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Understanding Rates of Genital Injury: Role of Skin Color and Skin Biomechanics

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Abstract

Purpose.—A series of studies suggest that non-Hispanic White women have significantly more injuries than non-Hispanic Black women after sexual assault and consensual sexual intercourse. One explanation for this difference is that the degree of skin protection may vary as skin mechanics and skin pigmentation vary. The aim of the study was to determine the association among genital-anal injury, skin color, skin viscoelasticity and skin hydration in women following consensual sexual intercourse when controlling for age, smoking history, body mass index (BMI), sun exposure, and health status.

Procedures.—We employed a prospective cohort study design to enroll women 21 years of age or older at two study sites. They underwent two data collection sessions, baseline and follow-up after consensual sexual intercourse. Baseline genital-anal injury identification occurred with a standard forensic examination (direct visualization, nuclear staining with toluidine blue contrast, and colposcopy examination) and measurements of other variables (skin color, skin viscoelasticity, skin hydration, age, smoking history, body mass index [BMI], sun exposure, and health status). Participants were then asked to have consensual sexual intercourse with a male partner of their choice and to return for a second forensic examination for injury detection. Genital-anal injury was regressed on skin color, skin viscoelasticity, skin hydration, age, smoking history, BMI, sun exposure, and health status.

Findings.—We enrolled 341 participants, 88 non-Hispanic White (25.8%), 54 non-Hispanic Black (15.8%), 190 Hispanic/Latina (55.7), and 9 Other Identities (2.6%). At baseline the genital-anal injury prevalence was 57.77% and at follow-up after consensual sexual intercourse, injury prevalence was 72.73%. External genital injury prevalence was associated with increased L* (lightness) values (Adjusted Odds Ratio [AOR] = 1.98, 95% Confidence Interval [CI] = 1.03, 4.04) and decreased skin elasticity (AOR = 0.96, 95% CI = 0.93, 0.99) at baseline. Increased skin hydration was associated with a significantly higher frequency of external, internal, anal, and total genital-anal injuries (Adjusted Rate Ratio [ARR] > 1.27) at follow-up. Also at the follow-up examination, Hispanic/Latina participants had significantly lower external genital and total genital-anal injury prevalence and frequency as compared to non-Hispanic White participants (AOR < 0.40).

Conclusions.—Our findings provide qualified support for the importance of skin color during the forensic examination. Women with lighter skin tones may have skin that is more easily injured than women with darker tones. In contrast, external genital injuries may be more easily identified in women with light as compared to dark skin, a situation that is important in both the health care and criminal justice systems. Additionally, women with decreased viscoelasticity and increased hydration may be more easily injured. These findings support the need to develop forensic procedures that are effective in people across the range of skin colors and to interpret forensic findings considering the innate properties of the skin.

Keywords

Sexual assault; Genital-Anal Injury; Skin Color; Skin Biomechanics; Sexual Violence; Forensic Examination

Introduction

Detection and documentation of genital-anal injuries following sexual assault are essential components of the sexual assault forensic examination from both a healthcare and criminal justice standpoint.[1–5] Injuries need to be assessed and treated. Prosecutors note that injury evidence may corroborate a sexual assault survivor's statement and/or help prosecutors build a case against the alleged perpetrator, and are suggestive of the serious nature of the incident.[1] Research using prospective methods to study injury after consensual sexual intercourse can inform forensic findings and broaden our understanding about the nature of genital-anal injury after sexual assault.

Previous work in predominantly non-Hispanic African American/Black (self-identify as African American or Black, but not Hispanic or Latino) and non-Hispanic White (self-identify as White but not Hispanic or Latino) female samples has found significant differences in genital-anal injury prevalence based on racial/ethnic categories. After both consensual sexual intercourse and sexual assault (nonconsensual intercourse), non-Hispanic White females have a significantly higher injury prevalence than non-Hispanic Black females.[4,6–8] However, race/ethnicity may not explain the difference in injury prevalence. Following consensual sexual intercourse with a male partner, investigators found a higher prevalence and frequency of injury in non-Hispanic White as compared to non-Hispanic Black females. These differences were explained more fully by variations in skin color rather than by race/ethnicity.[6] Investigators noted that, when adding skin color variables (L* = lightness/darkness; a* = redness/greenness, b* = yellowness/blueness) derived from spectrophotometry to the statistical model, the effect of race/ethnicity became nonsignificant. They also determined that higher L* values (lighter skin) were significantly associated with injury to the external genitalia.[6] In work focused on an adolescent sample following sexual assault, investigators found that while race/ethnicity was associated with frequency of genital-anal injuries, skin color was also associated with injury in many anatomical locations. Sexual assault survivors with light skin sustained significantly more external genital injuries than those with dark skin.[7]

Several considerations may explain the associations of injury prevalence/frequency with skin color. Injuries may be more visible on light as compared to dark skin.[7] Nuclear staining techniques such as toluidine blue used during the forensic examination may be more effective on lightly pigmented as compared to darkly pigmented skin.[4] Additionally, classic skin science work suggests that injury prevalence and frequency may differ by race/ethnicity because of biomechanical differences in skin. Weigand et al. found that that the number of tape strips required to remove the stratum corneum (SC, the outer layer of the skin) was significantly higher in non-Hispanic Black than non-Hispanic White participants ($p<0.01$). They concluded that, not only did non-Hispanic Black individuals have more layers in their SC (mean 21.87, min/max 19/27) than did non-Hispanic Whites (mean 16.7, min/max 13/20), but they also had heavier SC weight and density.[9] Racial/ethnic differences have been demonstrated among non-Hispanic Black, non-Hispanic White, and Hispanic/Latina samples with respect to skin conductance, skin thickness, extensibility, elastic recovery, and viscoelasticity, but the authors noted that the clinical ramifications of these differences are

unknown.[10] We were unable to find any studies that explored the role of skin color and biomechanics with respect to injury after sexual assault.

Skin biomechanics are the biological, physical, and chemical properties that allow the skin to protect the body.[11] The focus of this paper is on two biomechanical properties of the skin: skin viscoelasticity and skin hydration, and how they relate to skin color and genital-anal injury in a diverse sample of women. Viscoelasticity has two components. Elasticity is the tendency of solid materials to return to their original shape and size after the application of force. Viscosity is a measure of a fluid's resistance to flow when a shearing force or stress is applied to the fluid.[11] As compared to elasticity alone, viscoelasticity protects the skin against injury and allows for additional movement away from and returning to its original shape without injury.[12]

Skin hydration, defined as the water content of the SC, maintains the plasticity of the skin, thereby protecting it from damage.[13] Because viscoelasticity and skin hydration can be affected by age,[14] smoking history,[15] body mass index (BMI),[16,17] sun exposure,[18] and general health,[11,15] these variables require consideration during skin studies. To understand the relevance of genital-anal injury, skin color, and skin biomechanics (viscoelasticity and hydration) following sexual assault, we investigated these variables prospectively in a cohort of women following consensual sexual intercourse. The aim of the study was to determine the association among genital-anal injury, skin color, skin viscoelasticity and skin hydration in women following consensual sexual intercourse when controlling for age, smoking history, body mass index (BMI), sun exposure, and health status.

Materials and Methods

Study Design and Procedures

We employed a prospective cohort study design at two sites (Philadelphia, PA and San Juan, PR) with two data collection sessions, baseline and follow-up after consensual sexual intercourse. Baseline genital-anal injury identification occurred with a standard forensic examination (direct visualization, nuclear staining with toluidine blue contrast,[19] and colposcopy examination)[4,20] and measurements of other variables (skin color, skin viscoelasticity, skin hydration, age, smoking history, BMI, sun exposure, and health status) in our skin science laboratories. Participants were then asked to have consensual sexual intercourse with a male partner of the participant's choice at a location of their choice. We did not dictate the type and nature of the sexual interaction, but asked the participants: "Please have sexual intercourse with your partner." Participants returned to the laboratory for a second, duplicate forensic examination and data collection session at a prescribed time (see below) following intercourse. All examinations were performed by experienced sexual assault nurse examiners who performed at least 10 examinations under observation by an expert examiner prior to participant enrollment and every six months during enrollment. All procedures were approved by the Institutional Review Boards of the affiliated universities, all female participants signed informed consent written in English or Spanish. All male partners provided verbal assent to participate in English or Spanish. Female participants were paid $50 for the initial interview, $150 for the first examination, and $150 for the second examination. Male partners were not interviewed or compensated.

Sample and Sampling Procedures

Participants were recruited from urban health sciences centers and their environs by flyers and word of mouth. Interested candidates were screened by phone to determine whether or not they met inclusion/exclusion criteria. Participants were English- and Spanish-speaking, cis gender female (gender identity and gender expression are aligned with their assigned sex listed on their birth certificate) community dwellers, 21 years of age and older. We included women who had previously healed after a variety of procedures such as conization of the cervix, partial or total hysterectomy, or treatment for gynecologic cancer in order to increase the comparability with sexual assault survivors. Exclusion criteria included injury to the genitalia or rectum/anus in the last month (pre-existing injury may change the injury findings after consensual sex), pregnancy (to avoid the risk of complications because of the examinations), heavy menses at the time of examination that obscured injury findings,[20] and allergy to contrast media because of the application of toluidine blue. All participants, regardless of age, received pregnancy and sexually transmitted infection testing prior to the first examination and a referral to a nurse practitioner and/or the health department for positive findings.

In order to obtain a representative sample, we recruited females who matched the age and race/ethnicity of survivors of sexual assault in an existing emergency department sexual assault registry (N > 1,000 cases). In step 1, we determined the proportion of women in various age groups (21–24, 25–34, 35–44, 45–54, 55–64, ≥ 65 years old) and race/ethnicity categories from the registry. In step 2, we distributed the total projected sample size across the categories from step 1. In step 3, as participants were recruited into the study, they were included in those categories until they were filled. In step 4, as given categories were filled, participants matching on their age and race/ethnicity were excluded. A second study was funded to test our aims with a Hispanic/Latina sample, allowing for an additional 200 Hispanic/Latina participants to be enrolled. Age categories and time interval between sexual intercourse and examination from the sexual assault registry were also applied to the Hispanic/Latina sample.

We asked our participants to identify their race and ethnicity using the categories provided by the United States National Institutes of Health.[21] Ethnicity was classified as either Hispanic/Latino or non-Hispanic/Latino. Racial categories included African American or Black, White, and Other (American Indian or Alaska Native, Asian, Native Hawaiian or Other Pacific Islander). We recognize that self-identification is not a biological indicator of race/ethnicity, but rather an indication of affiliation with a group or groups.

After applying the inclusion and exclusion criteria, we recruited 88 non-Hispanic White, 54 non-Hispanic Black, 190 Hispanic, and 9 participants of other or mixed race/ethnicity into our sample, for a total of 341 women. A sample of 341 women yielded more than 90% power to detect odds and rate ratios as small as 1.50 in our statistical models (see below), given alpha ≤ .05. A wash-out period of 24 hours was used between the baseline examination and consensual sexual intercourse to reduce any genital-anal injury that may have occurred from the baseline examination itself. Following consensual sexual intercourse, participants were asked if vaginal or anal penetration occurred. They were also asked to describe the roughness or gentleness of the behaviors on a scale of 1 (gentle) to 10 (rough).

Measures

Injury was determined by total count of tears, ecchymoses, abrasions, redness, and swelling (TEARS classification)[22] at the external, internal, and anal sites. Several classification systems are available to categorize injury in forensic sexual assault examination.[3,23,24] The Core Curriculum for Forensic Nursing does not recommend any one system; rather the authors of the Core Curriculum recommend the use of consistent terminology, strategies to estimate injury severity, and a standardized nominclature.[23] We chose the TEARS classification because of its prevalence in the recent forensic literature,[4,19,20,25] consistent use of terminology, and our ability to compare our findings with previous published work using the TEARS categories.[6,7,19,20,22,26,27]

Tears were defined as any breaks in tissue integrity including fissures, cracks, lacerations, or cuts. Ecchymoses were defined as skin or mucous membrane discolorations, known as "bruising," due to the damage of small blood vessels beneath the skin or mucous membrane surface. Abrasions were defined as skin excoriations caused by the removal of the epidermal layer and with a defined edge. Redness was defined as erythemous skin abnormally inflamed due to irritation or injury without a defined edge or border. Swelling was defined as edematous or transient engorgement of tissues.[3] Injury prevalence was defined as the proportion of participants with an occurrence of any genital-anal injury. Injury frequency was defined as the total number of injuries counted by examiner during direct visualization, nuclear staining with toluidine blue contrast, and colposcopy examination. Injuries detected with more than one method were counted once.

All skin measurements (viscoelasticity, hydration, color) were made at the right, inner upper thigh two inches below the groin (inguinal area) during the baseline examination. This site was chosen because it is proximal to the genital-anal area. The immediate genital-anal area contains a significant amount of moisture secreted from mucous membranes and cannot be used for skin measurements. Moisture damages the instruments used to collect skin color, viscoelasticity, and hydration and creates error in measurements.[28–30]

To determine *skin color*, we used a reflectance spectrophotometer (ColorTec® PSM hand-held spectrophotometer, Clinton, NJ). Color measurement was based on a commonly-accepted color space, the 1976 CIELAB (CIE L*a*b*), a three dimensional model representing colors relative to a white reference point.[31] The CIELAB color space consists of three axes at right angles to each other: the L* axis represents the light/dark component of color (0 [black] to 100 [white]), the a* axis represents the red/green component of color (+127 to −127), and the b* axis represents the yellow/blue component of color (+127 to −127). Human skin color is found in the positive a* (red) and positive b* (yellow) quadrants of the CIELAB color space; skin color L* values generally range between 25 (dark) and 70 (light).[32] Before each data collection session with the spectrophotometer, we performed color quality control procedures to ensured that the L* values were 100 (white/lightness) and 1 (black/darkness) with no more than +/− 5% error.

Measurements of *skin viscoelasticity* were made with a Cutometer® MPA 580 (Courage + Khazaka electronic GmbH, Kőln, Germany),[30] viewed as the gold standard for measurement of skin elasticity.[14,33] Viscoelasticity of the upper layers of the epidermis is measured by the

skin's deformation response under a predetermined negative pressure within a circular aperture of a skin probe.[16] The negative pressure deforms the skin as it is drawn into the aperture of a probe. After a defined period of time, the skin is released again. We used a probe with a 2mm aperture to apply 5-seconds of vacuum of 400 mbar, followed by a 5 second relaxation period. Skin viscoelasticity was operationalized as biological elasticity, described as the "R7" measurement by the manufacturer and defined as the ratio of elastic recovery (*Ur*, in millimeters, 0.1 second after release of negative pressure) and elastic deformation (*Uf*, in millimeters, total displacement from initial position at maximum negative pressure).[16,33,34] Higher values indicate more elastic skin.[16]

Measurements of *skin hydration* were made with a Corneometer® CM 825 (Courage + Khazaka electronic GmbH, Kőln, Germany),[29] considered the gold standard for skin hydration measurement.[14,35] The corneometer is used to determine skin capacitance and reflects the water content of the superficial epidermal layers down to a depth of approximately .01 to .04mm[36,37]. Measurements are based on principle that the dielectric constant of water (81) and other substances (generally less than 7) are very different.[36,38] Corneometer measurements are expressed as arbitrary units (au) from 0 to 130,[29,39] which in theory are proportional to the stratum corneum water content.[37] The moisture-related skin type is determined as follows: very dry skin is characterized as having corneometer units below 30 au, dry skin between 30 and 40 au, and normal skin higher than 40 au.[40]

As noted earlier, viscoelasticity and skin hydration can be affected by age, smoking history, BMI, and sun exposure; therefore, we controlled for these variables. *Smoking status* was determined by the following question: In the past 6 months, on the average, how many cigarettes/tobacco do you smoke/use a day? *BMI* was determined by height and weight measurements obtained in the skin science laboratory by trained study staff. *Sun exposure* was determined by the following question: In the past 12 months, how many times did you have a red, blistering, or painful sunburn that lasted a day or more? *Health status* was determined by the following question: Using a scale of 1 to 10, where 1 is poor health and 10 is excellent health, how would you rate your general health? All participants were interviewed by trained study staff prior to the second examination to determine the length and characteristics of the sexual interaction with their partner.

Data Analysis

Indicators for each injury type and anatomical area were recoded to create a set of composite binary and count variables for external genital injuries, internal genital injuries, anal injuries, and injuries to any area. Binary variables represented the presence or absence and count variables represented the number of injuries to the given anatomical area.

Descriptive statistics were computed for all study variables. Genital-anal injury types (external, internal, anal, and any), were modeled in two ways. First, binary logistic regression analyses were used to model the odds for the presence or absence of each type of genital-anal injury. Next, negative binomial count process regression analyses were used to model the number of each type of genital-anal injury. For both sets of models, the full set of predictors included age, race (non-Hispanic White, non-Hispanic Black, Hispanic/Latina, Other Identities), skin color values (L*, a*, and b*), skin viscoelasticity, skin hydration,

current smoking status (yes/no), BMI, sunburn in the last 12 months (yes/no), health status, and prevalence or frequency of the baseline examination injury. One set of analyses used injury results from the baseline examination as outcomes, and another set of analyses used injury results from the follow-up examination as outcomes, controlling for baseline examination injuries. Two and three-way interactions among skin color values, hydration, and elasticity were also evaluated in our models, but the effects were largely found to be non-significant statistically or so small as to be clinically irrelevant, and, as a result, are not included in among the results. Additionally, although models were adjusted for duration of intercourse (minutes), this variable is not presented in the tables because it had no effect (adjusted odds and rate ratios = 1.0). Adjusted odds ratios (AOR) and their 95% confidence intervals were calculated for all logistic regression models, and adjusted rate ratios (ARR) and their 95% confidence intervals were calculated for all negative binomial models. Analyses were conducted using the R environment for statistical computing.[41]

Results

Table 1 presents descriptive statistics for all study variables. At the follow-up examination, 72.73% of women in the sample had at least one genital-anal injury, and the average number of injuries was 2.49 (SD = 2.96). External genital injury was observed for 51.32% (M = 1.61, SD = 2.45), internal genital injury was observed for 44.57% (M = 0.61, SD = 0.82), and anal injury was observed for 12.90% (M = 0.26 injuries, SD = 0.99) of the sample. Prevalence and frequency of injury at the baseline examination was lower for all genital-anal regions (see Table 1).

Results of logistic regression models predicting prevalence of genital-anal injury are presented in Table 2. For the baseline examination, increased skin elasticity was associated with a significant decrease in the prevalence of any injury, external genital injury, and anal injury. Non-Hispanic, Black women had a significantly greater prevalence of any injury and anal injury, while women of Other Identities had a significantly greater prevalence of only anal injury, as observed during the baseline examination. Higher L* values were associated with a significantly greater prevalence of external genital injury, as observed during the baseline examination. For the follow-up examination, Hispanic/Latina women had a significantly lower prevalence of any injury, external genital injury, and internal genital injury, while women of Other Identities had a significantly lower prevalence of only internal genital injury. Non-smokers and women with increased elasticity had a significantly greater prevalence of internal genital injury, as observed during the follow-up examination. Also from the follow-up examination, women with a sunburn in the last 12 months had a significantly greater prevalence of any injury.

Results of negative binomial regression models predicting genital-anal injury frequency are presented in Table 3. For the baseline examination, and similar to results for injury prevalence, increased elasticity was associated with a significant decrease in the frequency of any injury, external genital injury, and anal injury. Higher a* values were associated with a significantly lower frequency of any injury and internal genital injury, as observed during the baseline examination. Additionally, a more positive health status was associated with a significantly lower frequency of any injury and external genital injury. For the follow-up

examination, Hispanic/Latina women had a significantly lower frequency of any injury and external genital injury, while women of Other Identities had a significantly higher frequency of anal injury. Although higher a* values were associated with a significantly lower frequency of external genital injury, higher b* values were associated with a significantly higher frequency of any injury and external genital injury, as observed during the follow-up examination. From the follow-up examination, women with a sunburn in the last 12 months had a significantly greater frequency of any injury.

Discussion

Following sexual intercourse, participants had a significant increase in the prevalence of injuries from baseline. Approximately 73% of women had at least one injury to the external genitalia, internal genitalia, or anal area at the follow-up exam (an increased from 58% at baseline). Several studies of injury after consensual sexual intercourse report an injury prevalence in a lower range (30–60%),[42–44] while Jones et al. found an injury prevalence 73% in adolescents after consensual sexual intercourse,[45] similar to our findings. Our relatively high rates of injury at baseline and follow-up were surprising. We propose that they may reflect sexual activity prior to enrollment at baseline or that women routinely have some degree of genital-anal redness or injury unrelated to intercourse. We did not ask our participants to abstain from sexual intercourse prior to our baseline examination because we were seeking a sample of women comparable to that seen by a sexual assault program. However, the mean time from last intercourse to the baseline examination was 205.6 hours (Mdn = 71.0 hours, SD= 692.67 hours, minimum = 3.0 hours, maximum = 9040.0 hours), indicating that the baseline injuries were likely not intercourse-related. Rather, most intercourse-related injuries would have had on average 8 to 9 days (205.6 hours) to heal prior to the baseline examination, leading to complete healing.[46]

The most common location for genital-anal injury in the sample was the external genital area. Baseline external genital injury prevalence was 34.02% and follow-up external genital injury prevalence was 51.32%, with an external genital injury frequency of 0.77 at baseline and 1.61 at follow-up. Similarly, other investigators have found that the external genital area is the most commonly injured area after consensual and non-consensual intercourse.[6,22,45] Given the prevalence and frequency of external genital injury in our sample and the strength of our findings, much of the following discussion will focus on external genital injuries.

Skin Color

Higher L* values (lighter skin) were positively associated with injury prevalence of the external genitalia in our baseline data. Several explanations have been offered in the literature explaining increased injury prevalence and frequency in women with light as compared to dark skin. Investigators have noted non-Hispanic, Black/African American people have an additional layer of SC,[10] which may serve as protection from injury. Clinicians have suggested that nuclear stains used in the forensic examination, particularly those dark in color, may highlight external genital injury more successfully in people with light as compared to dark skin.[5]

Re-enforcing the theory that light skin may be more susceptible to genital-anal injury than dark skin, our participants who reported a sunburn within the previous 12 months also had significantly higher overall injury prevalence and frequency in the follow-up examination following consensual intercourse. While URV injury occurs in people regardless of skin color, people with lighter skin are known to be more sun-sensitive than people with darker skin,[47] and their skin may be more prone to injury.[10]

The meaning of the other skin color findings, redness (positive a* value) and yellowness (positive b* values), is less clear. Decreased redness levels were associated with less injury at some locations and timepoints, and increased yellowness levels with more injury. We were not able to find any literature supporting changes in injury detection based on these skin color types.

Skin Viscoelasticity and Skin Hydration

Data from the baseline examination demonstrated that decreased skin viscoelasticity was significantly associated with increased external genital injury prevalence. As the literature suggests, higher skin viscoelasticity may have a protective effect against injury.[11] Individuals with high levels of viscoelasticity have skin able to return to its original shape after stress, whereas lower viscoelasticity is associated with hysteresis, the residual deformation of skin that increases injury risk.[48]

Data from the follow-up examination showed that increased levels of skin hydration were associated with increased external genital injury frequency and injury frequency in any anatomical area after consensual sexual intercourse. The role of skin hydration is relatively unexplored with respect to skin injury except for a series of studies that investigated the relationship between hydration and dermatological changes leading to facial wrinkles.[48,49] We suspect that the positive relationship between hydration and injury many have occurred because of the presence of edema in the tissues caused by mild trauma during intercourse, although other explanation such as changes in humidity, increases in skin surface moisture, or instrument error may have occurred.

Baseline and Follow-up Examinations

External, internal, and anal injuries at baseline were all significantly associated with the injuries found in the follow-up examination. There are three possible explanations for these findings. People who are highly susceptible to injury at baseline because of factors such as decreased viscoelasticity may be more susceptible to injury after consensual intercourse, although we did not find significant associations among those variables in the follow-up examination. Secondly, injuries that were detected during baseline examination but no longer visible at follow-up may have sensitized the skin, thereby contributing to injuries at follow-up. Finally, injuries that were detected in baseline may have remained and were counted again during the follow-up examination.

The Hispanic/Latina sample had a significantly lower prevalence and frequency of external genital injury at the follow-up examination than the non-Hispanic White sample. The mean L* (lightness value) for the Hispanic/Latina group was lower (M = 55.9, SD = 3.4) than the mean L* for the non-Hispanic White reference group (M = 64.4, SD = 3.4), which may

explain the difference in injury rates. As noted earlier, there is some evidence that women with lighter skin have more injuries detected than women with darker skin,[4] which may explain this finding.

Health status and BMI were also factors associated with injury. Participants with higher health status had decreased injury frequency at baseline, indicating that good health may serve a protective function against injury. The increased anal injury prevalence that we found in our non-Hispanic Black sample as compared to other groups may be associated with their BMI. The BMI in non-Hispanic Black participants (M = 31.2, SD = 8.6) was higher than the other groups (non-Hispanic White: M = 25.9, SD = 7.1; Hispanic = 29.3, SD = 8.0; Other Identities M = 27.6, SD = 7.9). Increased BMI is positively associated with increased injury, particularly in obese patients.[50] The significant increase in overall injury prevalence at all locations in non-Hispanic Black participants as compared to non-Hispanic White participants was driven by the high rate of anal injury in our sample of non-Hispanic Black participants.

Limitations

Our study was limited by a number of factors. In spite of quality control for our instruments, we may have incurred error in the skin viscoelasticity, skin hydration, and skin color measurements. Because we performed the study in Puerto Rico and the US, the two locations may have contributed geographic bias to our findings. Response bias may have occurred with our self-reported measures of smoking history/tobacco use, sun exposure, and general health. Our study methods were observational in nature and did not allow us to determine causality among variables. While we did not prescribe the type and nature of the sexual interaction, duration of intercourse had no effects on our statistical models but may have created error. We did control for vaginal and anal penetration and the roughness/gentleness of intercourse (Table 1) based on self-reported data. Our study findings are not applicable to males.

We were unable to take measurements of skin viscoelasticity and hydration on the mucous membranes of the external genital area because moisture would have created instrument error.[29,30] Instead, our skin measurements were taken at a location on the upper thigh, which is proximal to but outside of the genital-anal area. At the cellular level, the surface areas of the external genitalia is comparable in structure to other areas of the body's exposed skin.[51] The skin thickness is higher at the labia majora and perineum but decreases from the outer to inner surface towards the labia minora and the inner genital structures.[52,53] In general, the SC of vulvar skin is thinner than other non-exposed skin, but measurements take at the thigh provided representative data for vulvar and genital-anal tissues.[52,53]

We did not control for severity of injury. Walker noted that lacerations, abrasions, and bruising are significant for implying injury, whereas redness and swelling may be more subjective in their interpretation.[54] Table 1 provides information on injury prevalence by race/ethnicity. When considering the number of external genital tears, ecchymosis (bruising), and abrasions only (excluding redness and swelling), Hispanic and non-Hispanic White participants (mean skin lightness level 55.93 and 64.38 respectively) had a higher prevalence of tears (21–22%), ecchymosis, (0–2.3%) and abrasions (4–16%). In contrast, the

non-Hispanic Black participants (mean skin lightness level 41.05) had a lower prevalence of extragenital tears, ecchymosis and abrasions (11.11% 0.0%, and 9.26% respectively.) The prevalence rates demonstrate that, when removing injuries classified as redness and swelling, participants with lighter skin tones still had higher rates of injury than those with darker skin tones.

The self-identification of race and ethnicity was a limitation of the study. Participants of mixed or multiple races and ethnicities could not identify all aspects of their ancestry. Additionally, self-identification is not a biological indicator of race/ethnicity, but rather an indication of affiliation with a group or groups.[47]

Conclusions

Our findings provide qualified support for the importance of skin color during the forensic examination. Women with light skin tones may have skin that is more easily injured than women with darker tones. Examiners may detect external genital injuries more easily in women with light as compared to dark skin. Injuries that are detected can be treated medically and serve as evidence to corroborate a sexual assault survivor's statement and/or help prosecutors build a case. Women with decreased viscoelasticity and increased hydration may be more easily injured. These findings support the need to develop forensic procedures that are effective in people across the range of skin colors and to interpret forensic findings considering the innate properties of the skin.

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Highlights

- Protection of skin from injury may vary as skin mechanics and skin pigmentation vary
- We used a prospective cohort design to study genital-anal injury after consensual sex
- We measured skin color, elasticity, hydration to determine association with injury
- Women with lighter as compared to darker skin tones may be injured more easily
- Women with decreased elasticity and increased hydration may be injured more easily

Table 1.

Demographic and Health Characteristics, Sexual Behavior, and Genital-Anal Injury Prevalence among Women Evaluated Following Consensual Intercourse, Stratified by Race and Ethnicity (N = 341)

Demographic and Health Characteristics	Total Sample (N = 341)	Non-Hispanic White (N=88)	Non-Hispanic Black (N = 54)	Hispanic/Latina (N = 190)	Other (N = 9)	X^2/F	p-value
Age (missing 0 (0%))	32.59 (9.74)	32.13 (9.42)	35.60 (12.00)	32.19 (9.19)	27.32 (4.52)	4.72	**0.006**
Skin Color[a]							
Lightness/Darkness (L*)	55.69 (9.61)	64.39 (3.39)	41.05 (6.23)	55.93 (6.92)	53.26 (11.28)	227.79	**<.001**
Redness/Greenness (a*)	8.95 (1.70)	7.71 (1.42)	10.16 (0.94)	9.15 (1.67)	9.45 (1.33)	48.69	**<.001**
Yellowness/Blueness (b*)	19.56 (2.78)	18.12 (2.66)	19.40 (2.97)	20.26 (2.55)	19.90 (1.92)	13.30	**<.001**
Smoking Status (yes)	78 (22.87%)	20 (22.73%)	14 (25.93%)	43 (22.63%)	1 (11.11%)	1.00	0.802
Health Status	8.70 (1.14)	8.61 (0.92)	8.76 (1.32)	8.73 (1.19)	8.44 (0.88)	0.51	0.678
Sunburn in Last 12 months (yes)	76 (22.29%)	34 (38.64%)	2 (3.70%)	38 (20.00%)	2 (22.22%)	24.92	**<.001**
Body Mass Index	28.45 (7.83)	25.78 (6.96)	29.91 (7.35)	29.35 (8.06)	26.81 (8.34)	5.20	**0.002**
Viscoelasticity	64.82 (9.25)	61.25 (9.36)	64.20 (8.16)	66.50 (9.20)	68.05 (4.82)	7.26	**<.001**
Hydration	32.87 (9.41)	34.54 (9.03)	35.24 (10.75)	31.28 (8.94)	35.93 (9.22)	4.32	**0.005**
Sexual Behavior							
Anal Penetration (yes)	10 (2.93%)	2 (2.27%)	2 (3.70%)	6 (3.16%)	0 (0.00%)	0.56	0.906
Vaginal Penetration (yes)	334 (97.95%)	85 (96.59%)	53 (98.15%)	187 (98.42%)	9 (100.00%)	0.35	0.951
Roughness of Sex (gentle=1, rough=10)	5.05 (1.75)	4.52 (1.50)	4.79 (2.09)	5.37 (1.71)	5.11 (1.62)	5.88	**0.002**
Prevalence of Genital-Anal Injury							
Injury to Any Area	248 (72.73%)	79 (89.77%)	48 (88.89%)	115 (60.53%)	6 (66.67%)	34.43	**<.001**
Tears	79 (23.17%)	21 (23.86%)	8 (14.81%)	47 (24.74%)	3 (33.33%)	2.93	0.403
Ecchymoses	7 (2.05%)	6 (6.82%)	1 (1.85%)	0 (0.00%)	0 (0.00%)	14.12	**0.003**
Abrasions	36 (10.56%)	15 (17.05%)	7 (12.96%)	12 (6.32%)	2 (22.22%)	9.17	**0.027**
Redness	224 (65.69%)	78 (88.64%)	45 (83.33%)	95 (50.00%)	6 (66.67%)	48.77	**<.001**
Swelling	14 (4.11%)	11 (12.5%)	2 (3.7%)	1 (0.53%)	0 (0.00%)	22.34	**<.001**
External Genital Injury	175 (51.32%)	62 (70.45%)	29 (53.70%)	79 (41.58%)	5 (55.56%)	20.30	**<.001**
Tears	68 (19.94%)	19 (21.59%)	6 (11.11%)	41 (21.58%)	2 (22.22%)	3.14	0.371
Ecchymoses	2 (0.59%)	2 (2.27%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	5.78	0.123
Abrasions	29 (8.5%)	14 (15.91%)	5 (9.26%)	9 (4.74%)	1 (11.11%)	9.79	**0.020**

Demographic and Health Characteristics	Total Sample (N = 341)	Non-Hispanic White (N=88)	Non-Hispanic Black (N = 54)	Hispanic/Latina (N = 190)	Other (N = 9)	X^2/F	p-value
Redness	138 (40.47%)	57 (64.77%)	27 (50.0%)	50 (26.32%)	4 (44.44%)	39.47	**<.001**
Swelling	14 (4.11%)	11 (12.50%)	2 (3.7%)	1 (0.53%)	0 (0.00%)	22.34	**<.001**
Internal Genital Injury	152 (44.57%)	46 (52.27%)	31 (57.41%)	72 (37.89%)	3 (33.33%)	9.60	**0.022**
Tears	7 (2.05%)	3 (3.41%)	1 (1.85%)	3 (1.58%)	0 (0.00%)	1.22	0.749
Ecchymoses	3 (0.88%)	2 (2.27%)	1 (1.85%)	0 (0.00%)	0 (0.00%)	4.31	0.230
Abrasions	4 (1.17%)	2 (2.27%)	1 (1.85%)	1 (0.53%)	0 (0.00%)	1.92	0.588
Redness	146 (42.82%)	44 (50.00%)	29 (53.70%)	70 (36.48%)	3 (33.33%)	7.57	0.560
Swelling	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0.00	1.000
Anal Injury	44 (12.90%)	9 (10.23%)	12 (12.22%)	20 (10.53%)	3 (33.33%)	9.03	**0.029**
Tears	15 (4.4%)	1 (1.14%)	2 (3.70%)	11 (5.79%)	1 (11.11%)	4.13	0.248
Ecchymoses	2 (0.59%)	2 (2.27%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	5.78	0.123
Abrasions	10 (2.93%)	1 (1.14%)	3 (5.56%)	4 (2.11%)	2 (22.22%)	14.52	**0.002**
Redness	22 (6.45%)	7 (7.95%)	9 (16.67%)	5 (2.63%)	1 (11.11%)	14.58	**0.002**
Swelling	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0.00	1.000
Prevalence of Genital-Anal Injury							
Injury to Any Area	248 (72.73%)	79 (89.77%)	48 (88.89%)	115 (60.53%)	6 (66.67%)	34.43	**<.001**
External Genital Injury	175 (51.32%)	62 (70.45%)	29 (53.70%)	79 (41.58%)	5 (55.56%)	20.30	**<.001**
Internal Genital Injury	152 (44.57%)	46 (52.27%)	31 (57.41%)	72 (37.89%)	3 (33.33%)	9.60	**0.022**
Anal Injury	44 (12.90%)	9 (10.23%)	12 (12.22%)	20 (10.53%)	3 (33.33%)	9.03	**0.029**
Frequency of Genital-Anal Injury							
Injury to Any Area (total TEARS)	2.49 (2.96)	3.66 (3.15)	2.93 (3.60)	1.79 (2.39)	3.11 (3.92)	9.21	**<.001**
Tears	0.45 (1.19)	0.39 (0.88)	0.22 (0.60)	0.55 (1.43)	0.33 (0.50)	1.20	0.309
Ecchymoses	0.03 (0.25)	0.11 (0.47)	0.02 (0.14)	0.00 (0.00)	0.00 (0.00)	0.00	1.000
Abrasions	0.35 (1.55)	0.42 (1.12)	0.76 (3.03)	0.17 (0.95)	1.00 (2.12)	1.90	0.149
Redness	1.60 (1.81)	2.53 (2.15)	1.89 (1.53)	1.07 (1.45)	1.78 (2.49)	12.83	**<.001**
Swelling	0.06 (0.32)	0.20 (0.59)	0.04 (0.19)	0.01 (0.07)	0.00 (0.00)	0.00	1.000
External Genital Injury (total TEARS)	1.61 (2.45)	2.75 (2.91)	1.59 (2.94)	1.11 (1.85)	1.33 (2.24)	9.76	**<.001**
Tears	0.35 (0.99)	0.34 (0.83)	0.17 (0.50)	0.42 (1.17)	0.22 (0.44)	0.94	0.421
Ecchymoses	0.01 (0.12)	0.03 (0.24)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.74	0.158

Demographic and Health Characteristics	Total Sample (N = 341)	Non-Hispanic White (N=88)	Non-Hispanic Black (N = 54)	Hispanic/Latina (N = 190)	Other (N = 9)	X^2/F	p-value
Abrasions	0.25 (1.21)	0.38 (1.01)	0.50 (2.49)	0.12 (0.61)	0.11 (0.33)	1.86	0.136
Redness	0.94 (1.51)	1.80 (2.02)	0.89 (1.08)	0.56 (1.13)	1.00 (1.94)	9.57	**<.001**
Swelling	0.06 (0.32)	0.20 (0.59)	0.04 (0.19)	0.01 (0.07)	0.00 (0.00)	0.00	1.000
Internal Genital Injury (total TEARS)	0.61 (0.82)	0.74 (0.88)	0.85 (0.92)	0.50 (0.76)	0.33 (0.50)	3.82	**0.010**
Tears	0.02 (0.14)	0.03 (0.18)	0.02 (0.14)	0.02 (0.12)	0.00 (0.00)	0.40	0.751
Ecchymoses	0.01 (0.13)	0.03 (0.18)	0.02 (0.14)	0.00 (0.00)	0.00 (0.00)	1.41	0.239
Abrasions	0.02 (0.24)	0.02 (0.15)	0.02 (0.14)	0.02 (0.29)	0.00 (0.00)	0.03	0.994
Redness	0.56 (0.76)	0.65 (0.77)	0.80 (0.90)	0.46 (0.70)	0.33 (0.50)	3.51	**0.016**
Swelling	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00	1.000
Anal Injury (total TEARS)	0.26 (0.99)	0.17 (0.57)	0.48 (1.48)	0.19 (0.68)	1.44 (3.28)	1.13	0.352
Tears	0.08 (0.46)	0.01 (0.11)	0.04 (0.19)	0.12 (0.60)	0.11 (0.33)	1.20	0.310
Ecchymoses	0.01 (0.17)	0.05 (0.34)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.54	0.203
Abrasions	0.09 (0.64)	0.02 (0.21)	0.24 (1.27)	0.03 (0.23)	0.89 (2.03)	1.03	0.393
Redness	0.09 (0.39)	0.09 (0.33)	0.20 (0.49)	0.04 (0.27)	0.44 (1.33)	2.23	0.102
Swelling	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00	1.000

Note. Values represent N (%) or M (SD). Injury prevalence and frequency are from the follow-up examination.

[a]Raw values; standardized values are used in statistical modeling. X^2/F = Chi-square (for categorical variables) or F-statistic (for continuous variable) following univariate comparison between race/ethnicity groups. Bold indicates p<.05.

Table 2.

Prevalence of Genital-Anal Injuries as a Function of Demographic, Health, Skin Color, and Skin Biomechanical Characteristics among Women Evaluated Following Consensual Intercourse (N=341).

	External Genital Injury	Adjusted Odds Ratio (95% CI)		Injury to Any Area
		Internal Genital Injury	Anal Injury	
Exam I Genital-Anal Injuries as Outcomes				
Age	0.98 (0.95, 1.01)	0.99 (0.97, 1.02)	0.98 (0.94, 1.02)	0.99 (0.96, 1.02)
Race (Reference = White)				
Black	2.60 (0.71, 10.01)	1.76 (0.52, 5.97)	**12.84 (2.05, 89.41)**	**4.28 (1.26, 15.39)**
Hispanic	0.86 (0.44, 1.68)	1.33 (0.68, 2.63)	2.62 (0.87, 8.66)	1.17 (0.59, 2.32)
Other	0.25 (0.01, 1.63)	2.26 (0.48, 10.22)	**9.45 (1.09, 63.69)**	0.93 (0.19, 4.64)
Skin Color				
Lightness/Darkness (L*)	**1.98 (1.03, 4.04)**	1.01 (0.57, 1.80)	2.05 (0.85, 5.47)	1.62 (0.92, 2.91)
Redness/Greenness (a*)	0.97 (0.62, 1.53)	0.69 (0.45, 1.06)	1.14 (0.56, 2.35)	0.80 (0.53, 1.22)
Yellowness/Blueness (b*)	1.07 (0.79, 1.44)	0.99 (0.74, 1.32)	0.84 (0.52, 1.37)	0.93 (0.70, 1.24)
Smoker (Reference = No)	1.29 (0.71, 2.32)	0.81 (0.45, 1.44)	0.88 (0.32, 2.14)	1.27 (0.72, 2.29)
Health Status	0.94 (0.76, 1.17)	0.95 (0.77, 1.16)	0.81 (0.59, 1.11)	0.92 (0.75, 1.13)
Sunburn Last 12 Months (Reference = No)	1.11 (0.62, 1.98)	1.27 (0.71, 2.23)	0.76 (0.27, 1.91)	1.53 (0.84, 2.81)
Body Mass Index (BMI)	0.99 (0.95, 1.02)	0.99 (0.95, 1.02)	1.00 (0.95, 1.06)	0.98 (0.95, 1.02)
Viscoelasticity	**0.96 (0.93, 0.99)**	1.00 (0.97, 1.03)	**0.94 (0.90, 0.97)**	**0.95 (0.92, 0.98)**
Hydration	1.01 (0.98, 1.03)	0.99 (0.96, 1.01)	1.00 (0.95, 1.04)	1.01 (0.98, 1.04)
Exam II Genital-Anal Injuries as Outcomes				
Age	0.98 (0.95, 1.02)	1.01 (0.97, 1.05)	1.00 (0.95, 1.04)	0.99 (0.96, 1.03)
Race (Reference = White)				
Black	0.61 (0.15, 2.38)	1.25 (0.30, 5.11)	4.33 (0.64, 30.67)	0.77 (0.15, 4.26)
Hispanic	**0.40 (0.18, 0.88)**	**0.39 (0.17, 0.89)**	1.62 (0.50, 5.55)	**0.21 (0.08, 0.55)**
Other	1.19 (0.24, 6.09)	**0.12 (0.02, 0.79)**	6.26 (0.74, 46.30)	0.22 (0.04, 1.53)
Skin Color				
Lightness/Darkness (L*)	0.74 (0.40, 1.37)	0.99 (0.49, 1.98)	0.91 (0.38, 2.36)	0.63 (0.29, 1.30)
Redness/Greenness (a*)	0.74 (0.47, 1.18)	1.40 (0.84, 2.38)	0.60 (0.30, 1.19)	0.82 (0.50, 1.37)
Yellowness/Blueness (b*)	1.07 (0.78, 1.47)	0.78 (0.54, 1.10)	1.20 (0.76, 1.87)	0.92 (0.64, 1.32)

	External Genital Injury	Adjusted Odds Ratio (95% CI)		Injury to Any Area
		Internal Genital Injury	Anal Injury	
Smoker (Reference = No)	1.16 (0.60, 2.23)	**0.47 (0.23, 0.94)**	1.11 (0.42, 2.70)	0.68 (0.33, 1.38)
Health Status	0.94 (0.74, 1.19)	0.88 (0.68, 1.13)	1.04 (0.80, 1.56)	1.08 (0.82, 1.40)
Sunburn Last 12 Months (Reference = No)	1.07 (0.54, 2.12)	1.87 (0.92, 3.80)	1.42 (0.54, 3.56)	**2.89 (1.26, 7.17)**
BMI	0.99 (0.95, 1.04)	0.99 (0.95, 1.03)	0.99 (0.93, 1.05)	0.98 (0.94, 1.03)
Viscoelasticity	0.98 (0.95, 1.02)	**1.04 (1.01, 1.09)**	0.99 (0.94, 1.01)	1.00 (0.96, 1.04)
Hydration	1.00 (0.97, 1.03)	1.02 (0.99, 1.05)	1.03 (0.98, 1.07)	1.02 (0.99, 1.06)
Exam I Genital-Anal Injury Prevalence	**19.15 (9.85, 40.27)**	**25.76 (13.31, 53.57)**	**19.02, (8.07, 47.17)**	**9.23 (4.94, 18.05)**

Notes: Bold indicates statistical significance. All models adjusted for time since intercourse. Skin color variables are standardized.

Table 3.

Frequency of Genital-Anal Injuries as a Function of Demographic, Health, Skin Color, and Skin Biomechanical Characteristics among Women Evaluated Following Consensual Intercourse (N=341).

	External Genital Injury	Adjusted Rate Ratio (95% CI)		Injury to Any Area
		Internal Genital Injury	Anal Injury	
Exam I Genital-Anal Injuries as Outcomes				
Age	0.98 (0.96, 1.01)	1.01 (0.99, 1.03)	0.99 (0.94, 1.03)	0.99 (0.98, 1.01)
Race (Reference = White)				
Black	1.26 (0.40, 4.15)	1.62 (0.68, 3.80)	6.41 (0.70, 67.62)	1.48 (0.69, 3.18)
Hispanic	0.69 (0.39, 1.23)	1.34 (0.82, 2.20)	2.37 (0.68, 8.85)	0.91 (0.61, 1.37)
Other	0.41 (0.09, 1.88)	1.48 (0.43, 3.97)	8.18 (0.82, 122.71)	0.92 (0.36, 2.37)
Skin Color				
Lightness/Darkness (L*)	1.18 (0.65, 2.14)	0.88 (0.60, 1.31)	1.43 (0.45, 4.61)	1.04 (0.72, 1.51)
Redness/Greenness (a*)	0.74 (0.48, 1.14)	**0.69 (0.51, 0.93)**	0.76 (0.31, 1.83)	**0.73 (0.55, 0.96)**
Yellowness/Blueness (b*)	1.02 (0.78, 1.33)	1.07 (0.87, 1.32)	1.02 (0.58, 1.77)	1.05 (0.88, 1.26)
Smoker (Reference = No)	1.05 (0.62, 1.80)	0.78 (0.50, 1.18)	0.66 (0.22, 1.90)	0.94 (0.66, 1.34)
Health Status	**0.79 (0.66, 0.93)**	0.89 (0.78, 1.03)	0.76 (0.55, 1.04)	**0.82 (0.73, 0.92)**
Sunburn Last 12 Months (Reference = No)	1.04 (0.63, 1.73)	1.11 (0.74, 1.65)	0.51 (0.16, 1.52)	1.02 (0.73, 1.44)
Body Mass Index (BMI)	0.99 (0.96, 1.03)	1.00 (0.98, 1.03)	1.01 (0.94, 1.08)	1.00 (0.98, 1.02)
Viscoelasticity	**0.96 (0.93, 0.99)**	1.00 (0.98, 1.02)	**0.93 (0.88, 0.98)**	**0.97 (0.95, 0.99)**
Hydration	1.01 (0.98, 1.03)	0.99 (0.97, 1.01)	1.02 (0.97, 1.06)	1.00 (0.99, 1.02)
Exam II Genital-Anal Injuries as Outcomes				
Age	0.99 (0.97, 1.01)	1.00 (0.98, 1.01)	1.00 (0.96, 1.05)	0.99 (0.98, 1.01)
Race (Reference = White)				
Black	0.85 (0.42, 1.74)	1.19 (0.58, 2.42)	4.64 (0.64, 36.46)	1.01 (0.65, 1.84)
Hispanic	**0.59 (0.40, 0.86)**	0.67 (0.45, 1.01)	1.46 (0.49, 4.52)	**0.61 (0.46, 0.81)**
Other	0.74 (0.26, 1.84)	0.41 (0.10, 1.14)	**33.07 (5.78, 242.51)**	1.15 (0.63, 2.14)
Skin Color				
Lightness/Darkness (L*)	0.87 (0.62, 1.24)	1.23 (0.87, 1.74)	0.94 (0.38, 2.38)	0.97 (0.75, 1.24)
Redness/Greenness (a*)	**0.76 (0.59, 0.97)**	1.22 (0.94, 1.60)	0.64 (0.33, 1.22)	0.84 (0.70, 1.01)
Yellowness/Blueness (b*)	**1.24 (1.04, 1.47)**	0.93 (0.78, 1.11)	1.19 (0.78, 1.85)	**1.14 (1.01, 1.29)**

	External Genital Injury	Adjusted Rate Ratio (95% CI)		Injury to Any Area
		Internal Genital Injury	Anal Injury	
Smoker (Reference = No)	1.06 (0.76, 1.47)	0.69 (0.46, 1.01)	1.13 (0.47, 2.68)	0.94 (0.73, 1.20)
Health Status	1.06 (0.94, 1.20)	0.93 (0.82, 1.05)	1.31 (0.92, 1.89)	1.05 (0.96, 1.14)
Sunburn Last 12 Months (Reference = No)	1.32 (0.96, 1.81)	1.15 (0.81, 1.59)	1.73 (0.70, 4.33)	**1.31 (1.03, 1.66)**
BMI	1.00 (0.98, 1.02)	1.00 (0.98, 1.02)	0.98 (0.92, 1.04)	0.99 (0.98, 1.01)
Viscoelasticity	0.99 (0.97, 1.01)	1.01 (0.99, 1.03)	0.98 (0.93, 1.02)	1.00 (0.98, 1.01)
Hydration	0.99 (0.98, 1.01)	1.02 (1.00, 1.03)	1.02 (0.98, 1.06)	1.00 (0.99, 1.01)
Exam I Genital-Anal Injury Prevalence	**1.49 (1.37, 1.63)**	**2.00 (1.70, 2.34)**	**2.63 (1.70, 4.50)**	**1.27 (1.21, 1.33)**

Notes: Bold indicates statistical significance. All models adjusted for time since intercourse. Skin color variables are standardized.