沒有使用定量方法來測流汗的程度，而僅使用定性的碘酒澱粉反應，此乃是後續研究極需要改進的地方。(中華復健醫誌 1998; 26(1): 29-33)

關鍵詞：矽質吸入型套筒(silicon suction socket)，流汗(sweating)，流汗平衡(hidromeosis)

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