Common NOD2 Risk Variants in African Americans with Crohn’s Disease Are Due Exclusively to Recent Caucasian Admixture

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Background: Crohn’s disease (CD) is highly heritable. NOD2 has emerged as the main susceptibility gene among individuals of European ancestry; however, NOD2 does not appear to contribute to CD susceptibility among many non-European populations. Today’s African American (AA) population represents an admixture of West African (80%) and European (20%) ancestry. Since genotype-based tools are becoming increasingly available for CD, it is important that we validate the risk variants in different populations, such as admixed AAs.

Methods: We analyzed the NOD2 variants among admixed AAs (n = 321, 240 with CD and 111 healthy controls [HCs]) and nonadmixed West Africans (n = 40) by genotyping four known disease-causing NOD2 variants. We extracted the publicly available 1000 Genomes data on NOD2 variants from 500 subjects of West African origin. Association with disease was evaluated by logistic regression.

Results: An association with CD was found for the classical single nucleotide polymorphism (SNP) 1007fs (2.6% CD, 0% HC, P = 0.012); there was no association when the genotypic and allelic frequencies of the risk alleles were compared for SNPs R702W and G908R. No known NOD2 risk alleles were seen in either the West African cohort or in subjects of African ancestry from the 1000 Genomes project.

Conclusions: The NOD2 gene is a risk for CD in AAs, although the allele frequencies and the attributable risk are much lower compared with Caucasians. The risk alleles are not seen in the West African population, suggesting that the risk for CD contributed by NOD2 among AAs is due exclusively to recent European admixture.

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Key Words: African Americans, Crohn’s disease, NOD2

Crohn’s disease (CD) is a highly heritable disorder, with studies showing about 50% concordance among monozygotic twins, and siblings of patients with CD having a much higher risk of developing CD compared with the general population. In the past decade, candidate gene studies and genome-wide association studies have uncovered well over 50 susceptibility loci for CD. Among the confirmed genes, the association between NOD2 and CD susceptibility has been established beyond a doubt in European populations; homozygous or compound heterozygous carriers of the three classical polymorphisms (1000fs, R702W, G908R) have a 17-fold higher risk of developing disease, and heterozygous carriers have a 2.4-fold greater risk. Nonetheless, it is clear that CD affects all races, and that disease prevalence in other races, including African Americans (AAs), approaches that of Europeans. African Americans are a recently admixed population, with an estimated European admixture of around 20%, with the other 80% coming from an ancestral African population. It is known that the majority of the African ancestral genome found in AAs originated in West Africa. Today, little is known about the risk conferred by NOD2 polymorphisms among AAs with CD. As genetic-based testing begins to impact diagnostic and treatment decisions, the importance of this information for all CD patients will continue to grow, and with it the need to understand the applicability of genetic findings from all patient populations.

In total, four disease-associated single nucleotide polymorphisms (SNPs), all resulting in nonsynonymous
amino acid changes, have been reported in the European and Ashkenazi Jewish populations; these are 1000fs, R702W, G908R, IVS8+158 (or JW1). We also included R790Q, a variant unique to the African ancestral population in our analysis. Our study aimed to define the association of already known CD-associated NOD2 risk variants in the AA population. We hypothesized that any association between known NOD2 variants in AAs with CD could be attributable to recent European admixture.

**MATERIALS AND METHODS**

**Subjects**

The study population included self-identified unrelated individuals: AAs with CD (n = 210) and healthy AA controls (n = 111). In addition, we included 40 nonadmixed West Africans, recently migrated from Ghana, Nigeria, Cameroon, and Ivory, Coast who were living in the USA at the time of recruitment and enrolled as healthy controls (HCs). It is known that the founder population of African ancestry in AAs originated primarily from the slave trade in West Africa including the nations described above. All the AAs and West Africans reported in this study represent an independent cohort not studied before in any IBD genetic studies. We extracted NOD2 data from the 1000 Genomes diversity project from 500 individuals of West African origin. In addition, we genotyped 220 Caucasian subjects with CD and 210 Caucasian control subjects for comparison. The study protocol was approved by an Institutional Review Board and informed consent was obtained from each participant or from the legal guardians of minors.

**Genotyping**

Samples were plated for genotyping and blinded to the laboratory. Five SNPs (1000fs, R702W, G908R, IVS8+158 (or JW1). We also included R790Q, a variant unique to the African ancestral population in our analysis. Our study aimed to define the association of already known CD-associated NOD2 risk variants in the AA population. We hypothesized that any association between known NOD2 variants in AAs with CD could be attributable to recent European admixture.

**RESULTS**

We genotyped five previously published SNPs that map across the NOD2 locus. The SNPs R702W, G908R, and 1007fs known to be associated with CD in Caucasians were included, as was the SNP JW1, which is found in

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**TABLE 1. NOD2 Allele Frequencies in AAs Compared with West Africans and Caucasians**

<table>
<thead>
<tr>
<th>Gene</th>
<th>SNP Number</th>
<th>African Americans</th>
<th>West Africans</th>
<th>Caucasians</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Cases (n = 210)</td>
<td>Control (n = 111)</td>
<td>OR (95% CI)</td>
</tr>
<tr>
<td>NOD2 (C&gt;T, variant T)</td>
<td>rs2066844</td>
<td>0.054</td>
<td>0.050</td>
<td>1.08 (0.53 – 2.22)</td>
</tr>
<tr>
<td>NOD2 (G&gt;C, variant C)</td>
<td>rs2066845</td>
<td>0.012</td>
<td>0.004</td>
<td>2.83 (0.33 – 24.4)</td>
</tr>
<tr>
<td>NOD2 C_insertion</td>
<td>rs2066847</td>
<td>0.026</td>
<td>0</td>
<td>NA (NA)</td>
</tr>
<tr>
<td>NOD2 carrier (R702W + G908R + 1000fs)</td>
<td>rs2066729</td>
<td>0.09</td>
<td>0.04</td>
<td>0.03</td>
</tr>
<tr>
<td>NOD2 (G&gt;A, variant A)</td>
<td>rs2066729</td>
<td>0.038</td>
<td>0.034</td>
<td>1.13 (0.48 – 2.68)</td>
</tr>
<tr>
<td>NOD2 (C&gt;T, variant T)</td>
<td>rs2066729</td>
<td>0.078</td>
<td>0.042</td>
<td>1.93 (0.93 – 3.98)</td>
</tr>
</tbody>
</table>

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Caucasians mainly of Jewish ethnicity. The SNP R790Q was also genotyped, as this SNP is found only in African ancestral populations, and not typically found in Caucasians of European origin. Allelic association reached statistical significance only for 1007fs (2.6% CD, 0% HC, \( P = 0.012 \)). There was no association when the genotypic and allelic frequencies of the risk alleles were compared for SNPs R702W (5.47% CD, 5.08% HC, \( P = 0.83 \)), G908R (1.19% CD, 0.42% HC, \( P = 0.322 \)), R790Q (3.8% CD, 3.4% HC, \( P = 0.78 \)), and JW1 (7.8% CD, 4.3% HC, \( P = 0.07 \)). All SNPs examined are either uncommon or nonexistent in the West African population studied (Table 1), as well as in the 500 individuals from the 1000 Genomes database. The complete lack of NOD2 variants in the West African population, coupled with the low allele frequency of NOD2 variants among AAs, point to the risk for CD from known NOD2 variants in AAs being the result of European admixture.

**DISCUSSION**

All studies in Caucasians of European origin show that NOD2 mutations are more frequent among CD cases than controls. A recent meta-analysis found an overall NOD2 carrier risk of 3.2 among Caucasians with CD; however, numerous publications from Asia, North Africa, and the Middle East reveal that known disease-causing NOD2 mutations are rare or absent among non-Caucasians. The three common disease-causing NOD2 mutations associated with CD are assumed to have arisen in European ancestral populations or by admixture. In this study, first we confirmed independently that NOD2 is a risk for AAs, and second, we show that these NOD2 variants are not present among a nonadmixed West African population.

The clinical implications of having NOD2 mutations in CD are now well known. Numerous studies point to an association with ileal disease, and NOD2 is a risk factor for internal penetrating/stricturing disease in CD. It remains to be seen whether NOD2 variants have prognostic utility in admixed individuals, such as AAs, who constitute about 15% of the U.S. population and in whom each chromosome is likely to be a mosaic of blocks of DNA from different ancestral populations. Recent studies estimate European admixture in AAs to be around 20%, with the other 80% arising from ancestral African genome. Since genotype-based tools are becoming increasingly available for CD, it is crucial that we accurately understand risk variants in the admixed AA population.

Very little has been published on common NOD2 mutations in the African ancestral population. R702W and G908R mutations were not seen in 118 individuals of Yoruba descent, and Leu1007fsinsC was absent in 24 individuals with African ethnicity in the SNP500CANCER project. Recent study genotyping NOD2 mutations in seven sub-Saharan populations (including 25 Yorubans) likewise found no NOD2 mutations. In this study we show that the common CD-associated NOD2 variants are indeed absent in nonadmixed West African individuals. Our findings are further supported by the 1000 Genomes project data confirming the absence of these three SNPs among at least 500 African populations.

We conclude that NOD2 is a risk for AAs with CD, but their allele frequencies are much lower: about 20%–25% of the frequencies seen in Caucasians of European origin. Our data strongly suggest that the risk conferred by NOD2 in AAs is the exclusive result of Caucasian admixture. Deep sequencing will explore whether other SNPs within the NOD2 loci could contribute to disease susceptibility in African ancestral populations.

**REFERENCES**