



# **Rapid screening of ongoing substance abuse by sweat sampling and analysis**

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# Rapid screening of ongoing substance abuse by sweat sampling and analysis

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## Abstract

Information about illicit drug use is required in drug treatment programs, both in the criminal justice system and in various legal contexts. Blood-, saliva-, urine-, sweat- and hair analyses are used for accurate information about recent drug intake. 45% of the study volunteers reported or denied drug abuse, which could not be confirmed by urine-based testing. Those findings confirm that reported drug misuse is not fully reliable, and that more objective methods are necessary. Urine is the most widely-used specimen for analysis of drugs, and it comes with a well-researched technology. Because there are important disadvantages involved with urine sample collecting, there is a need for alternative methods. We examined the sensitivity, PPV, specificity and NPV of the sweat-based drug tests using a Biosensor instrument in clinical practice. Comparison was made with urine tests. Our findings confirm that the sweat-based drug test is easy to perform and is useful for detecting ongoing amphetamine and heroin/morphine misuse. However, it is not useful for detecting cannabis misuse. Sensitivity for morphine/heroin was 41.9% and for amphetamine 69.4%. Specificity for morphine/heroin was 90.5 %, and for amphetamine, 79%. The detection time for the sweat-based test is shorter than for the urine-based test. Individuals with positive urine-amphetamine and positive sweat-amphetamine test results had significantly higher urine-amphetamine levels than individuals with positive urine-amphetamine, but with negative sweat-amphetamine test results. Individuals with 6-MAM positive and morphine/heroin positive urine samples had positive sweat tests 20% more often than those with 6-MAM negative and morphine/heroin positive tests, but the difference was not significant. The higher amphetamine urine-based levels and 6-MAM in the urine indicate intake closer to the time of testing. Our conclusion is that the sweat test by Biosensor instrument is useful for detecting ongoing misuse of heroin/morphine and amphetamine, but not for detecting cannabis. Our results confirm that the sweat test is most useful when close to the drug intake. We therefore recommend using sweat-based tests more frequently than urine-based samples.

**Keywords:** drugs of abuse, urine-based drug testing, sweat-based drug testing, drug use under-reporting, self-reporting.

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## 1. Introduction

Information about illicit drug use is required in drug treatment programs, in the criminal justice system, and also in various legal contexts. Under- and over-reporting of illicit drug use are common and well-known in clinical practice. [1, 2, 3] The population of drug-dependent inmates is high in the remand prisons and prisons in many countries. [4, 5, 6, 7] Drug testing is therefore important in correctional services for objective measurement of misuse. [8, 9] There is a risk that the inmates would try to cheat the urine-based test which is one of the reasons for alternative test options. [10]

Blood-, saliva-, urine-, sweat- and hair analyses are used for obtaining accurate information about recent drug intake. Urine is the most widely used specimen for analysis of drugs, and comes with a well-researched technology. Screening tests have relatively high sensitivity and low specificity, and the most commonly-used analysis method is immunoassay. Positive screening tests are followed by confirmation tests (HPLC and MS technology). [11] The advantages of urine tests are that drugs and metabolites are highly concentrated, the testing methodology is credibly scientific, the testing is widely practiced, results are frequently accepted in court, and uniform testing criteria (e.g. cut-offs) are well-established and easily tested by commercial screening methods. Disadvantages are the short detection period, no dose-concentration relationship, drug concentration influenced by the amount of water intake, and susceptibility to adulteration and substitution. [12, 13] There are advanced methods for *in-vivo* adulteration (involves the addition of a chemical, including water, prior to micturition), *in-vitro* adulteration (involving the addition of a chemical to a sample after micturition), and urine substitution. [14] The task of supervising the sampling can be embarrassing for both the supervised and the supervisor. It is therefore of some interest to find alternative methods of complementing or replacing the urine tests. Detection times of abused drugs differ in different biological samples. The detection time is longest in hair, followed by urine, sweat, oral fluid, and blood. [13]

Sweat sample analysis is one of the alternative methods which is significantly less embarrassing than analysis of urine samples. [13] Sweat analysis is commonly accepted, but incorrectly named, because the analyses are usually performed on mixed secretions of sweat and sebum. [16] The collection of sweat samples is possible with a cotton swab by wiping the skin, or with patches worn for several days (usually one week). [15, 16, 17]

The aim of this study was to investigate the usefulness of on-site sweat-based drug tests in clinical practice.

## 2. Methods

### 2.1 Volunteers

The study was performed at the Addiction Centre, Mälarsjukhuset Eskilstuna, Sweden and at the Addiction Centre, Stockholm, Sweden after approval by the local Ethics Committee. The study lasted from January 2007 to June 2008. All the patients regularly undergoing drug monitoring by urine analysis were informed about the study. Those patients who had taken at least one of the drugs detected by sweat analysis (amphetamine, morphine/heroin, cannabis, cocaine) within one week were invited to participate. Previous drug intake was defined by

anamnesis or by analysis of a urine sample on site. If the patient agreed to participate, the sweat sampling was carried out immediately after the urine sample was collected to prevent any contact with drugs between the two sample collections.

## **2.2 Sweat sampling**

Two sweat samples were collected from the surface of the skin from each volunteer, one from the arm and one from the neck. The sweat sampling was standardized by five wiping movements on the same area.

## **2.3 Analysis**

Analysis of cannabis, amphetamine, morphine/heroin, and cocaine was performed. The screening test for urine samples was made by immunoassay, and for the confirmation test, a GC/MS (gas chromatography/mass spectrometry) method was used. Cut off for amphetamine was 500ng/ml, morphine 300ng/ml, cannabis 25ng/ml, and cocaine 150ng/ml.

Sweat samples were analysed by the BIOSENS<sup>®</sup> instrument, which is a commercially-available, small, portable, electronic analytical instrument for measurement of trace amounts of drugs and/or explosives using automatic, electronic immunoassay techniques. The key feature of the analysis technique is based on displacement of antibodies from the surface of a mass detector, i.e. quartz crystal microbalance (QCM), in the presence of the appropriate antigen. The displacement of the antibodies is monitored as a change in the frequency of the QCM and is directly related to the concentration of the analyte. The operation of the instrument is fully automatic. Sample collection and analysis take only a few minutes.

## **3. Results**

The main objective was to assess the sensitivity, specificity, and positive and negative predictive values for the results from the sweat samples, compared with results from the standard urine sample analytical method using (GC/MS). This comparison is not optimal because of the difference in detection time for those two methods, i.e. longer detection time for urine. To minimize this problem, we compared the amphetamine concentration in urine for sweat-positive and sweat-negative individuals, and the sensitivity for individuals with morphine +/-6-MAM positive and morphine +/-6-MAM - urine samples. A high amphetamine concentration and 6-MAM positivity indicate a drug intake closer to the time of analysis than a lower-amphetamine concentration and 6-MAM negativity. Amphetamine concentration was counted in terms of creatinine concentration.

7.8% of the urine samples were characterised as diluted according to the laboratory cut-off value (4 mmol/l). This is the same level as that used for diluted urine samples for patients in voluntary treatment or in prison settings. Diluted urine samples counted as missing values in the statistical analysis.

A sweat sample was considered positive if any of the two samples taken at the same time (one from the arm and one from the neck) was positive.

Statistical analyses of the sensitivity and specificity, Positive Predictive Value (PPV) and Negative Predictive Value (NPV), are listed in Table 1. Cocaine data were not calculated because of the few positive samples.

Sensitivity and PPV for amphetamine and morphine are good, but for cannabis, they were too low for use in clinical practice.

Comparison was made between the amphetamine concentration/creatinine quote and the sweat positivity for urine-positive individuals for amphetamine by t-test for Equality of Means (Table 2). Individuals with sweat positivity had significantly higher amphetamine concentration in their urine than individuals with sweat negativity (Figure 1).

6-MAM is a degradation product of heroin with a shorter half-life than morphine, the other degradation product. Morphine positivity with 6-MAM positivity indicates heroin intake within 24 hours, morphine positivity without 6-MAM positivity indicates heroin intake more than 24 hours before testing or morphine/codeine intake. Comparison was made between sensitivity for morphine +/6-MAM+ and for morphine+/6-MAM – individuals in urine samples by Wilson KI. Individuals with morphine+/6-MAM positive urine samples had a 20% higher sensitivity than individuals with morphine+/6-MAM negative urine samples, but the difference was not significant. (Table 3)

Our volunteers were patients who were undergoing examination and treatment of their own free will at the Addiction Centres. We evaluated the reliability of their reports of drug-intake within the last 7 days with the aid of the results from the urine-samples (Table 4). Our results show that 55.3% of the patients reported drug intake which could be confirmed by urine analysis, and 44.5% reported at least one drug-intake or lack of drug intake which could not be confirmed by urine analysis. We checked the differences with respect to amphetamine, morphine, and cannabis (Table 5). Those results show that drug intake is both under- and over-reported, but under-reporting occurs about twice more commonly for all the investigated drugs than over-reporting.

## 4. Discussion

103 drug users, who were divided up on the basis of drug intake within 7 days before the test participated in the study, 17 females and 86 males. The analysis results of the sweat samples were compared with those of the urine samples. This comparison is not optimal because of the difference in detection times (longer for urine), but it was chosen because urine samples are most commonly used in clinical practice and the results are scientifically well-evaluated.

Under- and over-reporting of drug intake occurred for all of the analysed drugs (about 20% under-reporting and about 10% over-reporting). Our conclusion is that the patients want to hide their drug abuse but even they are not always aware of the substance they have taken. Those findings confirm the need for an objective measurement of ongoing misuse.

The sensitivity for amphetamine by sweat sample analysis was 69.4%, PPV 65.8%, specificity 79%, and NPV 81.7% (Table 1). This makes the test usable for detection of amphetamine in clinical practice. Individuals with positive sweat sample results had significantly higher amphetamine concentration in their urine than the sweat-negative individuals. This indicates that the sweat test is more useful when it is performed closer to the drug intake. The accuracy can be higher if the sweat samples are collected more often, i.e. every day or every two days.

The specificity for morphine using sweat samples was 41.9%, PPV 68.4%, specificity 90.5% and the NPV 76% (Table 1). Using this method, less than half of the morphine-positive individuals can be identified. Individuals with 6-MAM positivity in urine were 20% more

often positive in urine samples, but our statistical analysis could not find any significant difference in sweat sample positivity between the 6-MAM positive and 6-MAM negative group. Our interpretation is that the lack of significance depends on the low number of samples and sensitivity can be higher if the sweat samples are collected more often, for instance, every day.

Sweat analysis is not usable for the detection of cannabis by Biosensor instruments today.

## **5. Conclusion**

Our findings confirm that the reports of the drug users concerning their drug intake are not reliable, and objective drug monitoring methods are necessary for the detection of ongoing drug misuse. The use of sweat as a specimen for testing for ongoing misuse of amphetamine and morphine is an alternative to urine testing, especially within the criminal justice system. Prison inmates are not there of their own free will, which makes the ethical constraints on the methods used higher than on the methods used in health care. The sweat-based method is easy and quick to perform, and refusal to allow sample collection cannot be attributed to embarrassment. We were also able to confirm that the Biosensor instrument is a useful tool for detecting ongoing heroin/morphine and amphetamine misuse. Our findings confirm that amphetamine and morphine are detectable in sweat within a shorter time than in urine, and therefore we recommend collecting sweat samples often. The method is feasible for daily use. In essence, sweat analysis is a screening method and any positive findings must be confirmed by urine analysis.

## **6. Contributors**

O Hoffmann designed the study, clinically supervised and cared for participants, analysed and interpreted the data, and prepared the manuscript.

B Göransson organized the technicalities, analysed and interpreted the data and prepared the manuscript.

## **7. Conflict of interest statement**

None of the authors has any conflicts of interest to disclose.

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Table 1

Statistical analyses of the sensitivity and specificity, Positive Predictive Value (PPV) and Negative Predictive Value (NPV) for three tested drugs.

	N	Sensitivity (in percentages)	PPV (in percentages)	Specificity (in percentages)	NPV (in percentages)
Amphetamine	98	69,4	65,8	79	81,7
Morphine	94	41,9	68,4	90,5	76
Cannabis	98	12,3	70	92,7	43,2

Table 2

Amphetamine concentration in urine for sweat positive and sweat negative individuals  
t-test for Equality of Means

Mean concentration µg/l Sweat negative	Mean concentration µg/l Sweat positive	Mean difference	Std Error Difference	Sig. (2-tailed)
370,02	1583,13	-1213,11	347,785	.002

Table 3

Difference in sensitivity for morphine +/6-MAM+ and for morphine+/6-MAM – by Wilson  
KI:

Difference	$0,538 - 0,333 = 0,205$
95% CI	-0.132 to 0.491

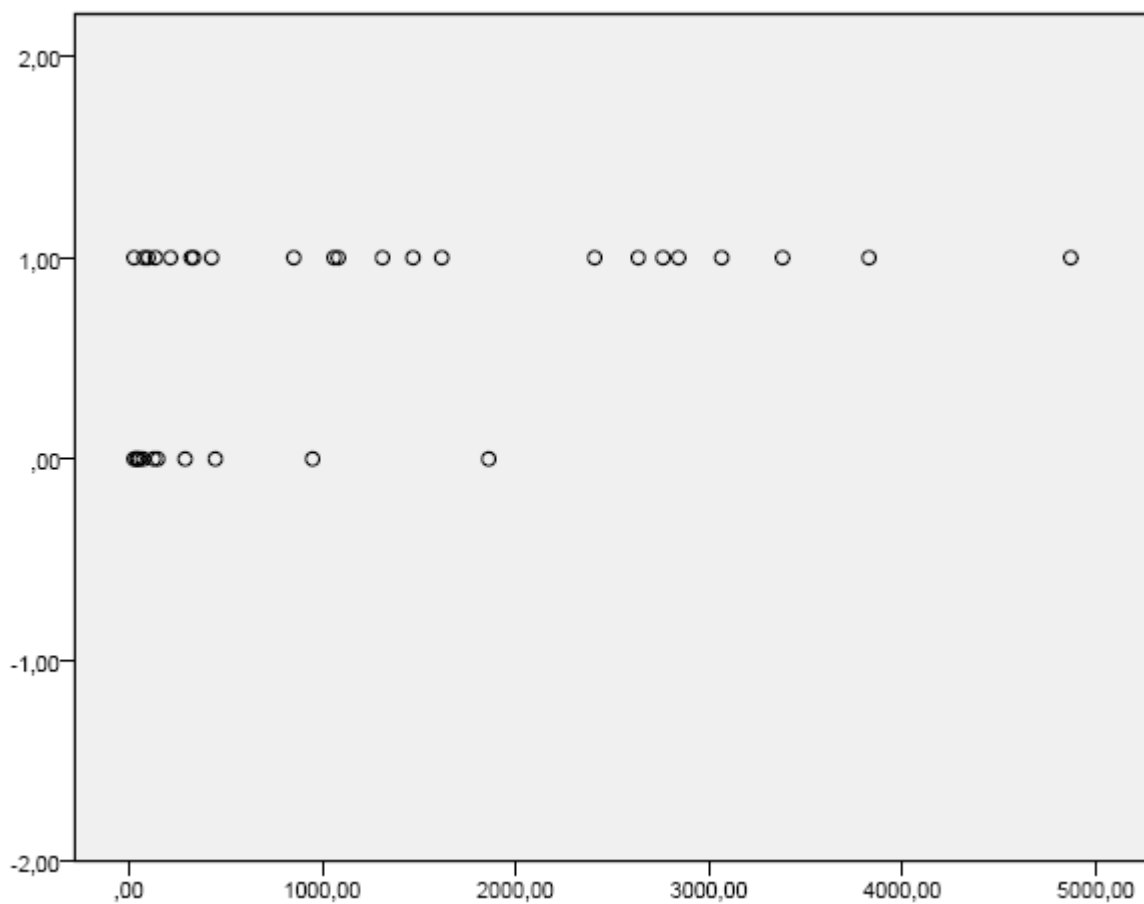
Table 4 Self-reports of drug intake

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	True	49	47,6	51,6	51,6
	Not true at least 1 drug	46	44,7	48,4	100,0
	Total	95	92,2	100,0	
Missing	System	8	7,8		
Total		103	100,0		

Table 5 Self-reports for different drugs

	N	No agreement	No agreement %
Amphetamine, urine +	36	6	16,7
Amphetamine, urine -	62	6	9,7
Morphine, urine +	31	7	22,6
Morphine, urine -	63	7	11,1
Cannabis, urine +	57	13	22,8
Cannabis, urine -	41	5	12,2

Figure 1 Amphetamine concentration in urine analyses



X: cc u-amphetamine, µg/l , Y: 0= negative sweat sample, 1= positive sweat sample

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