Published in final edited form as:
Addict Biol. 2003 June ; 8(2): 191–200. doi:10.1080/1355621031000117428.

Detecting crack and other cocaine use with fastpatches

HILARY JAMES LIBERTY[1], **BRUCE D. JOHNSON**[1], **NEIL FORTNER**[2], and **DORIS RANDOLPH**[1]

1*National Development and Research Institutes, Inc. (NDRI), New York, USA*

2*PharmChem, Inc., Haltom City, TX, USA*

Abstract

A continuing social problem is presented by the large number of individuals who use crack cocaine. Recent research has identified unique pyrolysis products of crack or burned cocaine as anhydroecgonine methylester (AEME) and ecgonidine (ECD) through gas chromatography/mass spectrometry (GC/MS) that allow for the detection of crack use distinct from other cocaine use. However, there have been no large-scale studies to document the presence and prevalence of these substances in sweat. A new sweat-testing appliance called a fastpatch was developed for this study. Through mild heating and a slightly larger collection pad than a standard Pharmchek™ sweat patch, this product shows the promise of shorter required wear periods than standard sweat patches, and possibly longer time-periods of detected use. One hundred and eighty subjects wore 360 fastpatch prototypes (one per hand). However, subsequent analysis determined that only one patch per subject was needed to obtain sufficient sweat eluate for GC/MS. Cocaine use was detected in sweat of 92% of subjects through GC/MS, comparing favorably with 91% with EMIT urinalysis. Crack metabolites were detected in 54% of subjects. The predominant analyte detected was AEME. There were no significant differences in detection rates between 15-, 20- and 30-minute wear periods. All wear periods detected both cocaine use in general and crack use successfully. These results suggest that crack use as distinct from other cocaine use can be detected in sweat and that fastpatches are a promising new way to detect drugs of abuse.

Introduction

Urinalysis remains a widespread, inexpensive means of testing for drugs of abuse. However, urinalysis is not without problems, including a narrow window of detection (detecting most drugs of abuse for approximately 2 – 4 days),[1-2] dilution or substitution of specimens, possibility of disease transmission, transportation of noxious fluids and violations of privacy (e.g. observed urination to prevent specimen tampering). Privacy violations are likely to become more problematic as work-place drug testing becomes more common, particularly at higher management levels (e.g. aircraft pilots).

Sweat patches have recently been documented as an effective means of detecting drugs of abuse in sweat which avoids many of the problems noted with urinalysis.[3–4] Fastpatches represent a new addition to sweat testing. Through the use of mild heating and a slightly larger collection pad than standard sweat patches, fastpatches may significantly decrease necessary wearing times while increasing the time window in which drugs can be detected. Making sweat

Correspondence to: Hilary James Liberty, National Development and Research Institutes, Inc. (NDRI), 71 West 23rd Street, New York, New York 10010, USA. Tel: (212) 845 4501; E-mail: hilary.liberty@ndri.org.

Declaration of interest
The opinions stated in this paper are solely those of the authors and not necessarily the opinions of NIDA or NDRI.

testing a viable drug-testing alternative to urinalysis could provide invaluable in drug treatment, criminal justice and in the work-place.

A continuing social problem is presented by the large number of individuals who use crack cocaine. Recent surveys of New York arrestees[5-7] indicate that about 10% report cocaine powder use and 25% report crack use, yet 50% typically test positive by EMIT urinalysis for cocaine. While all cocaine use is problematic, the ability to document crack use independently of respondent self-report would provide a valuable adjunct to the drug treatment and criminal justice systems. In fact, greater sanctions for crack than other cocaine use have been codified into US law indicating greater concern for the social consequences of crack use versus other cocaine use.[8-10] Researchers have recently detected unique pyrolysis products of crack which distinguish between smoked or burned cocaine (e.g. crack) and other cocaine.[11] Therefore, this study focused on using fastpatches to detect cocaine use and particularly crack use as distinct from powder cocaine.

Sweat patches

Laboratory tests have shown the efficacy of the sweat patch in detecting cocaine use. In controlled-dose clinical trials, Cone and associates[12] and Burns & Baselt[13] detected cocaine and its metabolites ecgonine methylester (EME), and benzoylecgonine (BE) in patches. Fogerson *et al.*[14] have documented the efficacy of the sweat patch for cocaine detection by comparing the patch with EMIT urines obtaining 93% agreement. They validated the EIA procedure against GC/MS, obtaining 94% specificity and 97% sensitivity. Liberty and associates[4] have shown that the minimum length of wear of the standard PharmChek™ patch to detect cocaine use is approximately one day. In these studies, the predominant analyte found in sweat was cocaine, followed by BE and EME.

The fastpatch

The fastpatch is a device that permits the collection of sensible sweat over a 15 – 30-minute time-period through mild heating. Published research is limited to two studies with small samples.

Huestis and associates,[15] at the NIDA Intramural Research Program, tested fastpatches that were hand-held or applied to the torso. Four subjects were administered three low (75 mg/70 kg body weight) and three high (150 mg/70 kg) doses of cocaine HCL with fastpatch specimens collected up to 29 days after each administration. As is usual with sweat, the predominant analyte found was cocaine with peak concentrations ranging from 33 to – 3579 ng/patch across doses for the hand-held fastpatch compared to 22 – 2085 ng/patch for the fastpatch applied to the torso. Peak concentrations occurred within 24 hours after dosing, but were highly variable within and between subjects without a clear dose – response relationship. Cocaine could be detected by hand-held patches for 24 days after the high dose and 17 days after the low dose.

Oyler and associates,[16] also at the NIDA Intramural Research Program, report on a controlled-dosing study of methamphetamine using the hand-held fastpatch. Patches detected methamphetamine and its chief metabolite amphetamine in two subjects.

In both these studies, the evidence suggests a longer window of detection (2 – 3 weeks) than is seen typically for most drugs of abuse in urine or with standard sweat patches. Researchers speculate that there may be a flushing effect resulting from large amounts of sensible sweat generated by external heat. However, this process is not well understood, and more research is needed.

Determining crack/freebase cocaine abuse by the analysis of cocaine pyrolysis products

The abuse of crack cocaine is a problem both for drug treatment programs and for the criminal justice system. Means to identify crack use by the analysis of biological specimens has focused attention recently on the crack pyrolysis product anhydroecgonine methylester (AEME). Smoking crack or freebase cocaine produces the pyrolytic product AEME. Thus, with inhalation of crack vapors, an individual will also inhale AEME. Once in the body, it can be metabolized to ecgonidine (ECD) and both chemicals will be excreted in the urine. The presence of either AEME or ECD can confirm the use of crack or freebase cocaine.

Studies performed by Martin *et al.*[11] have determined that the level of cocaine availability and pyrolysis to AEME is dependent upon both the airflow and temperature at which cocaine is volatilized. When the flow rate of cocaine inhalation is too low, cocaine will remain in the pipe and undergo significant pyrolysis. At extreme temperatures, cocaine will be subjected to substantial pyrolysis, again producing a high concentration of AEME and minimizing the amount of cocaine available for inhalation.

Jacob *et al.*[17] studied the amount of AEME found in urine when cocaine is consumed by either smoking, by intranasal administration or intravenously. The authors found that subjects who had smoked cocaine excreted substantial amounts of AEME in their urine. AEME was not found in the urine when both subjects were administered cocaine by intravenous and intranasal routes.

Cone *et al.*[18] determined the urinary excretion of cocaine, BE and AEME following the smoking of 42 mg of crack. The AEME concentration ranged from 5 to 27 ng/ml. The peak AEME concentration of 27 ng/ml occurred at the first urine collection, decreased below 10 ng/ml by 12 hours and was no longer detectable after 28 hours.

The detection of AEME from passive exposure to cocaine vapors is unlikely. An indirect test of this was performed by Cone *et al.*[18] Subjects were exposed to 100 and 200 mg of freebase cocaine heated at 200°C in a small, unventilated room for 1 hour. Urine specimens contained peak BE concentrations at 22 – 123 ng/ml, below the 150 ng/ml cut-off. Considering that BE was detected below cut-off concentrations, it is extremely unlikely that AEME would be detected in the urine from these individuals.

After smoking cocaine base, AEME is absorbed into the blood where it is metabolized to form ECD. ECD is more polar than AEME and can be detected in the urine at higher concentrations and for a longer period of time. Paul *et al.*[19] reported detecting ECD in 96% of BE positive urine specimens from a random drug-testing program indicating smoking as the major route of administration. In all specimens, the level of AEME was much lower when compared to ECD.

Riley and associates[20,21] have performed the largest study to date testing for crack pyrolysis products in urine. In a sample of recent arrestees, of 740 who tested positive for cocaine, 62.6% tested positive for AEME and 74.0% tested positive for ECD. Mean concentrations of AEME were only 341 ng/ml compared to 3030 ng/ml for ECD. This finding, along with that of Paul *et al.*[19] reviewed above, suggests that ECD is the pyrolysis product that is most abundant in urine. However, Riley *et al.*[20] also found that there was only a 48% overlap between specimens positive for ECD and those positive for AEME. When subjects positive for either AEME and/or ECD were counted, the positive rate increased to 85%.

These studies suggest that the presence of AEME in urine specimens from cocaine users can be used to determine if an individual has smoked crack or freebase cocaine. The window of detection of AEME following smoking cocaine can be up to 18 hours with a cut-off

concentration of 5 ng/ml. In urine, the analysis of the AEME metabolite, ECD, can significantly prolong the time period for detection due to its increased polarity and higher concentrations in the urine.

Kintz *et al.*[22] determined the prevalence of AEME in plasma, saliva, urine, sweat and hair from both clinical and forensic specimens. Only one of 87 sweat specimens had AEME. The positive patch was from an overdose case in which the cocaine concentration was 1231 ng/patch. Notably, this is the first report of AEME found in sweat.

These studies suggest that detection of crack use through identification of crack pyrolysis products is promising, but research on sweat testing for these analytes is limited.

Methods

Materials

The fastpatch is a device that permits the collection of sensible sweat over a 20 – 30-minute time-period. This device uses a 0.3 mm thick medical grade cellulose tissue 7 × 10 cm that is attached using Avery dot labels to a Prism Technologies Infant Heel Warmer. The Prism Technologies Infant Heel warmer is a chemical warmer that is used to stimulate the secretion of sensible sweat.

Research subjects

Participation in the study was obtained from 181 active cocaine users through ethnographic outreach. In this procedure, interviewers went to locations in Harlem, New York City, where crack and other cocaine users congregated, and obtained volunteers who were paid $20 for their participation in the study. Additionally, respondents were paid $5 if they brought in another user who was willing to participate in the study. One subject withdrew prior to completion for reasons unrelated to the wearing of fastpatches. Consistent with informed consent procedures, when this subject requested, she was released immediately from the study and paid. Therefore, while the effective sample for demographics is 181 subjects, for analysis of overall metabolite levels the sample size is 180. Because of loss of length of wear information for six subjects due to the World Trade Center disaster (where NDRI offices were formerly located), the length of wear analyses has a sample size of 174.

Informed consent and other subject protections

Subjects were read an informed consent form that described the study in detail, apprised them of the voluntary nature of their participation, and noted that they could withdraw at any time. Subjects signed this form which was kept separate from all data. Data were completely anonymous. A US Federal Certificate of Confidentiality was obtained which protects the privacy rights of subjects.

Procedure

Outreach workers (and in some cases other subjects) obtained volunteers from locations where crack and other cocaine users were known to congregate. Volunteer subjects were brought to a local apartment where the study was conducted. Sixteen different apartments were used as data collection sites. Owners were paid for 1 or 2 days' use. When volunteers in an area were depleted, interviewers negotiated a new location in a different Harlem neighborhood.

When subjects arrived, they were read an informed consent describing the study and indicating that their participation was voluntary and that they could withdraw at any time. After they signed the consent, they provided a urine specimen and were asked to wash their hands thoroughly. If the subjects' hands were not sufficiently clean on return with the urine specimen,

the interviewer cleaned them with tapwater in a spray bottle and a surgical scrub. The interviewer then cleaned all subjects' palms of both hands with isopropyl alcohol and the palms were allowed to air-dry. The purpose of this extensive cleaning was to prevent environmental contamination of the patch. Fastpatches were applied to both palms and each hand was wrapped in plastic to contain the heat from the warmer and to increase palmar sweating. Two patches were worn because it was uncertain whether a single patch would provide sufficient sweat for all the planned analyses. Subjects were assigned to one of three treatment conditions (15, 20 or 30 minutes) with order of assignment determined from a random number table. During the 15 – 30 minutes that the fastpatches were worn, subjects were asked about their recent crack use and about any other cocaine use. They were asked about usage during the last day, and 3, 7, 20 and 30 days as well as mode of administration (smoke, snort, inject).

Laboratory analysis

Fastpatches—Eluate from patch absorbent pads of sweat patches was extracted using 2.5 ml of 0.2 M acetate/methanol (25 : 75) buffer, pH 5.0. Sweat patch eluates were submitted for GC/MS. The sweat patch assay was performed using a Hewlett-Packard 5890/5971 GC/MS system. Selected Ion Monitoring (SIM) was used to acquire data on cocaine (182, 272, 303 amu) and benzoylecgonine (318, 334, 439 amu) and on the internal standards d3-cocaine (185, 306 amu) and d3-benzoylecgonine (321, 442 amu). The cut-off for the GC/MS confirmatory assay was 10 ng/ml.

The analysis of cocaine pyroylsis products involved solid-phase extraction followed by GC/MS confirmation. Two separate extraction procedures were required to isolate AEME and ECD. One extraction procedure was used to isolate AEME, BE and cocaine. Briefly, d3-AEME, d3-BE and d3-cocaine were added to a 0.25 ml specimen aliquot along with 3 ml of a 0.1 M phosphate buffer. This was then extracted using Bond Elut Certify columns. After elution of the drugs, the eluate was evaporated to dryness and the drugs were derivatized with HFIP and PFPA. The extract was then analyzed by GC/MS using a HP 5890/5970 system. The temperature parameters consisted of an injection port and detector temperatures of 250°C and 280°C, respectively. The oven was programmed from 90 to 170°C at 20°C/minute and then ramped from 170 to 320°C ar 40°C/minute. The ions monitored were as follows:

AEME—152, 166, 181

D3-AEME—155, 184

BE—318, 334, 439

D3-BE—321, 442

Cocaine—182, 272, 303

D3-cocaine—185, 306

The extraction and GC/MS analysis for ECD included the addition of the internal standard d3-ECD to an aliquot of the specimen followed by the addition of 4 ml of a phosphoric acid buffer solution. This was then extracted using Bond Elut Certify columns. After ECD was eluted off the column, BSTFA was added for derivatization. The extract was then analyzed by GC/MS using a HP 5890/5970. The temperature parameters consist of an injection port and detector temperatures of 250°C and 280°C, respectively. The oven was programmed 120 – 180°C at 20°C/minute and then ramped from 180 to 320°C at 40°C/minute. The ions monitored were as follows:

ECD—122, 210, 239

D3-ECD—125, 213

Urinalysis—Urine specimens were screened for cocaine using the Microgenics (Fremont, CA, USA) EMIT d.a.u. test. The assay was modified by the addition of NAD substrate to the reagent to enhance the reaction. Tests were performed on either an Olympus (Lake Success, NY, USA) AU 800 or a Hitachi 747 (Boehringer Manheim, Indianapolis, IN, USA) analyzer. The cut-off for the screening assay was performed using a Hewlett-Packard 5890/5970 GC/MS system. SIM was used to acquire data on the 224, 272 and 345 ions of benzoylecgonine and the 227 and 348 ions of the internal standard, d3-benzoylecogonine. Due to cost limitations of this study, it was not possible to test urine specimens for AEME or ECD.

Results

Sample

Subjects were half (52%) male, and predominantly black (90%) with 7% Hispanic. As shown in Table 1a, 37% of subjects were 30 – 39 years of age while 36% of subjects were 40 – 49 years of age. Range of ages was from 21 to over 60 years of age. An unexpected but not surprising characteristic of this sample is the lack of subjects younger than 21 years. The generational avoidance of crack and other cocaine among the young has been documented extensively,[23 - 25] but was unanticipated in this sample. Having seen the devastation caused in parents and older siblings by crack, young people avoid it.

Self-report data shown in Table 1 Section B suggest that the sample accrued is of very recent (last 24 hours) cocaine users (90.0%). A total of 86.7% reported recent crack use and 22.7% reported recent other cocaine use while 19.4% reported both crack and other cocaine use recently. Therefore, combined use of 90.0% represents only a 3.3% increase over crack use alone (86.7%). The high prevalence rates (proportion of subjects testing positive) shown in Table 2a lend credence to these self-report statistics. However, according to the data from self-reports, attempts by interviewers to locate subjects who used crack and other cocaine *but did not use it recently* were not successful. Almost no one who used cocaine had not used it in the last 7 days. It appears from this sample that cocaine users in this Harlem neighborhood consume cocaine nearly every day, with virtually no infrequent users.

This finding had important design implications. Without a group of subjects who used cocaine within the last month but not in the last 2 or 3 weeks, the sample could not be used to test the hypothesis that fastpatches will detect cocaine use up to 20 days.

Biological results in the whole sample

The prevalence rate for cocaine detected in patch eluate was 92.2% based on GC/MS testing of 180 fastpatches. This is comparable to the detection rate with matched urine EMITs of 91.1%. Table 2a shows these findings. Further, as documented by the literature on analytes found in sweat testing[4] the parent drug (cocaine) is found in the highest concentration and is detected most frequently in sweat. Additionally, these data show that AEME can successfully be detected in sweat as noted by Kintz *et al.*[22] above. ECD has also been detected but at a much lower rate.

Table 2b (left) documents that, of 180 fastpatches, 166 were positive for standard cocaine analytes while 98 were positive for pyrolitic analytes. These data document the success of the fastpatch in detecting smoked cocaine, yet the detection rates are substantially lower (54.4%) than the self-report rate for crack of 86.7%. Because subjects were paid $20 to participate in the study contingent upon cocaine use, this may be a case of subjects telling us what they think we want to hear, or it may indicate lower detection rates for crack metabolites. Table 2b (right) shows that in this fastpatch sample, detection of AEME was sufficient for detection of smoked cocaine. Analysis of ECD added only one positive case not detected by AEME. This finding,

if confirmed, could have clear implications for the development of a low-cost EIA screen for detection of smoked or burned cocaine in sweat.

While these findings are markedly different than those of both Paul[19] and Riley *et al.*,[20] who found the highest concentrations of ECD in urine, they are consistent with what is known about relative differences in analyte concentrations found in urine compared to sweat. In recent cocaine users BE is found in the highest concentration in urine, with only trace amounts of cocaine.[1] However, in sweat of recent users cocaine is found in much higher concentrations than BE.[4,12] Like cocaine itself, AEME is an analyte ingested into the system and metabolized to ECD, and therefore it is not surprising that the chief analyte found in urine is the metabolite (ECD) while the chief analyte found in sweat is cocaine (the parent compound). The relatively low levels of ECD seen in this sample are also consistent with the subjects' self-reports; this is a sample predominantly composed of very recent (last 24 hours) crack users.

Table 3 shows the average analyte concentrations of crack or powder cocaine and their metabolites found in fastpatches. This information is displayed in two ways: first, in Table 3a, the average analyte concentrations for all patches is shown and secondly, in Table 3b, the average concentrations in patches that were found to have concentrations greater than zero is shown. Thus, this table shows average concentrations in the entire sample vs. average concentrations for users. The high concentrations shown in these data indicate clearly that sweat testing for crack and other cocaine is viable, and that the fastpatch is an effective appliance with which to do so. Further, these data are consistent with the prevalence data reported above indicating that AEME is found in sweat among active cocaine users in much greater abundance than ECD. The implications of this for a low-cost EIA screen using fastpatches is clear, namely that the primary target analyte should be AEME. It will be important to replicate these findings in new and different samples.

Table 4 displays information on length of wear of patches. The top of the table (Table 4a) shows that the proportion of subjects found positive was not significantly different from 15 to 30 minutes of wear. Pairwise χ^2 tests (15 vs. 20, 20 vs. 30) were not significant. The lower portion of the table (Table 4b) shows mean analyte concentrations for different lengths of wear: 15, 20 and 30 minutes. Analyte concentrations are not normally distributed and are typically excreted following an exponential function.[26] Therefore, a logarithmic transformation of analyte levels was calculated. Logarithmic transformations are also helpful in meeting the parametric assumption of homogeneity of variance for significance tests.[27] There are two important findings in this portion of the table. First, analyte concentrations are measurable and high for all wear times. Secondly, there are no significant differences in analyte levels between wear times. Although it is anomalous that the intermediate wear time (20 minutes) has the highest average concentrations, this difference is not significant and wide standard deviations are noted.

Limitations

The major limitation of these findings is that the study was a dose-uncontrolled field trial. As such, these findings are dependent on the average cocaine usage levels of this particular sample and the purity of cocaine available on the street when the study was conducted. On the other hand, there are advantages to testing both the fastpatch and crack detection methods on actual users rather than limiting research to laboratory controlled dosing studies. Doses, modes of administration, and consumption patterns are more likely to match the applied settings in which these products will be used.

Discussion

This study examines the effectiveness of fastpatches as a means of detecting crack and other cocaine. Fastpatches detected cocaine use at about the same rate as urinalysis. Unanticipated sampling factors, namely the lack of infrequent users, made it impossible to test the hypothesis of drug detection over a longer time window (2 – 3 weeks); nonetheless, the possibility of longer detection periods remains attractive. The finding of few young crack users in this convenient sample matches similar results from studies employing statistical sampling frames.[5-7]

The prevalence rate of 54% for detection of crack metabolites is high enough to demonstrate that detection of crack use through sweat testing is possible. However, the difference between this rate and other estimates (self-report 90% and GC/MS for cocaine 92%) remains unexplained and warrants additional investigation.

The finding of no significant differences between three durations of wear (15, 20 and 30 minutes) suggests two possibilities. The obvious conclusion is that the time differences between wear durations was not sufficient to produce appreciable differences in analyte quantities. Alternatively, it may be that when heat is applied, a flushing effect occurs which produces sufficient sweat for analysis. Additional wear may produce only small increases both in sweat and in measurable analyte levels. Clearly, all three wear durations produced sufficient sweat for testing.

The results of this study clearly document that crack pyrolysis products can be found in sweat. Furthermore, coupled with the fastpatch, they present a new, convenient, and effective method of detecting crack use as well as other cocaine metabolites. In addition, anecdotal evidence from field staff suggest that the fastpatches are easy to use and are readily accepted by subjects. They are applied quickly and easily and subjects did not appear to mind. Expansion of testing to include other drugs of abuse is clearly the next step.

Acknowledgements

This research was supported by a grant from the National Institute on Drug Abuse (NIDA) (DA13542) to the first author and to National Development and Research Institutes, Inc. (NDRI). Also, the literature review was supported partly by a NIDA grant (DA11356-02) to the first author. We express our gratitude to the staff of NIDA for this support. All the data in this study were collected by Doris Randolph and Barry Randolph, to whom we extend our appreciation.

References

1. Visher, C. A comparison of urinalysis technologies for drug testing in criminal justice. National Institute of Justice, Research Report; Washington, DC: 1991.
2. Cone EJ. New developments in biological measures of drug prevalence. NIDA Res Monogr 1997;167:108–29. [PubMed: 9243559]
3. Sunshine, I.; Sutliff, JP. Sweat it out. In: Wong, SH.; Sunshine, I., editors. The handbook of analytical therapeutic drug monitoring and toxicology. CRC Press; New York: 1997. p. 253-64.
4. Liberty, HJ.; Fortner, N.; Armbruster, D.; Johnson, BD. Sweat patches: association between length of wear and concentrations of cocaine, benzoylecgonine, and ecgonine methylester; Annual Meeting of the Society of Forensic Toxicologists; 1999.
5. Johnson, BD.; Golub, A.; Durrah, T. Substance use among arrestees in the boroughs of New York City (third quarter 1998 through first quarter 1999). Arrestee Drug Abuse Monitoring Program in New York City; Presentation to American Society of Criminology; 1999.
6. National Institute of Justice. ADAM Preliminary 2000 findings on drug use and drug markets. Arrestee Drug Abuse Monitoring Program; Washington, DC: 2001. NCJ 189101
7. Golub A, Johnson BD, Taylor A, Liberty HJ. The validity of arrestee self-reports: variations across questions and persons. Justice Q 2002;19:101–26.

8. Bertram, E.; Blackman, M.; Sharpe, K.; Andreas, P. Drug war politics: the price of denial. University of California Press; Berkeley, CA: 1996.
9. Baum, D. Smoke and mirrors: the war on drugs and the politics of failure. Little Brown; Boston: 1996.
10. US Sentencing Commission. Report to Congress: cocaine and federal sentencing policy. Washington, DC: US Government Printing Office; 2002.
11. Martin BR, Lue LP, Boni JP. Pyrolysis and volatilization of cocaine. J Anal Toxicol 1989;13:158–62. [PubMed: 2755088]
12. Cone EJ, Hillsgrove MJ, Jenkins AJ, Keenan RM, Darwin WD. Sweat testing for heroin, cocaine, and metabolites. J Anal Toxicol 1994;18:298–305. [PubMed: 7823536]
13. Burns M, Baselt RC. Monitoring drug use with a sweat patch: an experiment with cocaine. J Anal Toxicol 1995;19:41–8. [PubMed: 7723301]
14. Fogerson, R.; Fortner, N.; Warren, M.; Sutliff, J.; Liberty, HJ.; Johnson, B. Detection of cocaine and its metabolites using the PharmChek sweat patch; Paper presented to the Society of Forensic Toxicology Annual Meeting; 1996.
15. Huestis, MA.; Oyler, JM.; Cone, EJ.; Moolchan, ET.; Wtsadik, AT.; Schoendorfer, D.; Joseph, RE. Sweat testing for cocaine and metabolites with hand-held and torso Fastpatches; Presentation to the Society of Forensic Toxicology Annual Meeting; 1999.
16. Oyler, JM.; Cone, EJ.; Huestis, MA.; Schoendorfer, DW.; Moolchan, ET.; Josseph, RE. Sweat testing for methamphetamine with the hand-held Fast patch; Puerto Rico: Presentation at Society of Forensic Toxicology Annual Meeting; 1999.
17. Jacob P, Lewis ER, Elias-Baker BA, Jones RT. A pyrolysis product, anhydroecgonine methyl ester (methylecgonidine), is in the urine of cocaine smokers. J Anal Toxicol 1990;14:353–7. [PubMed: 2087095]
18. Cone EJ, Yousefnejad D, Hillsgrove MJ, Holicky B, Darwin WD. Simultaneous measurement of cocaine cocaethylene, their metabolites, and "crack" pyrolysis products by gas chromatography-mass spectrometry. Clin Chem 1994;40:1299–305. [PubMed: 8013103]
19. Paul, BD.; McWhorter, LK.; Smith, ML. Detection of urinary ecgonidine as an indicator of active smoking of cocaine; Presentation to the Annual Meeting of SOFT-TIAFT; 1998.
20. Riley KJ, Lu NT, Meeker JE, Lo P, Fortner N, Taylor BG. Monitoring the crack epidemic through urine testing: Establishment of routine detection methods. Addict Biol 2001;6:83–95.
21. Lu NT, Taylor BG, Riley KJ. The validity of adult arrestee self-reports of crack cocaine use. Am J Drug Alcohol Abuse 2001;27:399–419. [PubMed: 11506259]
22. Kintz PK, Sengler C, Cirimele V, Mangin P. Evidence of crack use by anhydroecgonine methylester identification. Hum Exp Toxicol 1997;16:123–7. [PubMed: 9051417]
23. Golub, A.; Johnson, BD. Research in Brief. National Institute of Justice; Washington DC: 1997. Crack's decline: some surprises across U.S. cities.
24. Golub A, Johnson BD. Cohort changes in illegal drug use among arrestees in Manhattan: from the heroin injection generation to the blunted generation. Subst Use Misuse 1999;34:1733–63. [PubMed: 10540971]
25. Johnson, BD.; Golub, A.; Dunlap, E. The rise and decline of drugs, drug markets, and violence in New York City. In: Blumstein, A.; Wallman, J., editors. The crime drop in America. Cambridge University Press; New York: 2000. p. 164-206.
26. Ambre J. The urinary excretion of cocaine and metabolites in humans: a kinetic analysis of published data. J Anal Toxicol 1985;9:241–5. [PubMed: 4079334]
27. Winer, BJ.; Brown, DR.; Michaels, KM. Statistical principles in experimental design. McGraw-Hill, Inc.; New York: 1991.

Table 1

Characteristics of sample

(a) Demographics			
Sample size	181		
Gender		**Age (years)**	
Male	52%	21 – 29	8.7%
Female	48%	30 – 39	37.5%
Ethnicity		40 – 49	35.9%
Black	88.9%	50 – 59	13.3%
Hispanic	7.2%	60 – 60+	3.3%
White	2.7%	Unreported	1.6%
Multiracial/other	1.0%		
(b) Self-report			
Any cocaine use			
Last 24 hours	90.0%		
Last 3 days	8.3%		
Last 7 days	0.0%		
Last 20 days	0.6%		
Last 30 days	0.6%		
No use	0.0%		
Crack use		**Cocaine powder use**	
Last 24 hours	86.7%	Last 24 hours	22.7%
Last 3 days	7.7%	Last 3 days	10.5%
Last 7 days	0.0%	Last 7 days	1.7%
Last 20 days	0.0%	Last 20 days	1.7%
Last 30 days	0.6%	Last 30 days	1.7%
No use	5.0%	No use	61.9%
Crack mode of administration		**Cocaine powder mode of administration**[1]	
Smoke	100.00%	Smoke/freebase	37.6%
		Snort	71.0%
		Inject	10.1%

[1] Percentages sum to greater than 100 as respondents may use more than one mode.

Table 2

Comparisons of measures and analytes

(a) Prevalence of analytes

GC/MS of patch eluate	
Cocaine	92.2%
BE	60.0%
AEME	53.9%
ECD	7.8%
Any Cocaine analyte	92.2%
Urine EMIT	91.1%

(b) GC/MS comparison of cocaine analytes in fastpatch sweat eluate

		AEME and/or ECD					**ECD**		
		−	+				−	+	
COC	−	14	0	14	AEME	−	81	1	82
and/or	+	68	98	166		+	84	13	97
BZ		82	98	180			165	14	179

Table 3

Analyte concentrations in fastpatches

	n	Mean nanograms per milliliter of patch eluate	Standard deviation
(a) Concentrations calculated on all patches			
Cocaine	180	1623	5283
Benzoylecgonine (BE)	178	155	626
Anhydroecgonine methylester (AEME)	179	106	348
Ecgonidine (ECD)	179	4	24
(b) Concentrations calculated on positive patches with non-zero analyte values			
Cocaine	170	1718	5422
Benzoylecgonine (BE)	111	248	780
Anhydroecgonine methylester (AEME)	103	184	443
Ecgonidine (ECD)	29	26	55

Table 4

Analysis of fastpatch wear times

(a) Proportion of patches positive **N=174**	***15 minutes***	***20 minutes***	***30 minutes***	***Overall***
GCMS				
Cocaine	31.0%	31.0%	29.9%	91.9%
BE	20.1%	21.3%	17.2%	58.6%
AEME	17.2%	19.5%	15.5%	52.2%
ECD	3.4%	2.9%	1.1%	7.4%

(b) Average concentrations of analytes detected by GC/MS

	15 minutes		*20 minutes*		*30 minutes*	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*
Cocaine	1290	305	2555	8342	1007	2233
BE	174	814	222	722	71	157
AEME	90	286	160	513	69	158
ECD	6	36	5	20	2	7

(a) No differences in rates between conditions are significant. Overall rates differ slightly from earlier table due to smaller sample.

(b) Units shown are nanograms per millileter of patch eluate. For analysis purposes analyte levels were transformed using a log transformation, ln (1 + *x*). Analysis of variance was performed on these transformed values. There were no significant differences of analyte concentrations between different wear times.