Sugar sweetened beverages’ association with hyperinsulinemia among aboriginal youth population

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Type 2 diabetes mellitus - a major public health concern -

- **Epidemic proportions**
  - 2.4% in 1943 → 16% in 2003 → 21.4% in 2009 (CDIS, 2010)

- **Alarming rates and disparities** with non-aboriginal counterparts
  - 3.5 times higher than in the general population (CDIS, 2012)

- **Precocity** of onset
  - Mean age of diagnosis
    - 48 years old in 1989 → 41 years old in 2009 (CDIS, 2009)
Susceptibility of James Bay Cree youth

International Obesity Task Force (IOTF) cut-points

<table>
<thead>
<tr>
<th></th>
<th>Overweight</th>
<th>Obese</th>
</tr>
</thead>
<tbody>
<tr>
<td>US (12-17 yrs 1999-2002)</td>
<td>14%</td>
<td>19%</td>
</tr>
<tr>
<td>Canada (12-17 yrs 2004)</td>
<td>11%</td>
<td>21%</td>
</tr>
<tr>
<td>Cree (3-18 yrs 2005)</td>
<td>28%</td>
<td>40%</td>
</tr>
<tr>
<td>US (12-17 yrs 1999-2002)</td>
<td>13%</td>
<td>18%</td>
</tr>
<tr>
<td>Canada (12-17 yrs 2004)</td>
<td>7%</td>
<td>18%</td>
</tr>
<tr>
<td>Cree (3-18 yrs 2005)</td>
<td>44%</td>
<td>19%</td>
</tr>
</tbody>
</table>

Boys

Girls
SSBs - a potential modifiable risk factor -

- SSBs and obesity
  - Systematic review and meta-analysis of RCT and cohort studies (Morenga et al. 2013)
    - Global OR: 1.55 (1.32, 1.82)
  - NEJM: two recent randomized trials (Ruyter et al., 2012; Ebbeling et al., 2012)
    - ↓ SSBs consumption, replacement with non-caloric sweetened beverages → reduced weight gain

- SSBs and type 2 diabetes
  - Meta-analysis of 8 prospective cohort studies (Malik et al., 2010)
    - RR = 1.26 ; IC 95% (1.12-1.41)
Few studies have addressed SSB consumption and IR in children & adolescents.

However, studies among aboriginal youth populations are scarce.
To evaluate the association between SSBs and hyperinsulinemia (HI) among Québec James Bay Cree youth
METHODS

Study population and design

- Cross-sectional

- 307 Cree youth from 7 Cree communities of Eastern James Bay (Canada)

- Inclusion criteria
  - Aged 9-18 years old

- Exclusion criteria
  - Diagnosis of diabetes, pregnancy, missing data for fasting blood insulin, weight, height or waist circumference
METHODS

Data collection and variables

- Exposure – SSBs

  - “SSBs are beverages that contain added caloric sweeteners such as sucrose, HFCS” (Hu et al., 2010)

  ✔ soft drinks
  ✔ fruit drinks
  ✔ energy and vitamin water drinks
  ✔ sports drinks
  ✔ sweetened iced tea
  ✗ 100% fruit juice
  ✗ diet drinks
METHODS

Data collection and variables

• In this study

\[
\text{Sugary beverages} = \text{SSBs} + \text{real fruit juice}
\]

\[
\text{SSBs} = \text{soft drinks} + \text{fruit drinks} + \text{sports drinks} + \text{iced tea}
\]

\[
\text{Real fruit juice} = \text{100% pure, bottled or frozen fruit juice}
\]

\[
\text{ASB*} = \text{diet soft drinks} + \text{diet ice tea}
\]

*ASB: Artificially Sweetened Beverages
METHODS

Data collection and variables

- Intakes of SSBs obtained from food frequency questionnaire (FFQ)
  "Mean daily frequency over past month"

- Categorization
METHODS

Data collection and variables

- **Outcome – Hyperinsulinemia (HI)**
  - Blood sample collected after an overnight fast, by a research nurse

- **Categorization**
  - HI = fasting insulin ≥ 90 pmol/L
METHODS

Data collection and variables

- Mediator – obesity
  - General obesity
    - International Obesity Task Force (IOTF) criteria
  - Abdominal obesity
    - Age and sex specific waist circumference (WC) percentiles
    - Waist-to-height ratio (WHtR)
Odds ratio of HI were estimated using **multiple logistic regression analysis**

**Models**

- **1** Adjusted for
  
  *age (9-12, 13-18) and sex*

- **2** Adjusted for age (9-12, 13-18), sex,
  
  *moderate physical activity and walking (<60 min/d / >=60 min/d), vigorous physical activity (<60 min/d / >=60 min/d), smoking (never, occasional, current), oral contraceptive use (yes/no)*

- **3** Additionally adjusted for
  
  *fiber intake (g/day, quartiles), magnesium intake (mg/day, quartiles), vitamin D intake (IU/day, quartiles), alcohol (yes/no), coffee (yes/no), trans fatty acids (% of total fat intake)*

- **Intermediate variables**
  
  + BMI
  + WC
  + WHtR
## RESULTS

### Table 1. Characteristics of the participants according to SSB intake

<table>
<thead>
<tr>
<th>Intake levels of SSB (times/day)</th>
<th>0 - &lt;0.5 (n=93)</th>
<th>0.5 - &lt;1 (n=53)</th>
<th>1 - &lt;2 (n=78)</th>
<th>2+ (n=83)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>13.6 ± 2.9¹</td>
<td>13.1 ± 2.8</td>
<td>12.8 ± 2.8</td>
<td>13.5 ± 2.8</td>
</tr>
<tr>
<td>Girls (%)</td>
<td>50.5</td>
<td>47.2</td>
<td>48.7</td>
<td>47.0</td>
</tr>
<tr>
<td>Fasting blood insulin (pmol/L)</td>
<td>123.3 (105.7, 143.8)²</td>
<td>115.4 (97.7, 136.3)</td>
<td>129.5 (114.0, 147.0)</td>
<td>135.1 (117.7, 155.0)</td>
</tr>
<tr>
<td>Hyperinsulinemia (%)</td>
<td>59.1</td>
<td>66.0</td>
<td>71.8</td>
<td>77.1</td>
</tr>
<tr>
<td>Fasting blood glucose (mmol/L)</td>
<td>5.14 ± 1.00</td>
<td>4.97 ± 0.48</td>
<td>5.14 ± 0.39</td>
<td>5.23 ± 0.71</td>
</tr>
<tr>
<td>HOMA-IR</td>
<td>4.02 (3.39, 4.75)</td>
<td>3.65 (3.07, 4.35)</td>
<td>4.24 (3.71, 4.85)</td>
<td>4.49 (3.85, 5.23)</td>
</tr>
<tr>
<td>Weight (Kg)</td>
<td>71.5 ± 25.2</td>
<td>65.8 ± 20.9</td>
<td>66.9 ± 23.1</td>
<td>70.0 ± 20.7</td>
</tr>
<tr>
<td>BMI (Kg/m²)</td>
<td>26.1 ± 7.0</td>
<td>25.1 ± 6.2</td>
<td>25.4 ± 5.8</td>
<td>26.1 ± 5.9</td>
</tr>
<tr>
<td>Normal weight (%)</td>
<td>39.8</td>
<td>34.0</td>
<td>29.5</td>
<td>33.7</td>
</tr>
<tr>
<td>Overweight (%)</td>
<td>17.2</td>
<td>28.3</td>
<td>29.5</td>
<td>21.7</td>
</tr>
<tr>
<td>Obese (%)</td>
<td>43.0</td>
<td>37.7</td>
<td>41.0</td>
<td>44.6</td>
</tr>
<tr>
<td>WC (cm)</td>
<td>91.3 ± 18.2</td>
<td>88.8 ± 15.8</td>
<td>88 ± 17.0</td>
<td>91.3 ± 16.1</td>
</tr>
<tr>
<td>High WC (%)³</td>
<td>49.5</td>
<td>50.9</td>
<td>55.1</td>
<td>51.8</td>
</tr>
<tr>
<td>High WHtR (≥0.05) (%)</td>
<td>90.3</td>
<td>88.7</td>
<td>91.0</td>
<td>92.8</td>
</tr>
</tbody>
</table>

Abbreviations: SSB, sugar sweetened beverages; BMI, body mass index; WC, waist circumference; WHtR, waist-to-height ratio; ASB, artificially sweetened beverages

¹Mean ± SD (all such values)
²Geometric mean (IC) (all such values)
³≥90th age and sex specific percentiles
# RESULTS

<table>
<thead>
<tr>
<th></th>
<th>SSB</th>
<th>Soft drinks</th>
<th>Ice tea</th>
<th>Fruit or sports drinks</th>
<th>Real fruit juice</th>
<th>ASB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sugary beverages</td>
<td>0.79 (&lt;.0001)</td>
<td>0.45 (&lt;.0001)</td>
<td>0.36 (&lt;.0001)</td>
<td>0.45 (&lt;.0001)</td>
<td>0.59 (&lt;.0001)</td>
<td>-0.25 (&lt;.0001)</td>
</tr>
<tr>
<td>SSB</td>
<td>1.00</td>
<td>0.58 (&lt;.0001)</td>
<td>0.44 (&lt;.0001)</td>
<td>0.61 (&lt;.0001)</td>
<td>0.12 (0.06)</td>
<td>-0.38 (&lt;.0001)</td>
</tr>
<tr>
<td>Soft drinks</td>
<td>1.00</td>
<td>0.12 (0.04)</td>
<td>0.08 (0.15)</td>
<td>0.04 (0.52)</td>
<td>-0.68 (&lt;.0001)</td>
<td></td>
</tr>
<tr>
<td>Regular ice tea</td>
<td></td>
<td>1.00</td>
<td>0.03 (0.59)</td>
<td>0.10 (0.09)</td>
<td>-0.22 (&lt;.0001)</td>
<td></td>
</tr>
<tr>
<td>Fruit or sports drinks</td>
<td></td>
<td></td>
<td>1.00</td>
<td>0.08 (0.16)</td>
<td>0.00 (0.97)</td>
<td></td>
</tr>
<tr>
<td>Real fruit juice</td>
<td></td>
<td></td>
<td></td>
<td>1.00</td>
<td>0.02 (0.69)</td>
<td></td>
</tr>
</tbody>
</table>
**RESULTS**

A  **OR (95% CI) of HI by intake level of sugary beverages**

- Multivariate OR (P trend=0.02)
- Multivariate OR + BMI (P trend=0.03)

Intake levels of sugary beverages (times/d)
RESULTS

B  OR (95% CI) of HI by intake level of SSBs

- Multivariate OR (P trend=0.01)
- Multivariate OR + BMI (P trend=0.007)
RESULTS

C) OR (95% CI) of HI by intake level of real fruit juice

- Multivariate OR (P trend=0.47)
- Multivariate OR + BMI (P trend=0.86)

* Not statistically significant
RESULTS

D OR (95% CI) of HI by intake level of ASB

- Multivariate OR (P trend=0.68)
- Multivariate OR + BMI (P trend=0.15)

* Not statistically significant
Table 3. OR\(^1\) (95% CI) of HI according to intake levels of SSB by obesity status

<table>
<thead>
<tr>
<th>Intake levels of SSB (times/day)</th>
<th>0 - &lt;0.5 (n=93)</th>
<th>0.5 - &lt;1 (n=53)</th>
<th>1 - &lt;2 (n=78)</th>
<th>2+ (n=83)</th>
<th>P value for trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obese</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cases</td>
<td>119</td>
<td>36</td>
<td>19</td>
<td>30</td>
<td>34</td>
</tr>
<tr>
<td>Non-cases</td>
<td>10</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Multivariate OR</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Non obese</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cases</td>
<td>91</td>
<td>19</td>
<td>16</td>
<td>26</td>
<td>30</td>
</tr>
<tr>
<td>Non-cases</td>
<td>87</td>
<td>34</td>
<td>17</td>
<td>20</td>
<td>16</td>
</tr>
<tr>
<td>Multivariate OR</td>
<td>1.00</td>
<td>2.38 (0.76,7.48)</td>
<td>4.48 (1.49,13.5)</td>
<td>7.69 (2.28,25.9)</td>
<td>0.001</td>
</tr>
</tbody>
</table>

\(^1\) Odd ratios are adjusted for age (9-12, 13-18), sex, moderate physical activity and walking (<60 min/d / ≥60 min/d), vigorous physical activity (<60 min/d / ≥60 min/d), smoking (never, occasional, current), oral contraceptive use (yes/no), fiber intake (g/day, quartiles), magnesium intake (mg/day, quartiles), vitamin D intake (IU/day, quartiles), alcohol (yes/no), coffee (yes/no), trans fatty acids (% of total fat intake)
CONCLUSION

- **High prevalence of**
  - Hyperinsulinemia (68.4%)
  - Overweight/obesity (65.5%)
  - WC ≥90th percentile (51.8%)
  - WHtR ≥0.5 (90.9%)

- "**Higher intakes of SSBs were associated with hyperinsulinemia risk**, especially among non-obese Cree youth"

- **Further investigations, especially longitudinal and clinical studies, are needed to confirm the findings and to establish more targeted diabetes prevention policies**
Strengths and limitations

- Limitations
  - Cross-sectional design → cannot infer causality
  - SSB → marker of an overall unhealthy diet?
  - Ceiling effect?
  - Desirability bias?
  - Reverse causation?

- Strengths
  - Relatively large definition of the exposure variable
  - Measured not self reported weight and height
Acknowledgement

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