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Can synthetic urine replace authentic urine to "beat" workplace drug testing?

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Abstract

Synthetic urine (SU), which was primarily utilized by drug testing laboratories as a matrix for quality control preparations, is now commercially sold and can be used to "fool" a positive drug test. To determine if SU can pass as authentic urine, we challenged Army urine drug testing specimen accessioning and testing procedures using eight different commercial SU products. Adulteration (Sciteck AdultaCheck® 6) and Onsite SU (Synthetic UrineCheck™) test strips were also evaluated. Five of the eight SU were identified by physical observation. All SU products screened negative in the drug immunoassay and additionally passed the specimen validity testing (SVT) as authentic urine. Furthermore, SU was not detected as adulterated with the adulteration test strips (Sciteck AdultaCheck® 6) but was successfully detected as SU with the On-site synthetic urine (Synthetic UrineCheck™). To deter SU use, direct observation, as utilized by the military, may be recommended during the collection process.

KEYWORDS

drug abuse, synthetic urine, urine adulteration, workplace drug testing

1 | INTRODUCTION

The primary mission of the Department of Defense (DOD) Drug Reduction and Deterrence Program is to "detect and deter" military and civilian personnel from abusing illicit drugs and misusing prescription drugs.[1] Urine is still the preferred matrix for drug testing due to its ease of collection, sufficient volume, analyte stability, and longer drug windows of detection. Urine specimens are collected from service members under direct observation by a designated observer who ensures urine is voided by the donors.

If a specimen is reported positive, the service member can likely receive punishment in accordance with the Uniformed Code of Military Justice to include separation from military service and a "negative" federal record.

Due to the possibility of adverse actions, service members may attempt to "beat" the drug test. Previous practices include excessive hydration hours before the specimen collection, specimen adulteration,[2-7] and specimen substitution using a prosthetic penis such as the "Whizzinator."[8] In April 2017, Diagnostic Laboratory Services (DLS) on Oahu, Hawaii, believed that the decline in methamphetamine positive specimens received and tested in DLS was due to the substitution of urine with synthetic urine (SU).[9] In the news release, the laboratory director claimed that they were able to differentiate SU from authentic urine.

There are two differences between military and civilian drug testing: (a) In the military, urinalysis (UA) has to be observed, and (b) the military specimens are not required to undergo specimen validity testing (SVT) unless there is suspected urine adulteration or substitution.[10] Upon requests from unit commanders, these specimens are sent to Fort Meade forensic toxicology drug testing laboratory (FTDTL) to be tested for urine creatinine level, oxidant activity, pH, and if necessary, specific gravity.[11]

The concerns with SU raised valid questions in the military urine drug testing of whether specimen accessioning personnel can correctly identify urine as synthetic and if so, will it pass the SVT. The primary objectives of these studies are (a) Will SU be detected during

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physical examination of the urine specimen? (b) Will SU sample yield invalid screening results? (c) Will SU pass or fail the SVT? (d) Can commercially available SU and adulteration test strips differentiate SU from authentic urine samples?

2 | MATERIALS AND METHODS

A total of nine SU samples consisting of seven bought from local smoke shops (Figure 1), a powdered SU included in the "Whizzinator" reconstituted in deionized water (100 mg/mL), and in-house drug-free SU from Microgenics (Fremont, CA, USA) were evaluated. For comparison, five adulterated or substituted samples were prepared. Adulterated/substituted drug-free samples included 1:5 10% sodium hypochlorite (bleach):water; 1:5 bleach:authentic urine, apple cider vinegar, apple juice; and 1:5 10% hydrogen peroxide:authentic urine. Authentic negative urine purchased from UTAK (Santa Clarita, CA, USA), two donor urine samples, and deionized water were used as controls. On-site synthetic urine (Synthetic UrineCheck™) and adulteration strips (Sciteck AdultaCheck® 6) were provided by Sciteck (www.sciteck.org).

2.1 | Specimen Accessioning

All authentic de-identified negative urine specimens and SU/adulterated samples were handled in accordance with the Tripler Army Medical Center (TAMC) FTDTL laboratory procedures. Mock chain of custody forms were prepared for each specimen. Additionally, each specimen was labeled with a unique laboratory accession number and placed into screening batches in accordance with the laboratory procedures.

To evaluate whether the technician could distinguish a SU or adulterated urine from authentic urine, three specimen accessioning technicians with a minimum five years of experience were tasked to aliquot the urine samples for immunoassay screen. None of the technicians had prior knowledge of which bottles contained adulterated or SU samples. Technicians are trained to flag (i.e. assign "SB" discrepancy code) any specimen suspected of adulteration or substitution by smell (or absence of), color, and other physical characteristics such as bubbles produced when sample is gently swirled or presence of clots or undissolved objects in the urine. Once the technicians had completed pouring the aliquots, the batches were processed for immunoassay testing.

2.2 | Immunoassay screening

All specimens were analyzed in the Beckman Analyzer AU5800. The analyzer is calibrated once every 24 hours. Calibrators were prepared in house at the DOD cut-off concentrations for d-amphetamine (500 ng/mL), benzodiazepines (oxazepam, 200 ng/mL), cocaine (benzoylecgonine, 150 ng/mL), heroin (6-acetylmorphine, 10 ng/mL), delta-9-tetrahydrocannabinol (11-nor-delta-9-tetrahydrocannabinol-9-carboxylic acid 50 ng/mL), opiates (morphine 300 ng/mL and 2000 ng/mL), synthetic opioids (oxymorphone/hydrocodone 300 ng/mL), and synthetic cannabinoids (JWH-018 pentanoic acid, 10 ng/mL). Open quality controls were screened to verify acceptable calibration.

2.3 | Specimen validity testing

For this study, eight SU (excluding Microgenics), three authentic urine, and four adulterated/substituted samples were sent to Fort Meade to assess SVT performance. A specimen is reported valid (i.e., authentic urine), if the pH is between 4.5 and 9, creatinine >20 mg/dL, and there is no presence of an oxidizing agent. A specimen is considered "dilute" if creatinine is ≥2 mg/dL and <20 mg/dL, and specific gravity (SpGr) is >1.0010 and < 1.0030. A specimen is considered "substituted" if creatinine is <2 mg/dL and SpGr is ≤1.0010 or ≥1.020. A specimen is adulterated if the pH is <4.0 or >11.0 and the nitrite level is ≥500 μg/mL. A specimen is invalid if (a) creatinine <2 mg/dL but has acceptable SpGr, or (b) SpGr ≤1.0010 but has acceptable creatinine, or (c) abnormal pH (<3 or >11), or (d) oxidant activity ≥200 μg/mL.

2.4 | Field kits

Furthermore, the laboratory evaluated the on-site test strips (Synthetic UrineCheck™) with nine known SU samples and 116 randomly collected urine specimens to determine if SU could be detected at the point of collection. Any samples or specimens that produced abnormal results on the Synthetic UrineCheck™ were further evaluated with the Sciteck AdultaCheck® 6 to test for oxidant, creatinine, nitrite, glutaraldehyde, pH, and chromate. Three authentic urine samples and water were included as controls for the Synthetic UrineCheck™ and AdultaCheck® 6. An adulterated sample with 1:5 bleach:urine was tested with the AdultaCheck® 6.

FIGURE 1 Synthetic urine (SU) specimens purchased at the local smokeshops, Oahu, Hawaii. Top row (L-R): Quick Fix, Field Kit, Dr Green's X Agent; Bottom row (L-R): S5 Synthetix, Ultimate Gold, UPASS, XStream [Colour figure can be viewed at wileyonlinelibrary.com]

3 | RESULTS

3.1 | Specimen accessioning

The first technician flagged two samples (10% bleach in water and water), while the only SU in the batch (Field Kit) was missed. The second technician flagged all four SUs (UPASS, Quick Fix, Synthetix5, and Dr Greens) and two substituted (water and apple cider) as "SB." The third technician flagged 4 out of 8 samples that either were SU or adulterated. The technicians who correctly identified the SU samples noted that these were yellow, clear, and odorless. Overall, six out of nine SU samples were correctly assigned "SB", while apple juice and urine adulterated with 10% peroxide were missed. Results are summarized in Table 1.

3.2 | Immunoassay screening

The immunoassay results were reviewed by a certified QC technician and all the SU samples screened valid negative per the laboratory's acceptance criteria.

3.3 | Specimen validity testing

All eight SU samples (excluding Microgenics) shipped and analyzed at FTDTL Fort Meade were reported as "valid" or "diluted" with pH between 5.4 and 8.1. All had creatinine >20 mg/dL except for the "Whizzinator" (9.6 mg/dL), which was identified as diluted. Except for Quick Fix at 3 μg/mL nitrite equivalent, all SU produced no oxidant activity. Since SpGr was not measured for any sample with creatinine >20 mg/dL, measurements were subsequently taken at the TAMC Clinical Laboratory. SpGr for all SU were within normal range (>1.0010 and ≤ 1.020). A summary of the results is listed in Table 2.

3.4 | Field kits

With the Sciteck Synthetic UrineCheck™, urine is supposed to turn the test strip ranging from light yellow to dark yellow orange color. Results are considered "abnormal" when the test strips are a pinkish color or red. Using the Sciteck Synthetic UrineCheck™, all nine known SU samples, 8/116 (6.9%) randomly selected urine specimens and water produced "abnormal" results (Figure 2). Five of eight specimens appeared colorless, while all SU samples that produced "abnormal" colorimetric results with Synthetic UrineCheck™ appeared yellow and clear. The authentic urine controls produced "normal" results. When further evaluated with AdultaCheck® 6, seven out of eight SU samples produced normal results comparable to the authentic urine controls (Figure 3). An abnormal oxidant colorimetric result was observed with QuickFix SU (sample no. 2), but produced acceptable nitrite level (150 μg/mL) per Sciteck acceptance criteria. None of the eight

TABLE 1 Samples identified as "suspected adulteration" (flagged) by technicians who were tasked to prepare aliquots for immunoassay screening

Batch Number (n = total specimens)	Flagged	Not Flagged
1 (*n* = 96)	5:1 Water with 10% bleach, water	Field Kit (SU)
2 (n = 96)	UPASS (SU), QuickFix (SU), Synthetix5 (SU), Dr. Green's (SU), water, apple cider	
3 (*n* = 116)	Microgenics (SU), Whizzinator (SU), UTAK (AU), 5:1 urine with 10% bleach	Xtreme (SU), Liquid Gold (SU), apple juice, 5:1 urine with 10% hydrogen peroxide

Abbreviations: SU (synthetic urine), AU (authentic negative urine).

TABLE 2 Validity test results of synthetic, adulterated, and authentic urine samples analyzed at the Forensic Toxicology Drug Testing Laboratory, Fort Meade, Maryland, USA

Sample No.	Description	Creatinine (mg/dL)	Specific Gravity	pH	Oxidant Activity (μg/mL nitrite equiv)	Interpretation
1	Bleach *w*/water	18.6	1.0093	11.93	317	Adulterated
2	Field Kit	92.6	1.013*	7.2	0	Valid
3	UPASS	94.8	1.013*	7.2	0	Valid
4	Apple Cider Vinegar	1.1	1.0123	<2.94	0	Invalid
5	Quick Fix	21.4	1.008*	7.4	3	Valid
6	Synthetix5	61.8	1.011*	5.4	0	Valid
7	Dr. Greens	67.1	1.013*	7.7	0	Valid
8	Apple Juice	25.9	Not tested	3.63	0	Adulterated
9	UTAK	91.4	1.012*	6.5	0	Valid
10	Whizzinator	9.6	1.0014	8.1	0	Valid/Dilute
11	Xstream	58.9	1.009*	6.8	0	Valid
12	Liquid Gold	36.8	1.009*	7.8	0	Valid
13	10% peroxide (1:5)	78.2	Not tested	6.7	11	Valid
14	Donor (authentic)	39.8	Not tested	6.1	0	Valid
15	Donor (authentic)	55.2	Not tested	6.6	0	Valid

*Measurements taken separately at Tripler Army Medical Center Clinical Core Laboratory.

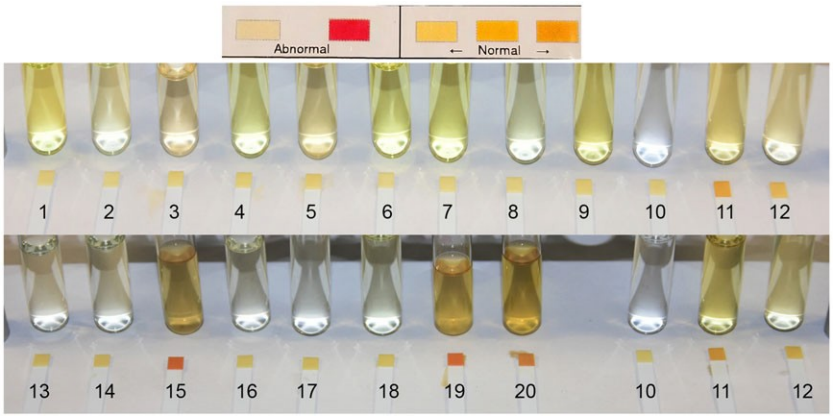

FIGURE 2 Colorimetric results of synthetic urine (#1–9), water (#10), authentic urine (#11–20) samples using the Scitex Synthetic UrineCheck™ [Colour figure can be viewed at wileyonlinelibrary.com]

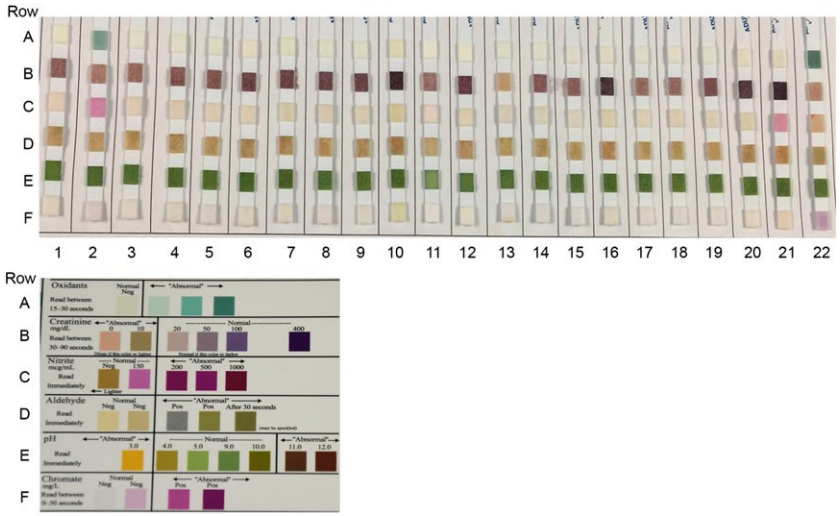

FIGURE 3 Colorimetric results of synthetic urine (#1–7, 9–10), water (#13), authentic urine (#8, 11, 12, 14–21), and urine adulterated with bleach (#22). Sample no. 22 is 1 part bleach to 5 parts authentic urine [Colour figure can be viewed at wileyonlinelibrary.com]

authentic urine specimens produced abnormal colorimetric results with the AdultaCheck® 6 test strips. The bleach-adulterated urine (sample no. 22) appeared "abnormal" for oxidant.

4 | DISCUSSION

Adulteration of urine specimens is a concern for any forensic urinalysis program, including the DOD military urinalysis program. The availability of SU commercially has added another avenue in which urinalysis may be "beaten." Whereas civilian urinalysis involves SVT as part of the urine drug testing, DOD compensates for this by having direct observation during urine collection. Although civilian urine specimens undergo mandatory SVT, the rate of authentic urine substitution with SU during the collection process is unknown. The implementation of SVT has assisted laboratories and medical review officers in identifying adulterated or substituted specimens,[11] but may not be sufficient for SU detection of either civilian and military specimens.

Based on the SVT results observations, SU are formulated to contain creatinine >2 μg/mL with pH between 5.5 and 7.5. This explains why the on-site AdultaCheck® 6 strips were not able to differentiate the SU from authentic urine. Furthermore, all the SU products screened negative with the multi-drug immunoassay test and SVT, which makes them even more appealing as urine substitutes for civilian urine drug testing.

Since SVT is not mandatory for service member urine specimens, the military relies on trained technicians to identify possible adulterated or substituted urine specimens by their color, odor, and other physical characteristics. In the past, technicians have correctly assigned "SB" to specimens due to lack of color and/or odor while other specimens produced bubbles and sweet odor similar to hand soap. Specimens with bleach give out a strong odor and can be easily identified. However, repeated exposure to strong urine odor can mask or weaken the technician's sense of smell. Thus, SU that appears as the same color and has similar characteristics as authentic urine can be missed in the process.

The use of direct observation in urinalysis is another viable way to decrease the use of adulterants and SU. In the DOD forensic urinalysis program, an observer must be present to observe the active stream of urine leaving the donor's body. Even this does not deter substitution of the urine in the military and direct observation is only as good as the observers' attention to detail. This was tested by the use of "Whizzinator," a prosthetic penis attached to a bladder with a temperature strip. We evaluated the effectiveness of the "Whizzinator" by asking volunteers to wear the contraption under direct observation of trained urinalysis coordinators. Two out of four observers observed the donors wearing the device (unpublished data).

Interestingly, the Synthetic UrineCheck™ strips were able to discriminate the SU products from authentic urine. Because the SU products passed as authentic urine (valid) in the SVT at Fort Meade, it is not surprising that these products also passed for authentic urine using the adulteration strips (AdultaCheck® 6). The Synthetic UrineCheck™ strips were designed to detect artificial urine versus authentic urine. They can be used as a qualitative tool. However, diluted specimens could result in an abnormal reading (Figure 2) and should be further evaluated with SVT.

Goggin et al recently proposed unique markers (antifungal, ethylene glycol, and uric acid) identified in artificial urine samples that can be used as targets in improving the specificity of on-site SU detection strips or SVT designed for high throughput.[12]

An online search of "states banning synthetic urine" reveals the state itself can vote to ban the sale of SU, include fines, and even make it a crime if used for cheating a drug test.[13]

5 | CONCLUSION

We determined that commercially available SU products are acceptable authentic urine substitutes in defeating the urine drug testing. We also strongly believe the most effective way to deter and detect adulterated and/or SU is improving the collection process. The observer should be made aware that bags, tubes, and prosthetic penises can be hidden under clothes. The environment where collections are performed should provide good visibility between the observer and the donor. SVT still remains the most effective method in identifying adulteration and can be further supplemented with test strips or reagents that may discriminate between SU and authentic urine.

DISCLAIMER

The opinions or assertions herein are those of the authors and do not necessarily reflect the views of Department of Defense, Army, Navy, or Air Force.

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