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Original Contribution

Assessment of Changes in Risk Behaviors During 3 Years of Posttrial Follow-up of Male Circumcision Trial Participants Uncircumcised at Trial Closure in Rakai, Uganda

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Risk compensation associated with male circumcision has been a concern for male circumcision scale-up programs. Using posttrial data collected during 2007–2011 on 2,137 male circumcision trial participants who were uncircumcised at trial closure in Rakai, Uganda, the authors evaluated their sexual behavioral changes during approximately 3 years' follow-up after trial closure. Eighty-one percent of the men self-selected for male circumcision during the period, and their sociodemographic and risk profiles were comparable to those of men remaining uncircumcised. Linear models for marginal probabilities of repeated outcomes estimate that 3.3% ($P < 0.0001$) of the male circumcision acceptors reduced their engagement in nonmarital relations, whereas there was no significant change among men remaining uncircumcised. Significant decreases in condom use occurred in both male circumcision acceptors (−9.2% with all partners and −7.0% with nonmarital partners) and nonacceptors (−12.4% and −13.5%, respectively), and these were predominantly among younger men. However, the magnitudes of decrease in condom use were not significantly different between the 2 groups. Additionally, significant decreases in sex-related alcohol consumption were observed in both groups (−7.8% in male circumcision acceptors and −6.1% in nonacceptors), mainly among older men. In summary, there was no evidence of risk compensation associated with male circumcision among this cohort of men during 3 years of posttrial follow-up.

behavior changes; behavioral disinhibition; HIV prevention; male circumcision; Rakai; risk compensation

Abbreviations: HIV, human immunodeficiency virus; PT_0, start of the posttrial surveillance; PT_1, first posttrial visit; PT_2, second posttrial visit; RCT, randomized controlled trial; STI, sexually transmitted infection.

Three randomized controlled trials (RCTs) in sub-Saharan Africa have shown that male circumcision reduces female-to-male human immunodeficiency virus (HIV) incident infection by 50%–60% (1–3). In 2007, the World Health Organization (WHO)/Joint United Nations Programme on HIV/AIDS (UNAIDS) recommended that male circumcision be promoted as an "additional, important strategy for the prevention of heterosexually-acquired HIV infection in men," and 13 sub-Saharan Africa countries, including Uganda, were identified as priority countries for male circumcision scale-up (4, p. 11; 5, p. 3). Although the RCTs proved the causal effect (i.e., efficacy) of male circumcision for reducing the risk of HIV infection in men, the long-term population-level impact of male circumcision on the HIV epidemic will depend on male circumcision coverage and the influence of male circumcision on sexual risk behaviors.

Risk compensation, defined as a change toward riskier sexual behaviors after adopting an HIV prevention strategy, has been a theoretical concern with male circumcision (6–23), particularly during rapid male circumcision scale-up where provision of risk reduction education, counseling,

and follow-up may be limited. Simulation studies suggest that risk compensation can reduce the impact of male circumcision on HIV incidence (24, 25), and a modest level of risk compensation in men could increase female HIV infections (26). Data on behavioral changes after male circumcision acceptance have been sparse, and no empirical data are available during the current period when the efficacy of male circumcision is well known and male circumcision rollout is taking place in programmatic settings.

The Rakai Health Sciences Program conducted one of the male circumcision RCTs in Rakai, Uganda, during 2003–2006, and has continued to follow the trial participants after trial closure. Using data on the trial participants who were uncircumcised at the end of the trial, we assessed whether the adoption of male circumcision in the posttrial programmatic setting encouraged men to engage in riskier behaviors (i.e., risk compensation associated with male circumcision).

MATERIALS AND METHODS

The original Rakai male circumcision RCT has been described elsewhere (3). Briefly, HIV-negative, uncircumcised men aged 15–49 years who received their HIV test results and posttest counseling and provided consent were enrolled and randomized to undergo either immediate circumcision (intervention) or circumcision delayed for 24 months (controls). Participants were followed up at 6, 12, and 24 months to assess HIV incidence and sexual risk behaviors. At each visit, men were examined to assess circumcision status and to diagnose any penile pathology. Repeat HIV testing and individual-level health education and counseling were also provided. Free condoms were offered to all sexually active participants at all study visits and were available through community-based condom depots stocked by the Rakai program. The trial was stopped in December 2006 following an interim analysis that demonstrated the efficacy of male circumcision for HIV prevention. After trial closure, all trial participants provided consent and enrolled into a posttrial surveillance study that was integrated into the schedule of an ongoing Rakai cohort study. By July 2011, all available participants had been contacted for their second posttrial follow-up interviews. In addition, all uncircumcised, control-arm participants and intervention-arm crossovers (i.e., the population for this study) were offered free male circumcision as a service, and surgeries were conducted as expeditiously as possible. The studies were reviewed and approved by 4 institutional review boards in Uganda and the United States.

Current study design and population

Figure 1 illustrates the current study period and population in relation to the original RCT. This current analysis is a prospective cohort study of men who were uncircumcised and HIV negative at the last trial visit. Men could opt for circumcision as their own choice during the posttrial follow-up, which represents a period when information about the efficacy of male circumcision for HIV prevention had been broadly disseminated, and free male circumcision services were widely available and promoted in Rakai.

Posttrial male circumcision service procedure

Surgery was performed by trained clinical officers in aseptic outpatient operating rooms using the dorsal slit procedure under local anesthesia. Men were followed up at 7–9 days to diagnose and manage surgery-related complications (~1.0%) and wound healing. Men with complications were also encouraged to return for unscheduled visits or call a hotline for counseling. Prior to surgery, all men, and where applicable their wives, were educated in wound care, told to abstain from intercourse until wound healing was complete (~4–6 weeks), and urged to consistently use condoms thereafter. All clients also received small-group health education on HIV/sexually transmitted infection (STI) prevention and were informed that male circumcision does not provide complete protection against HIV infection. Provider-initiated pretest HIV counseling was provided to all male circumcision clients, with posttest counseling for those who agreed to learn their results.

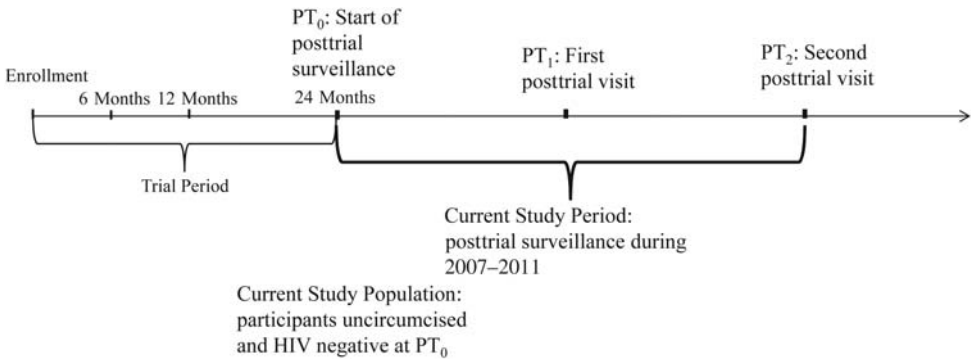

Figure 1. Illustration of the current study period and population in relation to the original male circumcision randomized controlled trial in Rakai, Uganda, beginning in 2007. PT_0, start of posttrial surveillance; PT_1, first posttrial visit; PT_2, second posttrial visit.

Study measurements

At each visit, men were interviewed in privacy at home or in central locations ("hubs") in the villages to ascertain sexual behaviors. Interviews by same-sex trained interviewers used structured questionnaires with direct electronic data entry on mobile personal computers to collect detailed sociodemographic, behavioral, health, and care-seeking information in the past year, including whether, where, and when they were circumcised. Information on the characteristics of and behaviors with sexual partners in the past year (up to 4 partners) was also elicited from the respondents. Editing was conducted in the field, facilitating error correction.

In this study, we used data collected at the last trial visit (i.e., start of the posttrial surveillance (PT_0)), providing information on men when they were still uncircumcised, and at the first posttrial follow-up (PT_1) and the second posttrial visit (PT_2). On the basis of HIV risk factors that have been identified in Rakai studies (27, 28), 6 variables were defined to quantify sexual behaviors reported for the past 12 months prior to interview, including being sexually active (yes/no), number of sex partners, number of nonmarital sex partners (i.e., partners not in a marital or long-term consensual relationship), condom use with all partners (always/sometimes/never), condom use with nonmarital partners (always/sometimes/never), and alcohol use before sex (sometimes/never). Variables for condom- and sex-associated alcohol use were evaluated on the basis of partner-specific information, including partner type and condom and alcohol use frequency. Only if the man reported using condoms with all partners (or all nonmarital partners) were the condom-use variables coded as "always."

In addition, in consideration of potential recall lapse over 12 months, we defined 2 variables for condom use at last sex (yes/no) with any type of partner and with nonmarital partners, where the value was "yes" only if the man reported using a condom in the last sex act with each of his partners (nonmarital partners). Other important variables considered were circumcision status and self-perceived risk of HIV infection (likely/unlikely) at each visit, as well as the age, religion, education, occupation, and marital status recorded at PT_0.

Statistical analysis

We first assessed possible self-selection of male circumcision by comparing men's sociodemographic characteristics and sexual behaviors reported at PT_0 by their subsequent circumcision acceptance during posttrial follow-up using the Pearson χ^2 test. Linear models for modeling the marginal distributions of repeated outcomes were used (29) to compare the within-individual behavior changes in relation to acceptance of male circumcision. Specifically, because the timeframe of risk behaviors referred to the 12 months prior to interview, we evaluated the behavior changes from PT_0 to PT_2, by which time the majority of men opting for male circumcision had been circumcised for more than 1 year. In addition, we compared the men observed with those lost to follow-up at PT_2 and used logistic regression with stepwise selection of predictors (measured at PT_0) to model the probability of loss to follow-up. Hosmer and Lemeshow goodness-of-fit tests were performed to check on the fitness of the logistic model for loss to follow-up. The inverse probability weighting method was then used in the aforementioned linear models to account for loss to follow-up at PT_2 (30–32).

For behavior variables that changed significantly during the posttrial follow-up, we further repeated the linear model analyses stratifying by age group, in order to investigate whether behavior changes or risk compensation associated with male circumcision occurred among men of certain age groups. Inverse probability weighting was applied if there was informative loss to follow-up within an age group. All hypothesis tests were 2 sided with a significance level of 0.05. Analyses were conducted in SAS, version 9.2, statistical software (SAS Institute, Inc., Cary, North Carolina).

RESULTS

Study population

There were 2,137 uncircumcised and HIV-negative men at PT_0 who constituted the study population. Their sociodemographic and risk behavior profiles at PT_0 are presented in Table 1. From PT_0, the median time to PT_1 was 1.63 (interquartile range: 1.28–2.17) years and to PT_2, 3.13 (interquartile range: 2.85–3.69) years. There were 1,534 men observed at PT_1 (retention rate, 71.8%), of whom 1,211 (78.9%) were circumcised. At PT_2, 1,597 men were observed (retention rate, 74.7%), of whom 1,297 (81.2%) had been circumcised. Figure 2 summarizes selected risk behaviors by using the cross-sectional data observed at each visit. There were no statistically significant differences at either PT_1 or PT_2 between circumcised and uncircumcised men with respect to nonmarital relations, condom use, or alcohol consumption and sex in the past 12 months.

Because our behavior variables generally refer to a 12-month recall period during which most uncircumcised men underwent the procedure, behaviors reported at PT_1 may not fully reflect the behaviors of circumcised men. Therefore, from here on, we focus on PT_2 where 99.1% of the circumcised men ($n = 1,285$) had been circumcised for more than 1 year.

Men lost to follow-up at PT_2 were significantly different from men observed at PT_2 by being more likely to be students, of younger age, with secondary or higher education, unmarried, and having nonmarital sex partners, less sex-related alcohol use, and less condom use in the past year. These variables were used to construct the logistic regression model for loss to follow-up using the stepwise procedure, and the final model retained marital status, age, religion, and education with reasonable goodness of fit (Hosmer and Lemeshow test, $P = 0.79$). Among men followed at PT_2, those opting for circumcision were not significantly different from those remaining uncircumcised in either sociodemographic characteristics or risk behaviors at PT_0 (i.e., when they were all uncircumcised), except for occupation where the male circumcision acceptors were

Table 1. Sociodemographic Characteristics and Risk Behaviors of Rakai, Uganda, Trial Participants Who Were Uncircumcised and HIV Negative at PT_0 beginning in 2007

	No.[a]	%
Age, years		
16–20	401	18.8
21–25	634	29.7
26–30	446	20.9
31–35	308	14.4
36–51	348	16.3
Education		
No education	122	5.7
Primary school	1,417	66.3
Secondary school or higher	598	28.0
Religion		
Catholic	1,483	69.4
Protestant	525	24.6
Other	129	6.0
Occupation		
Trading	475	22.2
Student	292	13.7
Fishing	122	5.7
Agriculture for selling	186	8.7
Agriculture for home	449	21.0
Other (e.g., motorcycle/taxi driver or trucker)	613	28.7
Currently married, yes	1,236	57.8
Sexually active past year, yes	1,839	86.1
Self-perceived HIV risk, likely	600	28.1
No. of sex partners in past year		
0	298	13.9
1	1,122	52.5
≥2	717	33.6
No. of nonmarital partners in past year		
0	1,139	53.3
1	657	30.7
≥2	341	16.0
Alcohol use before sex in past year, yes (i.e., sometimes)[b]	1,094	59.5
Condom use with all partners in past year[b]		
Never	860	46.8
Sometimes	695	37.8
Always	284	15.4
Condom use with nonmarital partners in past year[c]		
Never	169	17.5
Sometimes	347	36.0
Always	448	46.5
No condom use at last sex with any partner[b]	1,446	78.6
No condom use at last sex with nonmarital partners[c]	427	44.3

Abbreviations: HIV, human immunodeficiency virus; PT_0, start of posttrial surveillance.

[a] Total no. = 2,137.

[b] Among sexually active men.

[c] Among men reporting nonmarital/consensual sexual relations in the partner-specific blocks of the questionnaire.

slightly more frequently students than the nonacceptors (Table 2).

Changes in risk behaviors

Table 3 presents the changes in key sexual behavior variables and self-perceived risk of HIV infection between PT_0 and PT_2 for men who became circumcised and men who remained uncircumcised during the period (after adjustment for informative loss to follow-up). At PT_2, more men became married (15.0% increase in male circumcision acceptors and 18.4% increase in nonacceptors), and both groups reported an increase in sexual activity in the past year. Correspondingly, the distribution of number of sexual partnerships in the past year changed significantly in both groups: Among male circumcision acceptors, the proportion with single partnership increased, and there was no significant change in the proportion of multiple partnerships; whereas among the nonacceptors, the proportion of single partnership did not change significantly, but the proportion of multiple partnerships increased. The overall difference between the 2 groups in the change of number of partnerships was statistically significant, with uncircumcised men having a greater increase in multiple partnerships (Table 3).

Overall, men opting for circumcision and men remaining uncircumcised did not differ in change of the number of nonmarital partnerships (Table 3). Specifically, the number of nonmarital partnerships did not change significantly in the male circumcision nonacceptors, whereas male circumcision acceptors reduced their engagement in nonmarital partnerships. Both groups significantly reduced their sex-associated alcohol consumption, but there was no differential change in alcohol use before sex between the 2 groups.

Condom use with all partners and with nonmarital partners in the past 12 months decreased significantly in both male circumcision acceptors and nonacceptors, but the decreases in condom use were not significantly different between the 2 groups, suggesting that getting circumcised did not make men more likely to reduce use of condoms. Similar decreasing trends were observed in condom use at last sex with any partner and with nonmarital partners in both groups. In particular, the decrease within the nonacceptors with nonmarital partners was significantly greater than that in the male circumcision acceptors (Table 3).

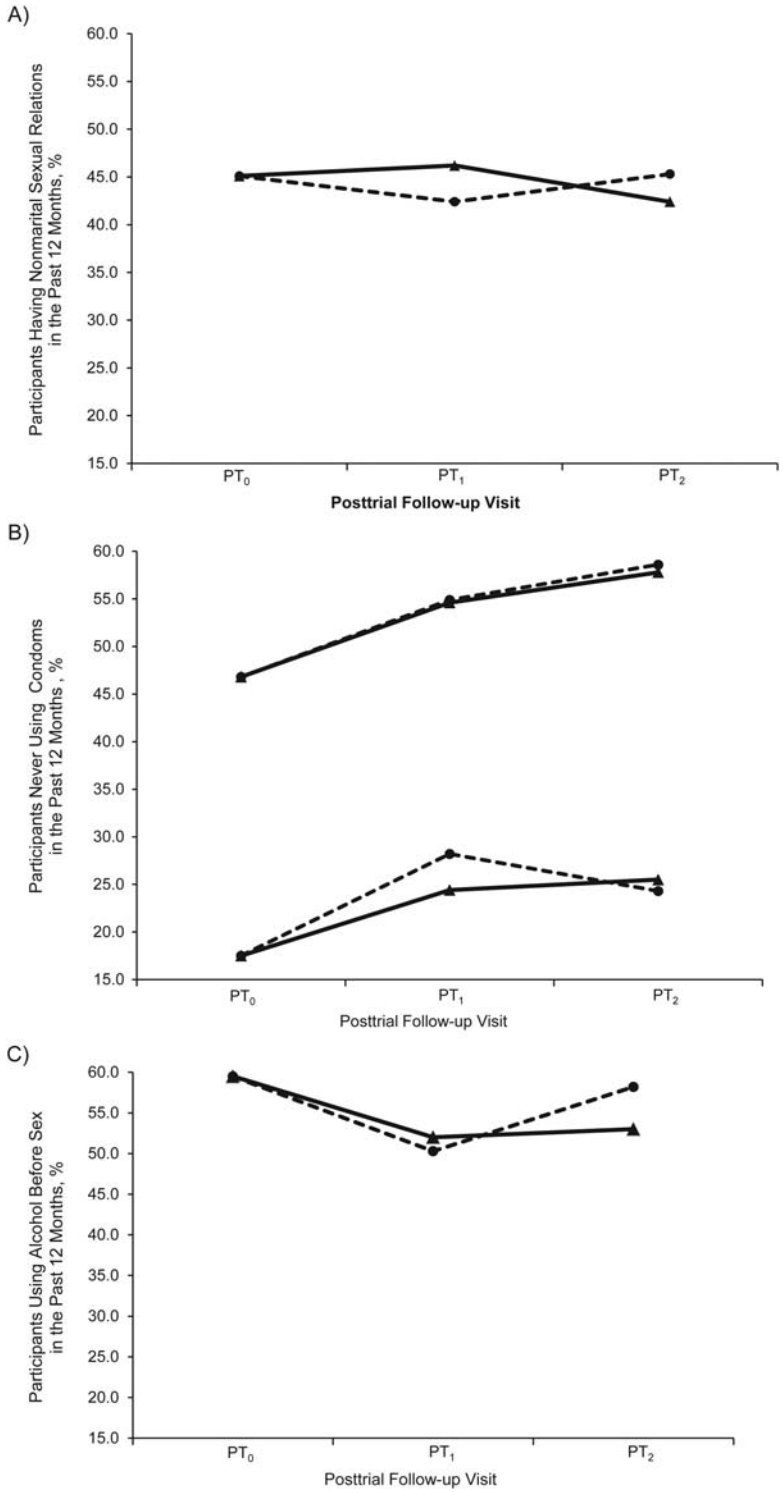

Figure 2. Trend of selected behavior variables by circumcision status using cross-sectional data at each posttrial follow-up visit (2007–2011) of the Rakai, Uganda, male circumcision trial participants uncircumcised at trial closure. PT_0, start of posttrial surveillance; PT_1, first posttrial visit; PT_2, second posttrial visit. A, proportion of participants reporting nonmarital sexual relations in the past 12 months. Pearson's χ^2 test comparing the circumcised (solid line) with the uncircumcised (broken line): $P = 0.22$ at PT_1 and $P = 0.36$ at PT_2. B, proportion never using condoms with all partners (the top lines in the figure) and with nonmarital partners (the bottom lines in the figure) in the past 12 months. Pearson's χ^2 test comparing the circumcised (solid line) with the uncircumcised (broken line) for no condom use with all partners: $P = 0.68$ at PT_1 and $P = 0.91$ at PT_2; and for no condom use with nonmarital partners: $P = 0.20$ at PT_1 and $P = 0.99$ at PT_2. C, proportion of sex-associated alcohol drinking in the past 12 months. Pearson's χ^2 test comparing the circumcised (solid line) with the uncircumcised (broken line): $P = 0.69$ at PT_1 and $P = 0.07$ at PT_2.

Table 2. Sociodemographic Characteristics and Risk Behaviors at PT_0 in Men Opting for Male Circumcision and Men Remaining Uncircumcised at PT_2, Rakai, Uganda, 2007–2011

	Male Circumcision Acceptors ($n = 1,297$)		Male Circumcision Nonacceptors ($n = 300$)		*P* Value[a]
	No.	%	No.	%	
Age, years					0.63
≤20	227	17.5	43	14.3	
21–25	362	27.9	91	30.3	
26–30	281	21.7	61	20.3	
31–35	195	15.0	50	16.7	
≥36	232	17.9	55	18.3	
Education					0.96
No education	70	5.4	17	5.7	
Primary school	885	68.2	206	68.7	
Secondary school or higher	342	26.4	77	25.7	
Religion					0.62
Catholic	73	5.6	18	6.0	
Protestant	913	70.4	218	72.7	
Other	311	24.0	64	21.3	
Occupation					0.01
Trading	312	24.1	72	24.0	
Student	165	12.7	21	7.0	
Fishing	65	5.0	25	8.3	
Agriculture for selling	120	9.3	20	6.7	
Agriculture for home	280	21.6	67	22.3	
Other (e.g., motorcycle/taxi driver or trucker)	355	27.4	95	31.7	
Current marital status, yes	806	62.1	190	63.3	0.70
Sexually active in past year, yes	1,132	87.3	269	89.7	0.26
Self-perceived HIV risk, likely	364	28.1	79	26.3	0.55
No. of sex partners in past year					0.40
0	165	12.7	31	10.3	
1	688	53.1	168	56.0	
≥2	444	34.2	101	33.7	
No. of nonmarital partners in past year					0.45
0	706	54.4	166	55.3	
1	399	30.8	83	27.7	
≥2	192	14.8	51	17.0	
Alcohol use before sex in past year, yes[b]	692	61.1	172	63.9	0.39
Condom use with all partners in past year[b]					0.86
Never	554	48.9	127	47.2	
Sometimes	427	37.7	106	39.4	
Always	151	13.3	36	13.4	
Condom use with nonmarital partners in past year[c]					0.13
Never	116	20.2	16	12.6	
Sometimes	204	35.5	47	37.0	
Always	254	44.3	64	50.4	
No condom use at last sex with any partner[b]	912	80.6	220	81.8	0.65
No condom use at last sex with nonmarital partners[c]	272	47.4	52	40.9	0.19

Abbreviations: HIV, human immunodeficiency virus; PT_0, start of the posttrial surveillance; PT_2, the second posttrial visit.
[a] *P* value based on 2-sided χ^2 test.
[b] Among sexually active men.
[c] Among men reporting nonmarital/nonconsensual relations in the partner-specific blocks of the questionnaire.

Corresponding to the sexual behavioral changes during the posttrial follow-up, men's self-perceived risk of HIV infection also increased significantly: 24.5% more male circumcision acceptors and 27.8% more male circumcision nonacceptors thought that it was "likely" that they had been exposed to HIV, but the increase in self-perceived risk did not differ significantly between the 2 groups.

Changes in risk behaviors by age group

For alcohol use before sexual intercourse and condom use that changed significantly in both groups, we further evaluated the behavior changes stratified by age. For simplicity of presentation, alcohol use in the past 12 months and condom use at the last sex act with any partner and with a nonmarital partner are shown in Table 4. In summary, in no age group were there significant differences in changes of alcohol or condom use between the male circumcision acceptors and nonacceptors. The only exception was for condom use with nonmarital partners among younger men aged 16–20 years, where men remaining uncircumcised had significantly greater decrease in condom use than men opting for male circumcision (Table 4).

Alcohol use before intercourse was lower at younger ages in both male circumcision acceptors and nonacceptors, whereas reduced alcohol consumption largely occurred in older age groups (Table 4). Regarding condom use at the last sex act with any partner, no significant decrease in condom use was observed in men older than 25 in either male circumcision acceptors or nonacceptors. The decrease in condom use centers on young men (age, ≤25 years) in both groups. Condom use with nonmarital partners declined in most age groups, especially among the male circumcision nonacceptors, although the reductions may not be statistically significant (Table 4). Similar findings were observed for condom use in the past 12 months (data not shown, available upon request).

DISCUSSION

After closure of the Rakai randomized trial of male circumcision, the majority of uncircumcised participants opted for male circumcision during the posttrial follow-up. Men who accepted the procedure were similar to men who remained uncircumcised in most sociodemographic characteristics and risk behaviors at their last trial visit (Table 2), suggesting minimal self-selection.

During the approximately 3 years of posttrial follow-up, we observed significant sexual behavior changes in both men who opted for male circumcision and men who remained uncircumcised. Nearly half the study population were young men (<25 years), and they progressively became sexually active over time. There was no significant increase in the number of nonmarital partnerships among men remaining uncircumcised; likewise, there was a slight decrease in nonmarital relationships among the male circumcision acceptors (Table 3). Alcohol use before sex declined significantly in both groups, mainly among the older men who originally had more frequent sex-associated drinking (Table 4). Condom use with all partners decreased significantly in both male circumcision acceptors and nonacceptors, especially among younger men. This is probably in part because more young men became married, and condom use within marriage is generally low in this population. Condom use with nonmarital partners also declined in both groups, where a decreasing trend was present in all age groups of the nonacceptors and was also shown in the male circumcision acceptors at ages 21–30 years.

The magnitudes of behavior changes were generally comparable between the male circumcision acceptors and nonacceptors, but the nonacceptors reported more multiple partnerships and greater reduction in condom use with nonmarital sex partners. The nonacceptors, compared with the acceptors, received less intensive counseling and fewer free condoms that were provided when men came for surgery. It is also possible that, although we did not find a significant difference in risk behaviors between the 2 groups when they were all uncircumcised at trial closure, the male circumcision nonacceptors may be more prone to risk-taking behaviors when follow-up and health education were less frequent after the trial.

Several factors may have contributed to the significant changes in sexual behaviors in both the circumcised and uncircumcised men. The first is that the population was growing older and, thus, more likely to marry and engage in sex. The second is that, during the 2-year trial period, all participants received repeated intensive education and counseling and free condoms that, of necessity, diminished in the posttrial setting where follow-up was also less frequent.

Although our empirical data do not show evidence of risk compensation associated with circumcision, recent qualitative studies in sub-Saharan Africa provide mixed findings. Qualitative studies on circumcised men reported no risk compensation among the majority of subjects, while a minority of men reported increased sexual risk behaviors (33) with the motivation to "test out" their circumcised penis or be "rewarded" for their abstinence during the healing period (34, p. 250). Another qualitative study among uncircumcised men in Nyanza Province of Kenya reported frequent opinions such as, "Male circumcision acts as a 'natural condom'," and for this reason circumcised men can enjoy sex 'skin-on-skin' without needing a latex condom." Participants also expressed fear that "male circumcision will make a man promiscuous" and, in a community, "male circumcision might create a generation of men, especially young men, who think that they can have sex without any risk" (35, p. 4). Our age-stratified analysis did not show that circumcised young men engaged in riskier behaviors than their uncircumcised peers 1 year or more after circumcision, but we do not know whether their sexual behaviors may have changed soon after wound healing postsurgery.

Among data prior to male circumcision rollout, the South African trial noted that circumcised men "had significantly more sexual contacts" (but no data on follow-up behaviors were provided) (1, p. 1121). Both the Ugandan and Kenyan trials reported increased condom use during trial follow-up. The increase was similar between the intervention and control arms in the Ugandan trial, whereas the Kenyan trial found a lower increase of condom use in

Table 3 Changes in Sexual Behavior and HIV Risk Perception From PT_0 to PT_2 Among Male Circumcision Acceptors and Nonacceptors, Rakai, Uganda, 2007–2011

	Male Circumcision Acceptors ($n = 1,297$)							Male Circumcision Nonacceptors ($n = 300$)							*P* Value Testing $H_0^{a,b}$: $\Delta_{ac} = \Delta_{nac}$
	PT_0		PT_2		Δ_{ac}[a]	95% CI	*P* Value Testing $H_0^{a,b}$: $\Delta_{ac} = 0$	PT_0		PT_2		Δ_{nac}[a]	95% CI	*P* Value Testing $H_0^{a,b}$: $\Delta_{nac} = 0$	
	No.	%	No.	%				No.	%	No.	%				
Sexually active in past year, yes	1,132	87.3	1,218	93.9	7.7	6.1, 9.4	<0.0001	269	89.7	283	94.3	5.4	2.2, 8.6	<0.01	0.21
No. of sex partners in past year															0.04[c]
0	165	12.7	79	6.1	−7.7	−9.4, −6.1	<0.0001	31	10.3	17	5.7	−5.4	−8.6, −2.2	<0.01	0.21
1	688	53.1	750	57.8	5.3	2.3, 8.2	<0.01	168	56.0	157	52.3	−3.1	−8.9, 2.7	0.30	0.01
2	444	34.2	468	36.1	2.5	−0.2, 5.2	0.08	101	33.7	126	42.0	8.5	3.0, 13.9	0.002	0.05
No. of nonmarital partners in past year															0.45[c]
0	706	54.4	747	57.6	3.3	0.5, 6.2	0.02	166	55.3	164	54.7	0.1	−5.8, 6.0	0.98	0.33
1	399	30.8	388	29.9	−0.9	−3.9, 2.0	0.53	83	27.7	94	31.3	3.3	−2.6, 9.2	0.28	0.21
≥2	192	14.8	162	12.5	−2.4	−4.6, −0.3	0.03	51	17.0	42	14.0	−3.4	−8.0, 1.3	0.16	0.72
Alcohol use before sex in past year, yes[d]	674	61.2	584	53.0	−7.8	−10.5, −5.0	<0.0001	169	64.8	152	58.2	−6.1	−11.3, −1.0,	0.02	0.58
Condom use with all partners in past year[d]															0.55[c]
Never	543	49.3	636	57.8	9.1	6.2, 12.0	<0.0001	123	47.1	153	58.6	12.4	6.2, 18.6	<0.0001	0.35
Sometimes	418	38.0	389	35.3	−2.1	−5.1, 0.9	0.17	106	40.6	89	34.1	−6.1	−12.7, 0.4	0.07	0.28
Always	140	12.7	76	6.9	−7.0	−8.9, −5.2	<0.0001	32	12.3	19	7.3	−6.3	−10.5, −2.0	<0.01	0.75
Condom use with nonmarital partners in past year[e]															0.28[c]
Never	59	17.9	84	25.5	7.0	2.6, 11.4	<0.01	8	10.8	18	24.3	13.5	4.4, 22.5	<0.01	0.21
Sometimes	130	39.4	123	37.3	−1.2	−6.9, 4.5	0.69	27	36.5	28	37.8	0.8	−10.4, 12.1	0.89	0.76
Always	141	42.7	123	37.3	−5.8	−11.3, −0.3	0.04	39	52.7	28	37.8	−14.3	−25.1, −3.4	0.01	0.17
No condom use at last sex with any partner[d]	895	81.3	977	88.7	8.7	6.5, 11.0	<0.0001	216	82.8	228	87.4	6.1	1.1, 11.2	0.02	0.36
No condom use at last sex with nonmarital partner[e]	155	47.0	176	53.3	6.4	0.9, 11.8	0.02	29	39.2	43	58.1	18.8	8.0, 29.7	0.01	0.04
Self-perceived HIV risk, likely	364	28.1	678	52.3	24.5	21.8, 27.3	<0.0001	79	26.3	164	54.7	27.8	21.9, 33.8	<0.0001	0.32

Abbreviations: CI, confidence interval; H_0, null hypothesis; HIV, human immunodeficiency virus; PT_0, start of the posttrial surveillance; PT_2, the second posttrial visit; Δ_{ac}, change in percentage from PT_0 to PT_2 within the male circumcision acceptors; Δ_{nac}, change in percentage from PT_0 to PT_2 within the male circumcision nonacceptors.

[a] After adjustment for loss to follow-up at PT_2 using the inverse probability weighting method. Results are similar to those without accounting for the informative loss to follow-up.

[b] *P* value based on the Wald test using linear models for modeling the marginal distributions of repeated outcomes.

[c] If the behavior variable has more than 2 categories (e.g., number of partners, condom use), the *P* value is provided for the global test for testing the overall difference in change of the behavior between the 2 groups (i.e., df = no. of categories − 1).

[d] Among men reporting being sexually active at both PT_0 and PT_2.

[e] Among men reporting nonmarital/nonconsensual relations at both PT_0 and PT_2.

Table 4. Changes in Alcohol Use and Nonuse of Condoms by Age From PT_0 to PT_2 Among Male Circumcision Acceptors and Nonacceptors, Rakai, Uganda, 2007–2011

	Male Circumcision Acceptors							Male Circumcision Nonacceptors ($n = 300$)							*P* Value Testing H_0[a,b]: $\Delta_{ac} = \Delta_{nac}$
	PT_0		PT_2		Δ_{ac}[a]	95% CI	*P* Value Testing H_0[a,b]: $\Delta_{ac} = 0$	PT_0		PT_2		Δ_{nac}[a]	95% CI	*P* Value Testing H_0[a,b]: $\Delta_{nac} = 0$	
	No.	%	No.	%				No.	%	No.	%				
Alcohol use before sex in past year by age, years[c]															
16–20	41	33.3	39	31.7	1.6	−11.2, 7.9	0.74	9	36	9	36	0	−22.2, 22.2	1	0.9
21–25	152	48	136	42.9	−5.5	−10.7, −3.2	0.04	37	46.8	48	60.8	−7.3	−16.7, 2.2	0.13	0.75
26–30	162	62.3	143	55	−5.7	−11.5, 0.2	0.06	38	64.4	38	64.4	1.4	−9.6, 12.5	0.8	0.27
31–35	146	78.5	117	62.9	−15.6	−21.5, −9.6	<0.0001	38	80.9	34	72.3	−7.8	−18.1, 2.4	0.13	0.2
36–51	173	80.5	149	69.3	−11	−17.0, −5.0	<0.001	47	92.2	40	78.4	−14	−25.0, −2.9	0.01	0.64
No condom use at last sex with any partner by age, years[c]															
16–20	65	52.9	87	70.7	17.9	7.8, 28.0	<0.001	13	52	21	84	32	13.7, 50.3	<0.001	0.19
21–25	225	71	281	88.6	18.3	13.6, 22.9	<0.0001	58	73.4	66	83.5	11.3	1.3, 21.4	0.03	0.22
26–30	233	89.6	238	91.5	3.2	−1.1, 7.4	0.14	54	91.5	52	88.1	−2.6	−12.6, 7.3	0.6	0.29
31–35	173	93	174	93.6	0.8	−3.1, 4.8	0.67	42	89.4	42	89.4	0.5	−10.6, 11.7	0.93	0.96
36–51	199	92.6	197	91.6	−0.9	−4.6, 2.8	0.63	49	96.1	47	92.2	−3.9	−12.3, 4.6	0.37	0.53
No condom use at last sex with nonmarital partner[d]															
≤20	39	46.4	40	47.6	1.2	−12.2, 14.6	0.86	9	47.4	14	73.7	26.3	6.5, 46.1	<0.01	0.04
21–25	59	48.8	70	59.9	9.3	1.0, 17.6	0.03	8	30.8	12	46.2	16.4	−4.9, 37.7	0.13	0.54
26–30	29	43.3	36	53.7	12.5	−0.8, 25.7	0.07	6	46.2	8	61.5	11.4	−15.6, 38.4	0.41	0.96
31–35	16	57.1	16	57.1	0.3	−21.0, 21.6	0.98	4	44.4	6	66.7	23.8	0.0, 47.6	0.05	0.15
≥36	12	40	14	46.7	4.9	−14.5, 24.3	0.62	2	28.6	3	42.9	14.3	−28.8, 57.4	0.52	0.7

Abbreviations: CI, confidence interval; H_0, null hypothesis; PT_0, start of the posttrial surveillance; PT_2, the second posttrial visit; Δ_{ac}, change in percentage from PT_0 to PT_2 within the male circumcision acceptors; Δ_{nac}, change in percentage from PT_0 to PT_2 within the male circumcision nonacceptors.

[a] After adjustment for loss to follow-up at PT_2 using the inverse probability weighting method. Results are similar to those without accounting for the informative loss to follow-up.

[b] *P* value based on the Wald test using the linear models for modeling the marginal distributions of repeated outcomes.

[c] Among men reporting being sexually active at both PT_0 and PT_2.

[d] Among men reporting nonmarital/nonconsensual relations at both PT_0 and PT_2.

the intervention arm (2, 3). However, a substudy on the Kenyan trial participants during the RCT period concluded that there was no risk compensation associated with male circumcision on the basis of analysis of a summary behavioral risk score and the incidence of 3 nonviral STIs (10). Outside the RCT context, early cross-sectional studies in South Africa and Uganda reported that circumcision was associated with higher sexual risk behaviors (36–38), which may be because men with riskier behaviors were more likely to acquire STIs and to be circumcised for medical reasons. Another longitudinal study from 2003 to 2004 (i.e., before the RCT results) in western Kenya found no risk compensation 1 year after circumcision (22).

To our knowledge, this is the first analysis to assess risk compensation associated with male circumcision in a posttrial setting, where the health benefits of circumcision were widely known and men voluntarily chose to accept or decline free circumcision services. A range of sexual behaviors were examined, and we found no evidence of risk compensation associated with circumcision.

However, our study has important limitations that preclude a definitive statement on postcircumcision risk compensation. The study participants were self-selected and motivated to enroll into the RCT, and they received intensive health education and counseling during the 2-year trial period. Consequently, although it is reassuring that no male circumcision-associated risk compensation was found during the posttrial follow-up, the results may not be generalizable to the general male population who receive male circumcision through routine services. Moreover, if the male circumcision nonacceptors were more prone to riskier behaviors than the acceptors, using their behavioral changes as a caliber may underestimate the magnitude of risk compensation associated with circumcision. Additionally, we evaluated behavioral changes during an approximately 3-year period, where the majority of circumcised men had been circumcised for over a year, but it is unknown whether risk compensation would occur soon after wound healing among circumcised men where, on one hand, men may seek more nonmarital sex partners to "test out" their circumcised penis or be "rewarded" for their abstinence during the healing period (34, p. 250). On the other hand, the education component in the male circumcision service package may help to prevent risk compensation, particularly for a short term.

Another limitation is the use of self-reported sexual behaviors that may be vulnerable to social desirability and recall bias. Nevertheless, prior Rakai studies repeatedly showed that self-reported risk behaviors are associated with HIV/STI acquisition (27, 33, 34, 39–41). In addition, our recent analysis of posttrial HIV incidence among the Rakai RCT participants (42, 43) found that the effectiveness of male circumcision on HIV prevention (67%) was maintained after the trial, thus supporting our observation based on self-reported risk behaviors.

In summary, we observed significant risk behavior changes in both circumcised and uncircumcised men but found no evidence of behavioral risk compensation associated with male circumcision during the approximately 3 years of posttrial surveillance. Future studies of risk compensation with male circumcision should focus on the general population of men in programmatic settings and behavior changes within the short term after male circumcision (e.g., 3 or 6 months after male circumcision). The significant decrease in condom use observed in all men also indicates the importance of behavior interventions that can be incorporated into male circumcision scale-up programs to synergistically combat the HIV epidemic in sub-Saharan Africa.

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