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Short communication

Aluminium in human sweat

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ABSTRACT

It is of burgeoning importance that the human body burden of aluminium is understood and is measured. There are surprisingly few data to describe human excretion of systemic aluminium and almost no reliable data which relate to aluminium in sweat. We have measured the aluminium content of sweat in 20 healthy volunteers following mild exercise. The concentration of aluminium ranged from 329 to 5329 μg/L. These data equate to a daily excretion of between 234 and 7192 μg aluminium and they strongly suggest that perspiration is the major route of excretion of systemic aluminium in humans.

Introduction

Humans are experiencing a burgeoning exposure to aluminium with concomitant effects upon the body burden [1]. The latter is the sum of all aluminium associated with the internal and external body at any one time and is significantly influenced by excretion. Currently it is assumed that urine is the major route for excretion of systemic aluminium with up to 100 μg being excreted daily [1]. Recent data have suggested that perspiration might be a significant route of excretion of systemic aluminium [2,3]. Data on the aluminium content of sweat are, nevertheless, rare and range from as little as 15 μg/L [4] to in excess of 5000 μg/L [2]. Since humans produce anything from between 0.5 and 4.0 L of sweat per day [5,6], often depending upon the level of physical activity, then perspiration could represent a significant and largely ignored route of excretion of aluminium from the body. Herein we have collected samples of sweat from 20 healthy volunteers and measured their content of aluminium. The data point towards perspiration as a significant route of excretion of systemic aluminium in humans.

Materials and methods

Twenty participants, 10 male and 10 female (age range 20–23) were recruited from the student population at Keele University and ethical approval was obtained from the University's Life Sciences Ethical Review Body. All participants were self-assessed as healthy and agreed to partake in moderate exercise as part of the procedure for collecting sweat samples. Sweat was collected using a bespoke device made from a 5 cm × 5 cm square of filter paper (Whatman's 541 hardened ashless) covered with a polythene patch and secured on the skin with transparent medical tape. Before use the squares of filter paper were rinsed in 5% high purity HCl (Aristar) for 1 h, soaked in ultrapure water (conductivity < 0.067 μS/cm) for 24 h and dried in an incubator. To collect sweat an area between the shoulder blades was cleaned with 50% ethanol and the patch secured in place. Participants completed 30 min of exercise on a training bicycle which consisted of 5 min of fast cycling on either side of a 20 min period of moderate cycling. Participants then observed a cool down period of 10 min before the patch was removed and placed immediately in an acid-washed centrifuge tube. Sweat was extracted from the filter paper by centrifugation at 5000 rpm for 10 min and poured into an acid-washed centrifuge tube and stored frozen at −18 °C. The volumes of sweat collected using this method ranged from *ca* 0.3 to 1.0 mL. Method blanks which consisted of the same squares of filter paper to which 1 mL of ultrapure water had been added were similarly centrifuged and the extracted solution stored frozen in acid-washed centrifuge tubes. These method blanks [7] were estimates of contamination by extraneous aluminium of the procedure used for collecting and processing the sweat.

Samples of sweat (and method blanks) were thawed and 0.25 mL volumes were subjected to microwave-assisted digestion using a combination of 0.25 mL 15.8 M HNO_3 and 0.25 mL 30% w/v H_2O_2. Digests were clear and made up to 1.25 mL (20% HNO_3) with ultrapure water. The aluminium content of all sweat samples and method blanks was measured by transversely heated graphite furnace atomic absorption spectrometry (TH GFAAS) using an established method [7]. The mean aluminium content of 7 method blanks was 25 ± 19 ng which equated to a contamination level of 57 ng/digest (mean ± 1.654 SD) and this value was subtracted from each sweat sample before the aluminium content of sweat samples

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Table 1
The aluminium content of sweat excreted by healthy volunteers during mild exercise.

Sample ID.	Gender	Age year	[Al] Sweat μg/L	Al Excreted μg/24 h*
1	F	22	1737	1237
2	F	20	624	444
3	F	21	1727	1230
4	F	21	486	346
5	F	20	2925	2083
6	F	20	1307	931
7	F	20	586	417
8	F	20	333	237
9	F	21	329	234
10	F	20	569	405
Mean (SD)			1062(849)	756(605)
11	M	20	1748	2346
12	M	20	368	494
13	M	20	1204	1616
14	M	23	329	442
15	M	21	555	745
16	M	22	1161	1558
17	M	20	333	447
18	M	22	1097	1472
19	M	20	5359	7192
20	M	22	908	1219
Mean (SD)			1306(1498)	1753(2011)

* Aluminium excreted over 24 h is based upon literature values for sweat production of 712 and 1342 mL/24 h for females and males (age range 18–24) respectively [6].

were calculated. Data for the aluminium content of 20 samples of sweat (Table 1) were not normally distributed and where appropriate Mann–Whitney U was used to test significant differences between groups.

Results and discussion

The concentration of aluminium in sweat for 20 (10 male and 10 female) healthy volunteers of average age 21 ranged from 329 to 5329 μg/L (Table 1). The mean aluminium content was higher in males (1306 ± 1498 μg/L) than females (1062 ± 849 μg/L) though the data for each group were not found to be significantly different from one another ($P > 0.05$). The volume of sweat collected ranged from 0.3 to 1.0 mL and corresponded well with literature values for perspiration rates [8]. The method blanks demonstrated a very low level of possible contamination by aluminium and were within the range of a previous study [7]. The latter demonstrated a high degree of confidence in the concentrations of aluminium measured herein which were towards the higher end of previous literature values. The values reported herein may be an underestimate of actual aluminium excretion as future research will need to test if the filter paper which was used to collect sweat in our study released aluminium from sweat proportionately during the centrifugation procedure, *i.e.* could some of the aluminium collected with the sweat have been retained by the filter paper? When the concentrations of aluminium in collected sweat were adjusted to take account of the volume of sweat produced by men (1342 mL/24 h) and women (712 mL/24 h) in this age range [6] and undergoing mild exercise the amount of aluminium excreted over 24 h ranged from 234 to 2083 μg/24 h for women to 442–7192 μg/24 h for men (Table 1) with men excreting significantly more aluminium than women ($P < 0.05$). These data are significantly higher than those that describe the daily excretion of aluminium in urine, up to 100 μg/24 h [1], and therefore they heavily implicate sweating as the major route of excretion of systemic aluminium in humans. In doing so they suggest that men, through perspiration, excrete aluminium from the body more effectively than women and they suggest that regular exercise might be a way to increase the excretion of aluminium from the body. If sweating is the major route for the removal of systemic aluminium from the body then this observation puts into question the practice of disrupting or blocking perspiration using antiperspirants and aluminium-based antiperspirants specifically [9,10].

Conflict of interests

The authors confirm that they have no conflict of interests with respect to this manuscript.

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