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The effect of time and environmental conditions on Touch DNA

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Abstract

Touch DNA analysis has become an important aspect of a forensic laboratory's workload and a crucial tool for investigators in many cases. However, there is a lack of research regarding the influence of environmental conditions on Touch DNA, which is proven to reduce traces of biological material in samples. This study investigated the influence of time between deposition and recovery of Touch DNA, as well as the impact of temperature and humidity on a range of porous and non-porous surfaces.

Keywords: Forensic science, Touch DNA, DNA recovery, PrepFiler Express BTA, AutoMate Express, Quantifiler™ Human DNA Quantification Kit

1. Introduction

Touch DNA analysis has become an important forensic technique and a crucial tool for investigators. However, there are many variables that affect the results of Trace DNA [1]. In addition to these factors, time and environmental conditions also affect Touch DNA. Although a few previous studies looked at the influence of time between deposition and recovery [2], there is a lack of research regarding the influence of environmental conditions, such as temperature and humidity, which have proven to reduce traces of biological material in samples [3].

Therefore, the aim of this study was to investigate the influence of time between deposition and recovery of Touch DNA and the impact of temperature and humidity on a range of porous and non-porous surfaces.

2. Materials and methods

2.1 Experimental set up and deposition

A selection of four surfaces (stainless steel, smooth non-porous; glass, smooth non-porous; textured wood, rough porous and textured plastic, rough non-porous) were chosen to replicate common items encountered in crime. All non-porous surfaces were cleaned by viricidal disinfectant (2% virkon) and ultraviolet radiation (UV) for 15 min, and only textured wood was irradiated with UV for 25 min.

For DNA deposition, a participant was asked to wash his hands with antibacterial soap and refrain from undertaking any activity for 10 min, then charge the fingers of both hands with eccrine sweat by touching behind their ears or forehead to load them with enough DNA. The participant was then asked to touch the surfaces using their index, middle, and ring fingers of both hands separately for deposition by applying medium pressure on a 5 x 7 cm area of the surface for 1 min. The same procedure was repeated on all surfaces for equal deposition on each surface.

2.2 Conditions

To assess the effect of time in different environmental conditions, the selected surfaces were left for four time periods (3 h, 12 h, 24 h and one week) in three conditions (two replicates of samples for each condition): (a) Room temperature (RT) with moderate humidity (20 °C to 25 °C/50%) (n=32), (b) High temperature (HT) with moderate humidity (40 °C/50%) to simulate Dubai weather (n=32) and (c) Low temperature (LT) with high humidity (5 °C/78%) to simulate London weather (n=32). The surfaces were stored in the oven and fridge for the HT and LT conditions respectively, and the temperature was monitored regularly using a hygrometer thermometer digital device. Ovens have very low humidity, so a plastic container of water was kept inside the oven to moderate the humidity.

2.3 DNA recovery and extraction

Samples were collected using a Copan 150C Cotton swab (Copan, Brescia, Italy) moistened with 100 µL of sterile distilled water applied using a plastic spray bottle technique (developed in Dubai police forensic DNA lab; each single spray contains approximately 50 µL). Water was added when Touch DNA was collected at room temperature and high temperature, but not at low temperature because of the high surface humidity.

Full swabs head were used for extraction immediately after collection using PrepFiler Express BTA™ kit with AutoMate Express Forensic DNA Extraction System according to the manufacturer's instructions (Thermo Fisher Scientific) and the final extracted sample elution was 50 µL.

2.4 DNA quantification, amplification and analysis

Extracted samples were quantified using the Quantifiler® Human DNA Quantification Kit, QuantStudio 5 Real-Time PCR (qPCR) and HID Real-Time PCR analysis software v1.3 according to manufacturer's instructions (Thermo Fisher Scientific). Amplification were performed using the GlobalFiler™ PCR Amplification Kit (Thermo Fisher Scientific), following the 30 cycles protocol. The data were analysed using GeneMapper® ID-X Software Version 1.2 (Thermo Fisher Scientific). Statistical analysis on the tested variables was performed with RStudio using factorial analysis of variance (ANOVA). In ANOVA the p-value is derived from the F-distribution which is different for every pair of degree of freedom (df) values ($F \text{ value} = \text{variance of the variables means (Mean Square Between)} / \text{mean of the within variables variances (Mean Squared Error)}$). Blanks were taken from surfaces after sterilisation, and negative controls for the collection and extraction methods, all of which proved negative for DNA when quantified.

3. Results and discussion

At RT the amount of collected DNA from the selected surfaces (stainless steel, glass, textured wood and textured plastic) (n=96) was not affected by time ($F_{3,16} = 0.29$, $p = 0.83$), but at HT and LT the amount of collected DNA was significantly affected by time ($F_{3,48} = 7.74$, $p < 0.001$), condition of the surfaces ($F_{2,48} = 20.72$, $p < 0.001$), the interaction between surface type and conditions ($F_{6,48} = 41.24$, $p < 0.001$), the interaction between conditions and time ($F_{6,48} = 3.26$, $p < 0.001$) and the interaction between all the variables ($F_{18,48} = 8.59$, $p < 0.001$).

Typically, more DNA is recovered from freshly touched surfaces when compared to surfaces stored over a long period of time [2], but the amount of recovered DNA is highly dependent on the conditions the touched object is exposed to. Over the four periods of time, the amount of DNA collected from each surface was stable at RT, but at HT and LT there was a slight change. Furthermore, the results showed that each surface behaved differently with the same conditions they were exposed to. This is caused by the interaction between each surface type with the different temperature and humidity (Figure 1). High heat can increase the rate of hydrolytic cleavage, leading to direct cleavage of the DNA strands due to drying.

Some non-porous smooth surfaces, such as stainless steel and glass absorb heat. Even though the quantity is low, it is more effective in comparison to rough surfaces, as they are known to retain more DNA than smooth surfaces. Moreover, although moisture in a sample can lead to an increased rate of degradation, it may also increase DNA transfer [4]. In this case, more DNA was collected from glass and stainless steel in LT with high humidity when dry cotton swabs were used. In contrary, high humidity can lead to decrease the amount of DNA on porous surfaces such as wood because the water content is higher due to the water moving through the pores, which deteriorates traces of DNA left on the object.

Samples from stainless steel, textured plastic and textured wood stored at the three conditions for a week were amplified to validate the quality of samples collected. All the amplified samples produced full DNA profile, but there was some variation in the peak height between the samples collected for each surface at different conditions (Figure 2).

4. Conclusion

This study showed that time itself does not influence Touch DNA on the surfaces at room temperature, but the effect of different environmental conditions, such as low/high temperature low/high humidity can impact the persistence of DNA. Different type of surfaces interacts differently with outdoor environmental conditions, so it is important to consider when dealing with Touch DNA Profiling. Moreover, in real-life cases DNA sample contamination can occur when items have been left for long periods indoors or outdoors, so it is important to collect Touch DNA as soon as possible to ensure higher DNA yields and to avoid contamination, especially if the items were found outdoors.

Conflict of interest

None.

Acknowledgements

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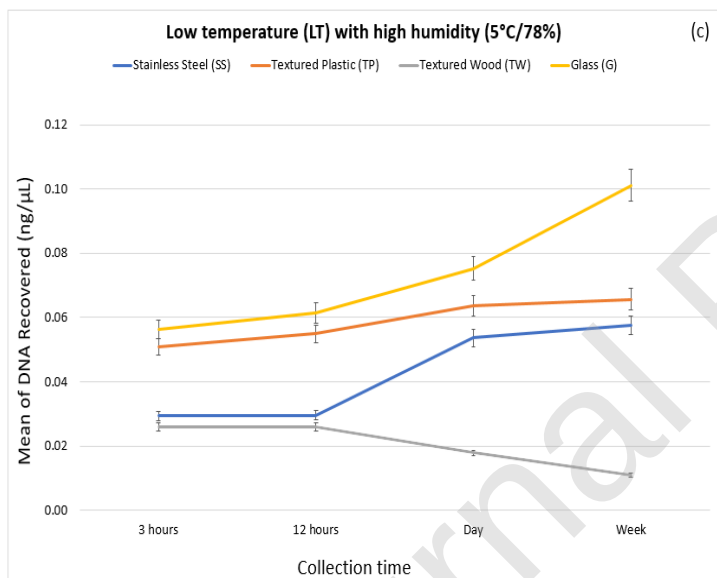
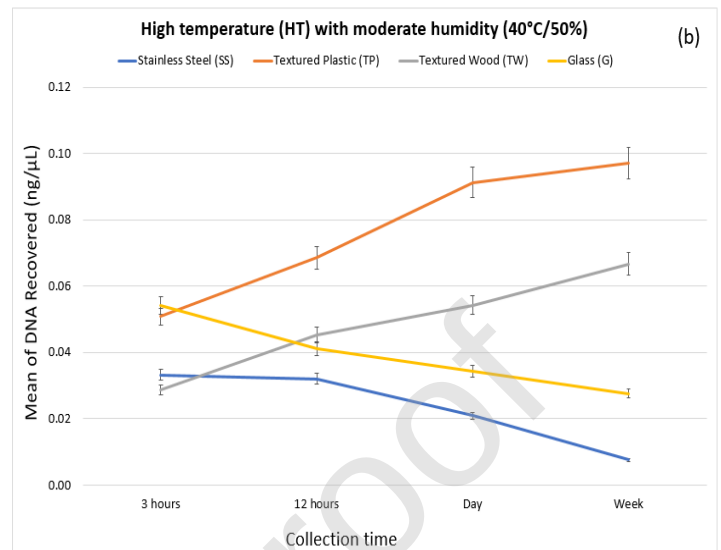
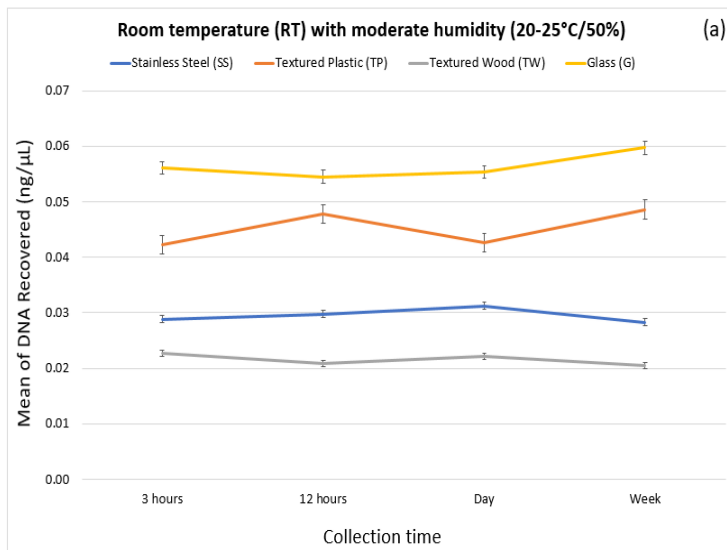


Figure 1 - The amount of DNA collected from the selected surfaces over four periods at three different conditions; RT^a (n=32), HT^b (n=32) and LT^c (n=32). The amount of DNA collected from glass and stainless steel decreased over time in HT, and increased in LT. In contrast, the amount of DNA collected from textured plastic increased in HT, and it was slightly stable in LT. Contrary to the glass the amount of DNA collected from textured wood increased in HT and decreased in LT. Error bars represent 95% confidence intervals.

STAINLESS STEEL

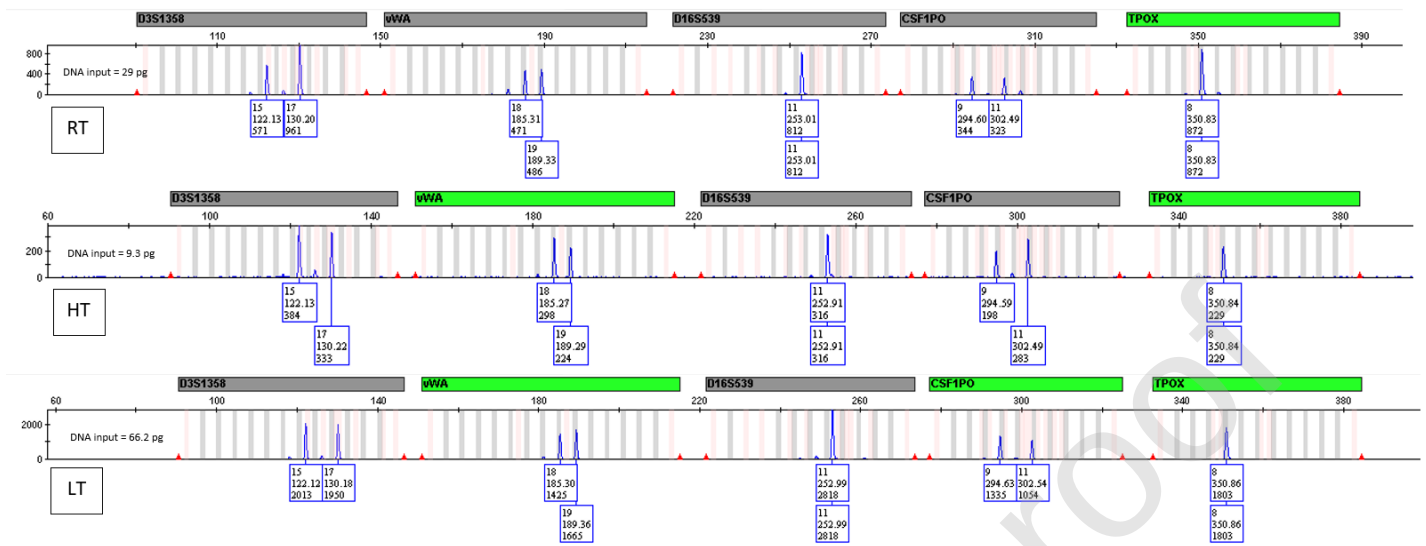


Figure 2 - Electropherograms of samples collected from stainless steel, at room temperature (RT), high temperature (HT) and low temperature (LT) over a week. The profiles show the difference in peak height between the three conditions at 5 autosomal STR loci (D3S1358, vWA, D16S539, CSF1PO, TPOX).