**Page 1 of 8**

**NHLBI Evidence Table: RF5-OB**

**1. Introduction**

- **Purpose:** To describe the relationship of serum lipoprotein levels with obesity measures in children.

**2. Study Design**

- **Design:** Prospective
- **Setting:** Bogalusa, LA
- **Sample:** Community-based cohort of black (B) and white (W) children

**3. Study Population**

- **Sample Size:** 1,799/1,586 children (83% and 85%, respectively)
- **Age Range:** 7-17 years
- **Gender Distribution:** 52% female (F), 48% male (M)
- **Race Distribution:** 44% B, 56% W

**4. Data Collection**

- **Baseline Study:**
  - **Methods:** Fasting lipid profile and Lp(a) measured
  - **Sample:** All members of the community of Bogalusa, LA
  - **Period:** 1981-82

- **Follow-up Study:**
  - **Methods:** Repeat evaluations
  - **Sample:** Same children re-tested in 1988-89
  - **Period:** 1988-89

**5. Results**

- **Baseline Study**
  - **Findings:**
    - Significant increase in TC, TG, LDL-C, Apo B
    - Significant decrease in HDL-C

- **Follow-up Study**
  - **Findings:**
    - TC and LDL-C levels decrease during adolescence, even in black children.
    - HDL-C levels increase with age, especially in WMs.

**6. Discussion**

- **Interpretation:**
  - TC, TG, LDL-C levels are higher in B children than in W children.
  - HDL-C levels are higher in W children than in B children.

- **Conclusion:**
  - The relationship between serum lipoprotein levels and obesity is complex and influenced by race, sex, and age.

**7. References**

- **Key References:**
  - Kikuchi DA, Relation of serum lipoprotein levels to obesity measures in children. Bogalusa Heart Study
  - Stuhldreher WL, Cholesterol screening in children: Bogalusa Heart Study

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**Page 2 of 8**
Bogalusa Heart Study

1. **Objective:** To examine the relationship between early life lipids and lipoproteins and adult lipid levels in a cohort of children and adolescents.

2. **Population:** Participants from Bogalusa, Louisiana, USA.

3. **Methods:** Cross-sectional and longitudinal studies.

4. **Findings:**
   - Lipids and lipoproteins from childhood to young adulthood.
   - The Bogalusa Heart Study evaluated the prediction of adult lipoprotein cholesterol in black and white children.

5. **Conclusion:** Lipid and lipoprotein levels in childhood are predictive of adult lipid levels.

6. **References:**

---

**Table:**

<table>
<thead>
<tr>
<th>Study Type</th>
<th>Study Population</th>
<th>Study Duration</th>
<th>Main Findings</th>
</tr>
</thead>
</table>
| Cross-sectional | Community-based cohort of black (B) and white (W) children and young adults - originally 624 B girls & 773 W girls evaluated at baseline & 25 years later. | 1981-82. | Lipids and lipoproteins from childhood to young adulthood.
| Longitudinal cohort study based in Muscatine, Iowa, USA | Community-based cohort of black (B) and white (W) male (M); 44% B. | Mean levels of all serum lipids and lipoproteins were followed from birth to 7 yrs of age. | Increases in obesity over time were associated with increases in TGs and decreases in HDL.
| Pediatric surveys into adult life. A total of 1234 F/1133 M. | Age: 5-17 y | Weight, height, BMI, SSFs, Tanner stage, Diet by questionnaire, hormone assessment. | Increases in obesity over time were associated with increases in TGs and decreases in HDL.

---

**Key Points:**

- Lipid and lipoprotein levels in childhood are predictive of adult lipid levels.
- Increases in obesity over time were associated with increases in TGs and decreases in HDL.
- Lipid and lipoprotein levels in childhood are predictive of adult lipid levels.

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**References:**

**Results**

- For LDL tracking, persistence in the lowest quintile was significantly greater (p=S**).
- For those in the lowest quintile in yr 1, 36% for apoA1 and 53% for apoB.
- In 883 subjects with repeated childhood measurements, prevalence of factors in apoE3 is greater than in apoE2 or apoE4 groups. For example, apoA1 was positively associated with apoE3, while apoB was negatively associated with apoE3.
- In general, lipid/lipoprotein results tracked from childhood into adult life: LDL-ApoB correlation ranged from .24-.45 for apoA1 and .57-.59 for apoB among different race-sex groups. Corresponding values for LDL-C and HDL-C were .39-.46 and .64-.67 respectively.
- No change after adjustment for age, height or PI.
- Average effect of E2 phenotype is to lower LDL & HDL-C and increase apoB. Conversely, the E4 allele increases LDL-C and decreases HDL-C.
- Marked increase in the prevalence of multiple RF clustering seen in apoE3, apoB, & apoE4 subgroups, but not with apoE2.
- ApoE4 carriers had a lower frequency of E3 allele and higher frequencies of E2 & E4 than the apoE3 group.
- Significant tracking was present for each lipid variable.

**Parent Characteristics**

- Parental history of MI by self-report.
- Parental history of MI was 1.6X (38%) as prevalent (p=S) for apoE2 vs. apoE3 group.
- In adult subjects who were classified as having dyslipidemia by NCEP guidelines, LDL-C was the most predictive of adult values.
- If elevated LDL persisted >90th percentile in childhood, adults had significantly higher LDL-C than those with LDL <90th percentile.
- Average effect of E2 phenotype is to lower LDL & HDL-C and increase apoB. Conversely, the E4 allele increases LDL-C and decreases HDL-C.
- Marked increase in the prevalence of multiple RF clustering seen in apoE3, apoB, & apoE4 subgroups, but not with apoE2.
- ApoE4 carriers had a lower frequency of E3 allele and higher frequencies of E2 & E4 than the apoE3 group.
- Significant tracking was present for each lipid variable.

**Child Characteristics**

- In 1,728 children and young adults examined at 5-17 yrs; 52% female (F), 48% male (M); 44% B.
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<thead>
<tr>
<th>Field</th>
<th>First Author</th>
<th>Title</th>
<th>Year</th>
<th>Study Type</th>
<th>Prospect./predictors of atherosclerosis in lesions in PDAY subjects. The cholesterol and apolipoproteins B and A-I levels in black and white children: the Bogalusa Heart Study</th>
<th>Duration Outcomes Measured</th>
<th>Results</th>
<th>Main Reported Findings by Critical Question</th>
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</thead>
<tbody>
<tr>
<td>PMID</td>
<td>Mohler B</td>
<td>Cholesterol screening in 9008838</td>
<td>9467707</td>
<td>Follow-up</td>
<td>retrospective. 10% random sample of 5 y old children (n=225) from each of the 3 countries &amp; Lp(a) data available</td>
<td>correlation for any lipid results over time.</td>
<td>There were no significant differences in the correlations between LDL &amp; apoB measures.</td>
<td>Neither apoA1 nor apoB measures were as strongly correlated with age &amp; race &amp; with raised lesions in TA (p=S) &amp; RCA (p=S).</td>
</tr>
</tbody>
</table>
### Trend of Lipoprotein Variables

<table>
<thead>
<tr>
<th>Study</th>
<th>Participants</th>
<th>Methods</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rask-Nissila et al.</td>
<td>Community-based cohort of black (B) and white (W) children and young adults</td>
<td>Diet: 540/265 vs. control: 265</td>
<td>Differences in LDL &amp; TG between groups were significant after age 20.</td>
</tr>
<tr>
<td>Chen et al.</td>
<td>All 2,843 W or B children who underwent lipid evaluation.</td>
<td>At baseline plus 3 and 6 y later.</td>
<td>TC levels were lower throughout for the intervention vs diet group.</td>
</tr>
<tr>
<td>Srinivasan et al.</td>
<td>Community-based cohort of black (B) and white (W) children aged 5 -17 y.</td>
<td>Non-HDL correlates with designated LDL cutpoints</td>
<td>For HDL, inverse association with age noted from ages 4 &amp; 20 in both groups.</td>
</tr>
<tr>
<td>Tershakovec et al.</td>
<td>1,076 Pediatric/829 Pediatric/2,843 Pediatric/273</td>
<td>Many associations with + fam hx were stronger in Ms than Fs.</td>
<td>With BMI, insulin or glucose added to model, association with HDL became inverse.</td>
</tr>
<tr>
<td>Bogalusa Heart Study</td>
<td>All those young adults aged 18-38 y residing in USA Community</td>
<td>TG from childhood to adulthood in 5-year-old children</td>
<td>Associations between BMI, BP, insulin and lipids were stronger with increasing age especially in HTC Fs.</td>
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<td>Chen et al.</td>
<td>All 2,843 W or B children who underwent lipid evaluation.</td>
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Friedman LA, Srinivasan SR. Sensitivity and specificity of childhood non-high-density lipoprotein lipid-related traits in predicting adult CVD was small - only 19 for LDL & 20 for TC. Differences in overall sensitivity between the selected top quartile for non-HDL-C and LDL-C in childhood were 4.5 X (CI: 2.51-8.04, p=S**) and 3.5 X (CI: 2.02-6.07, p=S**) in detection of a metabolic syndrome phenotype.

Bogalusa Heart Study: The overall prevalence of a metabolic syndrome phenotype among U.S. children and young adults - originally performed in 1973-4 (n=3446) & one in 2001-2 (n=1163) for whom fasting blood samples were obtained. For this study, children from Bogalusa study were stratified by age and gender and BMI status >95th percentile. Risk factors such as overweight, obesity, insulin resistance, elevated fasting insulin, and glucose intolerance were measured in children and adolescences who were stratified by age and gender.

Number of adult CVD events was small - only 150. Each LIPID risk factor was included in the logistic regression model. Risk factors such as overweight, obesity, insulin resistance, elevated fasting insulin, and glucose intolerance were measured in children and adolescences who were stratified by age and gender.
| Q1: | Epidemiologic and genetic evidence now suggests that metabolic syndrome is caused by several risk factors known in childhood. 

- Type IIb subjects had increased BMI and type IV subjects had reduced ratio of Apo B to Apo A-I.
- Risk factors present in childhood were identified in 68% of type IIb subjects, 19% of type IV subjects, and 21% of type III subjects.
- Type IV subjects were more likely to have elevated fasting glucose and insulin levels than type IIb subjects.

| Q2: | In addition to increased BMI, insulin resistance is a marker of increased metabolic risk in type IIb subjects.

- The epsilon2 allele was associated with increased risk of metabolic syndrome in young adults.
- In type IIb subjects, elevated insulin levels were observed in 31% of subjects, while in type III subjects, elevated insulin levels were observed in 23% of subjects.

| Q3: | Type IIb dyslipidemia has deleterious effects on cardiovascular risk in young adults.

- Type IIb subjects had increased BMI, insulin resistance, and elevated Apo B to Apo A-I ratio, which are markers of increased cardiovascular risk.
- Type IIb subjects had increased 1-year follow-up cIMT, which is a marker of atherosclerosis.

| Q4: | The epsilon2 allele was associated with increased prevalence of type IIb dyslipidemia.

- In type IIb subjects, the epsilon2 allele was present in 25% of subjects, while in type III subjects, the epsilon2 allele was present in 18% of subjects.
- In type IV subjects, the epsilon2 allele was not associated with increased prevalence of type IIb dyslipidemia.

| Q5: | These findings support the hypothesis that genetic factors may play a role in the development of metabolic syndrome.

- Type IIb subjects had increased BMI, insulin resistance, and elevated Apo B to Apo A-I ratio, which are markers of increased cardiovascular risk.
- Type IIb subjects had increased 1-year follow-up cIMT, which is a marker of atherosclerosis.

| Q6: | Prevalence rates for metabolic syndrome vary significantly in different populations.

- The prevalence of metabolic syndrome in young adults was highest in the USA, with 26% of subjects meeting criteria.
- The prevalence of metabolic syndrome in young adults was lowest in Finland, with 1% of subjects meeting criteria.

| Q7: | Only non-HDL-C, TC/HDL-C, and Apo B emerged as robust predictors of metabolic syndrome.

- Non-HDL-C was the strongest predictor of metabolic syndrome, with an odds ratio of 3.27 (95% CI 1.84 5.82) compared to the NCEP cutpoints.
- The TC/HDL-C ratio was also a robust predictor of metabolic syndrome, with an odds ratio of 2.53 (95% CI 1.54 4.12) compared to the NCEP cutpoints.

| Q8: | Using data from 3 prospective cohort studies, we found that the more abnormal the lipid profile, the greater the risk of metabolic syndrome.

- In type IIb subjects, the number of abnormal lipids was significantly associated with increased risk of metabolic syndrome.
- In type IV subjects, the number of abnormal lipids was significantly associated with increased risk of metabolic syndrome.

| Results: | 

- Non-HDL-C was the strongest predictor of metabolic syndrome, with an odds ratio of 3.27 (95% CI 1.84 5.82) compared to the NCEP cutpoints.

- TC/HDL-C ratio was also a robust predictor of metabolic syndrome, with an odds ratio of 2.53 (95% CI 1.54 4.12) compared to the NCEP cutpoints.

| Summary: | 

- Genetic factors may play a role in the development of metabolic syndrome.
- Prevalence rates for metabolic syndrome vary significantly in different populations.
- Only non-HDL-C, TC/HDL-C, and Apo B emerged as robust predictors of metabolic syndrome.

| References: | 

- National Heart, Lung, and Blood Institute, National Heart, Lung, and Blood Institute, National Heart, Lung, and Blood Institute.
<table>
<thead>
<tr>
<th>PMID</th>
<th>First author</th>
<th>Title</th>
<th>Year</th>
<th>Study Type</th>
<th>Prospect./Retrospect. Study</th>
<th>Country/Setting</th>
<th>Main Study Objective</th>
<th>Study Groups</th>
<th>n at Baseline</th>
<th>n at Follow-up</th>
<th>Total Follow-up Duration</th>
<th>Outcomes Measured</th>
<th>Results</th>
<th>Main Reported Findings by Critical Question</th>
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<tr>
<td>18450895</td>
<td>Frontini MG</td>
<td>Usefulness of Childhood Non–High Density Lipoprotein Cholesterol Levels Versus Other Lipoprotein Measures in Predicting Adult Subclinical Atherosclerosis: The Bogalusa Heart Study</td>
<td>2008</td>
<td>Cohort</td>
<td>Retrospective</td>
<td>Bogalusa Multiple Q1,3 (RF5) USA Community Setting</td>
<td>Examine the usefulness of childhood non-high-density lipoprotein cholesterol level versus low-density lipoprotein cholesterol level, high-density lipoprotein cholesterol level, triglyceride level, apolipoprotein B level, apolipoprotein A-I level, total cholesterol/high-density lipoprotein cholesterol ratio, and apolipoprotein B/apolipoprotein A-I ratio in predicting adult excess carotid intimamedia thickness, an indicator of subclinical atherosclerosis.</td>
<td>Pediatric/Young adults</td>
<td>Participants in the Bogalusa Heart Study as children 5-17 years of age and as adults 16-19 years later</td>
<td>White: 70%</td>
<td>Male: 40%</td>
<td>Mean age at F/U: 31.9 y (24-43 y)</td>
<td>Non-HDL-C</td>
<td>LDL-C, HDL-C, TG, ApoB, ApoA-I, CIMT</td>
</tr>
<tr>
<td>18634985</td>
<td>Juonala M</td>
<td>Childhood Levels of Serum Apolipoproteins B and A-I Predict Carotid Intima-Media Thickness and Brachial Endothelial Function in Adulthood</td>
<td>2008</td>
<td>Cohort</td>
<td>Prospective</td>
<td>Young Finns Multiple Q3,4 (RF4,5,8,10,14) Finland Clinical Setting</td>
<td>Determine whether CV RFs including apolipoproteins (apo) B and A-I measured in childhood and adolescence predict subclinical evidence of atherosclerosis in adulthood</td>
<td>Pediatric/Young adults</td>
<td>Participants in the Cardiovascular Risk in Young Finns Study aged 3,6,9,12,15, and 18 years old at the onset of the study in 1980.</td>
<td>Male: 45.7%</td>
<td>Mean age (SD) at F/U: 31.9 yr (5.0;)</td>
<td>Baseline and F/U: Apo B levels; Apo A-I levels; TC,LDL-C,HDL-C,TG</td>
<td>BP</td>
<td>Smoking status</td>
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