Childhood Obesity and Type 2 Diabetes

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Disclosures

- I serve as a Novo Nordisk Advisory Board Consultant
- I am funded for pharmaceutical studies by Roche-Genentech and NovoNordisk
- I will discuss unapproved uses of medications

Definition of Obesity

Organization	Overweight	Obese
US CDC	BMI 85th to < 95th percentile	BMI≥95th percentile
IOTF	Provides international BMI cut points by age and sex for overweight and obesity for children 2 to 18 years. Cut points correspond to an adult BMI of 25 kg/m2 (overweight) or 30 kg/m2 (obesity)	
WHO	**Birth to 5yr old**: BMI=2 standard deviations above the WHO growth standard median **5-19yr old:** BMI > 1 standard deviation above the WHO growth standard median	**Birth to 5yr old:** BMI >3 SD above the WHO growth standard median **5-19yr old:** BMI > 2SD above the WHO growth standard median

Obesity Classification

Adult

- Overweight- BMI= 25.00 to 29.99 kg/m2
- Class 1 Obesity-BMI= 30.00 to 34.99 kg/m2
- Class 2 Obesity-BMI=35.00 to 39.99 kg/m2
- Class 3 Obesity- BMI≥40.00 kg/m2

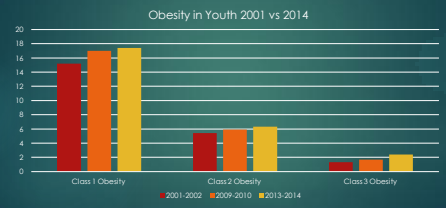
Kuczmarski RJ & Flegal KM. Am J Clin Nutr. 2000; 72:1074-1081.

Adolescent

- Overweight= BMI ≥ 85th and < 95th percentile
- Class 1 =BMI ≥ 95th %ile and <120% of 95th percentile
- Class 2=BMI≥ 120% of 95th percentile
- Class 3=BMI≥ 140% of 95th percentile

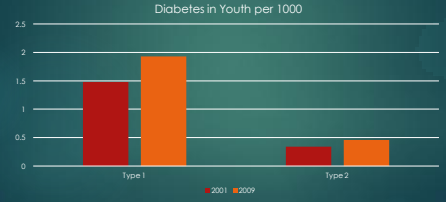
Jasik CB, et al. Childhood Obes. 2015; 11,#5: 630-637

Prevalence of Obesity



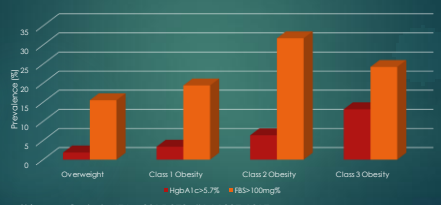
Skinner A, et al. Obesity 2016; 24:1116-1123

Prevalence of Diabetes by Type, 2001-2009



Dabelea D, et al. JAMA 2014;311(17):1778-1776

Prevalence of abnormal HgbA1c and FBS by Weight Category, 3 -19 yrs of age



Skinner AC et al. NEJM 2015;373, #14:1307-1317

Summary

- Obesity prevalence is increasing among youth
- Both Type 1 diabetes and Type 2 diabetes have increased in prevalence during this same period making weight less useful as a key determinant of who has Type 2 diabetes
- Obesity severity is associated with progressively abnormal measures of glucose intolerance suggesting that continued increases in obesity are likely to lead to increasing Type 2 diabetes.

Type 2 diabetes in youth

CHILDHOOD OBESITY AND TYPE 2 DIABETES

Testing for Type 2 DM in Children*(1)

- Criteria
  - Severe Obesity (BMI >99th percentile, or BMI>120% of 95th%ile);

  OR at onset of puberty with
  - Obesity (BMI≥ 95%ile)
  - Overweight (BMI>85th percentile but less than 95%ile with risk factors)
    - Patients on second generation antipsychotics,

    Or Any two for the following risk factors:
    - Family history of type 2 DM in first or second degree relative
    - Race/ethnicity (American Indian, African-American, Hispanic, Asian/Pacific Islander)
    - Signs of insulin resistance or conditions associated with insulin resistance (acanthosis nigricans, hypertension, dyslipidemia, PCOS)

*Pediatrics 105,#3:671-680, 2000. and Haemer MA, et al. Childhood Obesity 2014; 10, #4:292-303.

Testing for Type 2 DM in Children(2)

- Age of initiation: 10yrs, or

  at onset of puberty

  (if puberty occurs at a younger age)
- Frequency: Every 2 years when normal or more often if new risks emerge
- Test: Fasting Plasma Glucose

Pediatrics 105,#3:671-680, 2000. and Haemer MA, et al. Childhood Obesity 2014; 10, #4:292-303.

Criteria for Diagnosis of DM

- 1. Symptoms of diabetes plus casual plasma glucose concentration >=200 mg/dl (11.1 mmol/l).
  - Casual is defined as any time of day without regard to time since last meal.
  - The classic symptoms of diabetes include polyuria, polydipsia, and unexplained weight loss
- 2. FPG >=126 mg/dl (7.0 mmol/l)*.
  - Fasting is defined as no caloric intake for at least 8 h.
- 3. 2-h PG >=200 mg/dl (11.1 mmol/l)* during an OGTT.
  - The test should be performed as described by WHO, using a glucose load containing the equivalent of 75 g anhydrous glucose dissolved in water.
- 4. HgbA1c ≥ 6.5%
  - Performed in a lab that is NGSP certified and uses an assay standardized to DCCT

*Abnormal blood glucose values should be confirmed by repeat testing on a different day

Diagnosis and Classification of Diabetes Mellitus. Diabetes Care 37(suppl 1)L/s81-S90, 2014

How do we screen for Type 2 diabetes in youth

IS HGBA1C AN APPROPRIATE SCREENING TOOL IN THE CHILD OR, IS FBS OR AN OGTT MORE APPROPRIATE?

Which test is best for diagnosis of DM in youth?

- 4848 Obese Children and Adolescents aged 7 to 17yrs
  - oGTT & HgbA1c testing identified 2.4% of children with diabetes (n=115)
    - 68.7% had HgbA1c>6.5%
    - 46.1% had FPG≥126mg% and/or 2Hr glucose≥200mg%
    - 43.5% had diabetes confirmed

Ehehalt S. et al, Eur J Pediatric Diabetes 2016: DOI 10.1007/s00431-016-2807-6

Association between oGTT measure of IFG, IGT, and HgbA1c in children

- 4848 Obese Children and Adolescents aged 7 to 17yrs
- Correlation entire population:
  - FPG and 2-hr glucose= r=0.26
  - FPG and HgbA1c= r=0.18
  - 2-hr glucose and HgbA1c= r=0.17
- Correlation IFG
  - 2-Hr glucose vs HgA1c, r=0.30
- Confirmed diabetes
  - FPG and 2-Hr glucose, r=0.73
  - 2Hr glucose vs HgA1c, r= -0.47

Ehehalt S, et al. Pediatric Diabetes 2016:1-8, DOI 10.1111/pedi.12461

Summary

- In a general asymptomatic obese population of children, different results are obtained as indicators of diabetes by HgbA1c and oGTT
- The best correlation between values occurs in patients with confirmed diabetes not those at risk for diabetes

How persistent is Glucose intolerance?(1)

- Weiss R, et al. Diabetes Care 2005; 28,#4:902-909
  - 117 obese children, 4 to 18yrs of age, BMI>95%ile, mixed ethnicity had oGTT done at baseline and 18 to 24 m later
  - 84 wth NGT, 33 with IGT
    - 76(90.5%) with NGT maintained NGT
    - 8 (9.5%) with NGT progressed to IGT
    - 15 (45.5%) with IGT reverted to NGT
    - 10 (30.3%) with IGT persisted with IGT
    - 8(24.2%) with IGT progressed to T2DM
  - 7 of the 8 who progressed to T2DM were African American females with much higher BMI than the group

How persistent is Glucose intolerance?(2)

- Kleber et al. Diabetic Medicine 2010, 27,#5:516-521.
  - 79 obese white children, mean age 13 with IGT
  - 32% at 1yr with persistent IGT, 66% converted to NGT
  - 1 chld with IFG, 1 child progressed to diabetes
- Libman, et al. JCEM 2008;93, #11:4231-4237
  - 85 overwgt/obese children, mixed ethnicity, mean age=12.4yr
  - Repeat oGTT 1 week later
    - 10 with IGT, 30% concordonace at 2nd oGTT
    - Those with discordant oGTT had more measures of insulin resistance than those with concordant results as measured by HOMA or WBISI

Summary

- Results of oGTT are subject to change in children and adolescents
- Only about 30% of those with IGT persist with IGT and an even smaller fraction progress to Type 2 DM
- Those who progress to Type 2 DM are likely to be of heavier weight and African American Heritage.

Association of IFG and IGT with cardiometabolic risk in children

- 972 children and 2116 adolescents (OW/Ob) between 2003 and 2013 received oGTT tests
- Prevalence same between children and adolescents
  - IFG =3.2% vs 3.3% respectively
  - IGT= 4.6 vs 5.0% respectively
- Isolated IGT vs NGT
  - Children: 2 to11-fold increased risk of elevated LDL-C, non-HDL-C, Tg/HDL-C ratio and low insulin sensitivity
  - Adolescence: Similar increased cardiometabolic risk profile

DiBonito P, et al. J. Endocrinol Investig. 2016: DOI:10.1007/s40618-016-0576-8

What is treatment for Pre-Diabetes?

SHOULD WE TREAT PRE-DIABETES WITH METFORMIN OR IS LIFESTYLE SUFFICIENT?

Pre-Diabetes

- Impaired Fasting Glucose
  - Fasting plasma glucose ≥100 and ≤ 125mg%*
- Impaired Glucose Tolerance
  - 2-Hr glucose ≥ 140 and <200mg% in a 75gm (or 1.75mg/kg to a max of 75gm) oGTT*
- Category of increased diabetic risk
  - HgbA1c =5.7% to 6.4% *

*Diagnosis and Classification of Diabetes Mellitus. Diabetes Care 37(suppl 1):s81-S90, 2014

Prediabetes therapy

- Limited pediatric data available to determine optimum therapy
- Garnett S, et al. BMC Pediatrics 2014; 14, #1:289
  - 110 obese children, age 10 to 17, treated with metformin but randomized to high carb diet vs high protein, moderate carb diet showed improvements with 6.8% decrease in BMI, 2.4% decrease in percent body fat and an increase in insulin sensitivity
  - There were no dietary differences in response to combined intervention
- Haemer M, et al. Childhood Obesity 2014;10,#4:292-303.
  - Systematic review of clinical practice (25 pediatric obesity clinics), plus literature review to come to consensus statement
  - "The Committee takes no position on the use of pharmacological agents to prevent T2DM in children with prediabetes or elevated fasting insulin, given the limited studies in children and evidence that many children ith prediabetes may revert to normoglycemia without pharmacological treatment (Evidence C)."

Conclusion

- Increased obesity associated with increase prevalence of T2DM and prediabetes in youth
- Pre diabetes is associated with adverse cardiometabolic risk profile in children and adolescents
- Results of oGTT, either fasting or 2-Hr, have poor correlation with each other and with HgbA1c in an asymptomatic obese population of children,
- Prediabetic results in children frequently remit to normal results
  - All 3 tests may be used to diagnose T2DM, but results of any one episode of testing must be cautiously interpreted given the variability in results over time.
- More severe obesity, African American heritage and female status is most associated with progression from pre-diabetic to diabetic state.

Cardiovascular Consequences of Obesity in Children

Sheldon E. Litwin, M.D.
Alicia Spaulding-Paolozzi Professor of Cardiology
Medical University of South Carolina
Ralph H. Johnson VAMC

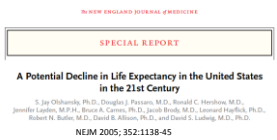
Disclosures:

None

Key Points

- Obese children more likely to become obese adults
- Coronary risk factors increased in obese children (DM, HTN, dyslipidemia, NAFLD, OSA)
- Childhood obesity associated with increased markers of atherosclerosis and CV death in adulthood
- Return to normal weight in adulthood may attenuate risk from childhood obesity
- Lifestyle modification programs disappointing
- Limited data on pharmacological therapy
- Bariatric surgery effective option for severe obesity (long term data lacking)

We all face consequences of the obesity epidemic


The NEW ENGLAND JOURNAL of MEDICINE

SPECIAL REPORT

A Potential Decline in Life Expectancy in the United States in the 21st Century

S. Jay Olshansky, Ph.D., Douglas J. Passaro, M.D., Ronald C. Hershow, M.D., Jennifer Layden, M.P.H., Bruce A. Carnes, Ph.D., Jacob Brody, M.D., Leonard Hayflick, Ph.D., Robert N. Butler, M.D., David B. Allison, Ph.D., and David S. Ludwig, M.D., Ph.D.

NEJM 2005; 352:1138-45

"Assuming that current rates of death associated with obesity remain constant in this century, the overall negative effect of obesity on life expectancy in the US is a reduction of 1/3 to 3/4 of a year. This is not trivial – it is larger than the negative effect of all accidental deaths combined…and there is reason to believe it could exceed the negative effect that ischemic heart disease or cancer has on life expectancy."


The NEW ENGLAND JOURNAL of MEDICINE

SPECIAL ARTICLE

Forecasting the Effects of Obesity and Smoking on U.S. Life Expectancy

Susan T. Stewart, Ph.D., David M. Cutler, Ph.D., and Allison B. Rosen, M.D., Sc.D.

NEJM 2009; 361:2252-60

"The negative effects of increasing BMI overwhelmed the positive effects of declines in smoking in multiple scenarios."

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VOLUME 337 SEPTEMBER 25, 1997 NUMBER 13

NEJM 1997; 337:869-73

PREDICTING OBESITY IN YOUNG ADULTHOOD FROM CHILDHOOD AND PARENTAL OBESITY

Robert C. Whitaker, M.D., M.P.H., Jeffrey A. Wright, M.D., Margaret S. Pepe, Ph.D., Kristy D. Seidel, M.S., and William H. Dietz, M.D., Ph.D.

N=854
Retrospective
Born 1965-71
16% obese age 21-29

Table 4. Odds Ratios for Obesity in Young Adulthood According to Subjects' Obesity Status in Childhood and Their Parents' Obesity Status, from Multivariate Logistic-Regression Models.*

Age (yr)	Subject Obese as a Child	No. of Obese Parents	
	yes vs. no	1 vs. 0	2 vs. 0
	odds ratio (95% confidence interval)		
1–2	1.3 (0.6–3.0)	3.2 (1.8–5.7)	13.6 (3.7–50.4)
3–5	4.7 (2.5–8.8)	3.0 (1.7–5.3)	15.3 (5.7–41.3)
6–9	8.8 (4.7–16.5)	2.6 (1.4–4.6)	5.0 (2.1–12.1)
10–14	22.3 (10.5–47.1)	2.2 (1.2–3.8)	2.0 (0.8–5.2)
15–17	17.5 (7.7–39.5)	2.2 (1.1–4.3)	5.6 (2.5–12.4)

*Young adulthood was defined as 21 to 29 years of age. The variables included in the model were childhood obesity status (obese or not obese) and the number of obese parents (0, 1, or 2). See the Methods section for an explanation of adjustments for siblings.

Obese children more likely to become obese adults. Strong parental influence. Genetic? Behavioral? Both?

The NEW ENGLAND JOURNAL of MEDICINE
ORIGINAL ARTICLE

NEJM 2015; 373:1307-17

Cardiometabolic Risks and Severity of Obesity in Children and Young Adults

Asheley C. Skinner, Ph.D., Eliana M. Perrin, M.D., M.P.H., Leslie A. Moss, M.H.A., C.H.E.S., and Joseph A. Skelton, M.D.

Age 2-19, 6% severely obese (NHANES 2011-12)

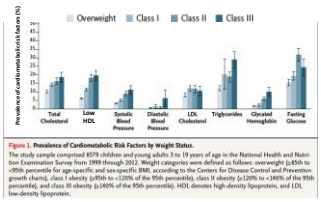


Figure 1. Prevalence of Cardiometabolic Risk Factors by Weight Status.
The study sample comprised 8579 children and young adults 3 to 19 years of age in the National Health and Nutrition Examination Survey from 1999 through 2012. Weight categories were defined as follows: overweight (≥85th to <95th percentile for age-specific and sex-specific BMI, according to the Centers for Disease Control and Prevention growth charts), class I obesity (≥95th to <120% of the 95th percentile), class II obesity (≥120% to <140% of the 95th percentile), and class III obesity (≥140% of the 95th percentile). HDL denotes high-density lipoprotein, and LDL low-density lipoprotein.

Increased CV Risk Factors in obese children and adolescents

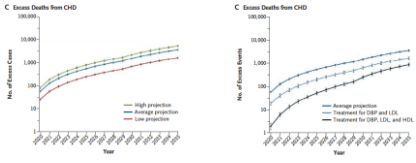
The NEW ENGLAND JOURNAL of MEDICINE
SPECIAL ARTICLE

NEJM 2007; 357:2731-9

Adolescent Overweight and Future Adult Coronary Heart Disease

Kirsten Bibbins-Domingo, Ph.D., M.D., Pamela Coxson, Ph.D., Mark J. Pletcher, M.D., M.P.H., James Lightwood, Ph.D., and Lee Goldman, M.D., M.P.H.

- Adolescent overweight projected to ↑ prevalence of obese 35 yr olds in 2020 to 30-37% in men & 34-44% in women.*
- Estimated that prevalence of CHD will ↑ 5-16%



* 37.7% in all adults NHANES 2013-14

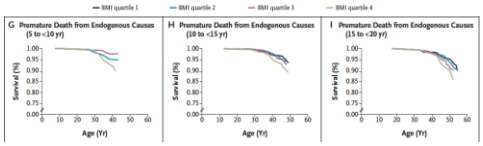
The NEW ENGLAND JOURNAL of MEDICINE

NEJM 2010; 362:485-93

Childhood Obesity, Other Cardiovascular Risk Factors, and Premature Death

Paul W. Franks, Ph.D., Robert L. Hanson, M.D., M.P.H., William C. Knowler, M.D., Dr.P.H., Maurice L. Sievers, M.D., Peter H. Bennett, M.B., F.R.C.P., and Helen C. Looker, M.B., B.S.

- 4587 American Indian children (11.3 yrs), median f/u 23.9 yrs
- Rates of death from endogenous causes in highest quartile BMI > double that in lowest quartile
- Obesity, glucose intolerance and HTN in childhood strongly associated with premature death



Obesity and age of first MI.

Madala et al. JACC 2008

CRUSADE registry, 189,000 patients, 2001-2007

Most obese subgroup (BMI > 40) were 15 years younger than leanest subgroup at time of first MI

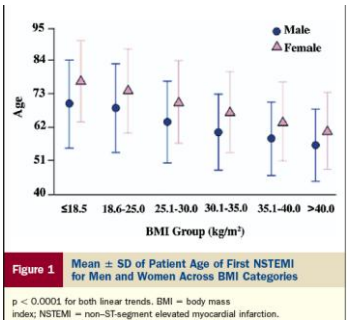


Figure 1 Mean ± SD of Patient Age of First NSTEMI for Men and Women Across BMI Categories

$p < 0.0001$ for both linear trends. BMI = body mass index; NSTEMI = non–ST-segment elevated myocardial infarction.

Main findings from the prospective Cardiovascular Risk in Young Finns Study

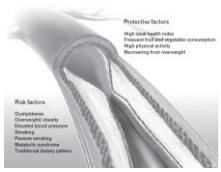
Markus Juonala[a,b], Jorma S.A. Viikari[b], and Olli T. Raitakari[b,c]

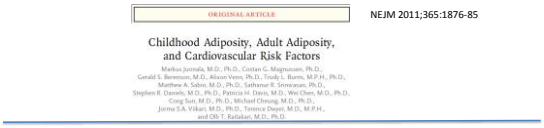
Curr Opin Lipidol 2013, 24: 57-64

- 3596 Finnish children & adolescents 3-18 years
- Followed up at 3-9 year intervals
- Currently at 30 year follow up (middle age)
- Intermediate phenotypes (CIMT, CAC, echo, FMD, PWV) 2001, 2007, 2010, 2012

KEY POINTS

- Cardiovascular risk factors are predictive of subclinical atherosclerosis in adulthood.
- Childhood risk factor measured at or after the age 9 years has strongest associations with later atherosclerosis.
- The effects of childhood overweight/obesity seem to be reversible, whereas childhood cholesterol and blood pressure (BP) levels and smoking have more permanent influence.
- Although risks associated with childhood adiposity are reversed, only a minority of overweight/obese children can achieve nonobese adult BMI.





ORIGINAL ARTICLE

NEJM 2011;365:1876-85

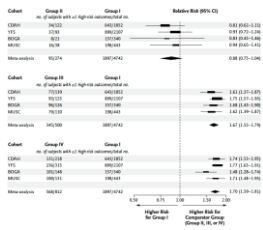
Childhood Adiposity, Adult Adiposity, and Cardiovascular Risk Factors

Markus Juonala, M.D., Ph.D., Costan G. Magnussen, Ph.D., Gerald S. Berenson, M.D., Alison Venn, Ph.D., Trudy L. Burns, M.P.H., Ph.D., Matthew A. Sabin, M.D., Ph.D., Sathanur R. Srinivasan, Ph.D., Stephen R. Daniels, M.D., Ph.D., Patricia H. Davis, M.D., Wei Chen, M.D., Ph.D., Cong Sun, M.D., Ph.D., Michael Cheung, M.D., Ph.D., Jorma S.A. Viikari, M.D., Ph.D., Terence Dwyer, M.D., M.P.H., and Olli T. Raitakari, M.D., Ph.D.

- International Cardiovascular Cohort Consortium (IC3)
- Bogalusa, Muscatine, Childhood Determinants of Adult Health (Australia), CV Risk Young Finns
- 6238 subjects

	Group 1	Group 2	Group 3	Group 4
Child	-	+	+	-
Adult	-	-	+	+

High risk outcomes:
LDL > 160, HDL < 40, TG > 200, T2DM, HTN, CIMT > 90th %



Obese children who become normal weight adults have lower risk

Weight loss pharmacotherapy

- Perception of physicians
  - Unproven
  - Ineffective
  - Unsafe
- Reality
  - > 17,000 patients in clinical trials
  - >10% weight loss~ 50% of patients
  - No evidence of adverse CV effects

Pharmacological Rx of Obesity

Drug	Class	Current status
Orlistat	Lipase inhibitor (blocks fat absorption)	OTC (small weight loss, GI side effects) *Approved for children*
Phentermine/Topiramate (Qsymia™)	NE reuptake blocker Anticonvulsant, migraine	Approved for adults
Liraglutide (Sandexa™)	GLP-1 agonist Injectable	Approved for adults
Lorcascerin (Belviq™)	Serotonin agonist (selective)	Approved for adults
Bupropion/Naltrexone (Contrave™)	Dopamine reuptake inhib/Opioid receptor antagonist	Approved for adults

Metformin in Obese Children and Adolescents: The MOCA Trial

D. Kendall, A. Vail, R. Amin, T. Barrett, P. Dimitri, F. Ivison, M. Kibirige, V. Mathew, K. Matyka, A. McGovern, H. Stirling, L. Tetlow, J. Wales, N. Wright, P. Clayton, and C. Hall

Metformin was associated with a significant reduction in BMI-SDS compared with placebo at 6 months [mean difference 0.1 SD (95% CI 0.18 to 0.02), P 0.02].

Bariatric Surgery

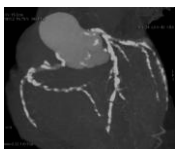
Roux en Y GBP
Restrictive/malabsorptive

A proud and happy participant in our study at the time of his 2 year follow up visit

Average weight loss in GBS subjects at 2 years = -100 lbs

Average change in BMI at 2 years = -15 units

Lower coronary Calcium Scores After Bariatric Surgery



Results of CAC Substudy (6 year follow up)

	GBS (n=71)	No Surgery (n=62)	P value
CAC score (mean)	33+114	107+340	<0.01
CAC score = 0	67%	43%	
CAC score 1-10	16%	22%	< 0.01
CAC score 11-100	10%	18%	
CAC score > 100	7%	17%	

Priester T....Litwin SE: Coronary calcium scores 6 years after bariatric surgery. Obes Surg 2015; 25:90-96

The NEW ENGLAND JOURNAL of MEDICINE

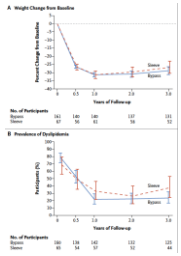
NEJM 2016; 374:113-23

Weight Loss and Health Status 3 Years after Bariatric Surgery in Adolescents

Teen LABS (Longitudinal Assessment of Bariatric Surgery
242 adolescents (17 yrs, BMI 53, 75% female, 72% white)
3 year follow up
Remission of:
- type 2 diabetes 95%
- prediabetes 76%
- elevated blood pressure 74%
- dyslipidemia 66%
- abnormal kidney function 86%

Improved weight related quality of life

Low ferritin 57%
Reduced vitamin B12, A, D levels
13% had repeat abdominal procedures



Journal of the American College of Cardiology
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Obesity and Cardiac Function

Reversibility of Cardiac Abnormalities in Morbidly Obese Adolescents

Holly M. Ippisch, MD, MS,* Thomas H. Inge, MD, PhD,† Stephen R. Daniels, MD, PhD, FACC,‡ Baiyang Wang, MS,* Philip R. Khoury, MS,* Sandra A. Witt, RDCS,* Betty J. Glascock, RDCS,* Victor F. Garcia, MD,† Thomas R. Kimball, MD, FACC*
Cincinnati, Ohio, and Denver, Colorado

38 adolescents (13-19 yrs, 29 female, 33 white)
Pre and post bariatric surgery (mean f/u 10 months)
BMI 60 => 40 kg/m^2

Table 2 Effects of Weight Loss on LV Geometry and Systolic Function

	Pre-Operative (n = 38)	Post-Operative (n = 38)	p Value
Indexed LVM (g/m$^{2.7}$)	54 ± 13	42 ± 10	<0.0001
LVM (g)	233 ± 61	177 ± 45	<0.0001
RWT	0.41 ± 0.07	0.33 ± 0.06	<0.0001
IVSd (cm)	1.07 ± 0.20	0.89 ± 0.18	<0.0001
LVPWd (cm)	1.09 ± 0.18	0.87 ± 0.14	<0.0001
LVEDD (cm)	5.29 ± 0.4	5.38 ± 0.5	NS
Shortening fraction %	39 ± 5	38 ± 4	NS

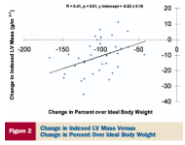
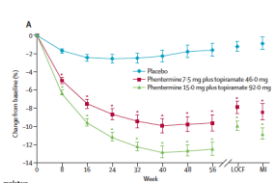


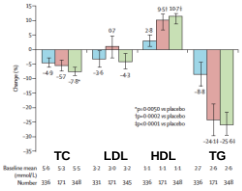
Figure 2 Change in Indexed LV Mass Versus Change in Percent Over Ideal Body Weight

Summary

- Obese children more likely to become obese adults
- Coronary risk factors increased in obese children (DM, HTN, dyslipidemia, NAFLD, OSA)
- Childhood obesity associated with increased markers of atherosclerosis and CV death in adulthood
- Return to normal weight in adulthood may attenuate risk from childhood obesity
- Lifestyle modification programs disappointing
- Limited data on pharmacological therapy
- Bariatric surgery effective option for severe obesity (long term data lacking)

Effects of low dose, controlled release, phentermine plus topiramate combination on weight and associated comorbities in overweight and obese adults (CONQUER): A randomized, placebo-controlled phase 3 trial
Gadde KM, et al Lancet 2011; 377:1341-52

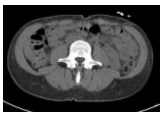




Abdominal CT Scans

Nonsurgery Subjects

Surgery Subjects



Orthopedic Implications of Childhood Obesity

VuMedi webinar 12/5/16

Dave Shenton MD

THE CENTERS OF EXCELLENCE
ORTHO MONTANA

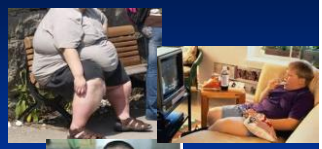
- I have nothing to disclose

General thoughts regarding childhood obesity and orthopedic problems

- Disclaimer – I am not a Pediatric Orthopedic surgeon. I specialize in Sports medicine (esp. shoulders, knees)
  - However, I have seen the dramatic change in childhood obesity in my practice over the past 30 years, became alarmed, participated in education of parents
- Children inherently have special orthopedic risks with obesity versus adults because they are growing and developing
  - Orthopedic Conditions - Growth plate injuries (SCFE, Blounts, etc)
    - Other musculoskeletal problems – Perthes, etc
  - General musculoskeletal complaints and injuries
    - Increased risk of injury and compromised recovery
    - Back, lower extremity, ankle and foot problems

The problem with childhood obesity:

- As a society we Americans are overfed and undernourished
- Inactivity is epidemic
  - Nearly 40% of kids physically unfit



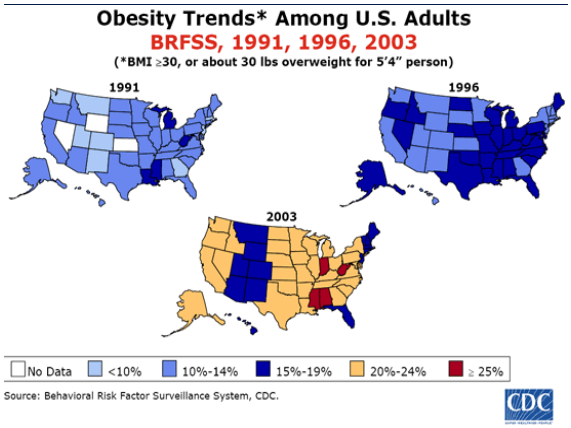

Society has taken notice

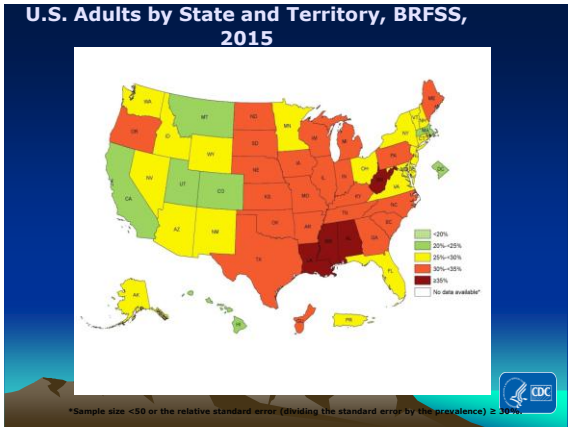
The Causes:

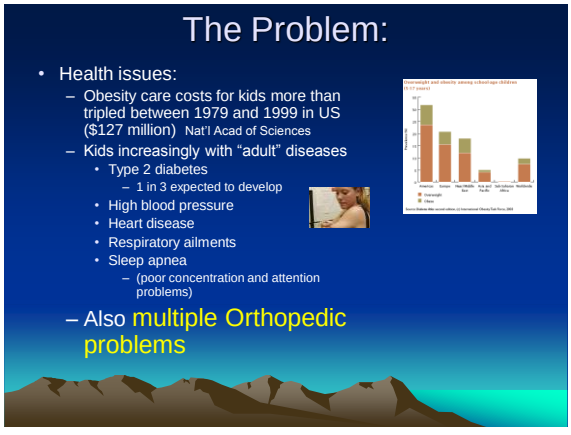
- "The biggest factor for obesity in the young is still parental overweight"!

B. Healy MD, USN&WR Sept 4, 2006

Children who are overweight or obese as preschoolers are five times as likely as normal-weight children to be overweight or obese as adults.

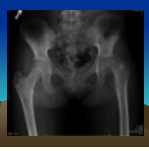
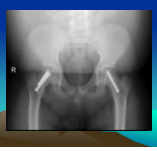


Obesity Trends* Among U.S. Adults
BRFSS, 1991, 1996, 2003
(*BMI ≥30, or about 30 lbs overweight for 5'4" person)
1991
1996
2003
No Data
<10%
10%-14%
15%-19%
20%-24%
≥ 25%
Source: Behavioral Risk Factor Surveillance System, CDC.
CDC


U.S. Adults by State and Territory, BRFSS, 2015
<20%
20%–<25%
25%–<30%
30%–<35%
≥35%
No data available*
CDC
*Sample size <50 or the relative standard error (dividing the standard error by the prevalence) ≥ 30%


The Problem:
• Health issues:
– Obesity care costs for kids more than tripled between 1979 and 1999 in US ($127 million) Nat'l Acad of Sciences
– Kids increasingly with "adult" diseases
• Type 2 diabetes
– 1 in 3 expected to develop
• High blood pressure
• Heart disease
• Respiratory ailments
• Sleep apnea
– (poor concentration and attention problems)
– Also multiple Orthopedic problems

Slipped Capital Femoral Epiphysis

- Orthopedic condition in adolescence where the femoral head slips posterior and inferior relative to the femoral neck
  - This can happen either acutely or more slowly and chronically.
  - Usually presents with hip and/or knee pain and limping.
  - Often occurs during periods of rapid growth or shortly after adolescence
  - This is a surgical problem classically requiring screws or pins to stabilize the slip and effect healing
    - Multiple complications possible including avascular process of the femoral head, chondrolysis, persistent pain and stiffness
    - The surgery is more difficult with increased risk of complications reported in obese children
  - Risk factors include obesity – resulting in increased shear forces

Multiple studies show association between overweight/obesity and slipped capital femoral epiphysis (SCFE) – e.g.:

- Aversano MW, et al. Association between body mass index-for-age (CDC ref) and SCFE: the long term risk for subsequent slips in patients followed until physeal closure. J Child Orthop 2016.
  - Association between obesity measured by BMI-for-age percentiles and SCFE
  - All but one patient (79/80) greater than 85th percentile
- Nasreddine AY, et al. a reduction in body mass index lowers risk for bilateral SCFE. Clin Orthop Relat Res 2013
- Loder RT. The demographics of slipped capital femoral epiphysis. *Clin Orthop*. 1996; 322:8–27.
  - reviewed the cases of 1630 children with 1993 SCFE.
  - worldwide - 47.5% white, 24.8% black, 16.9% Amerindian, 7.4% Indonesian-Malay, 2.1% Native American/Pacific Islands, and 1.3% Indo-Mediterranean children
  - 671 were girls (41.2%) and 959 were boys (58.8%) avg age 12 and 13.5 years, respectively
  - The age at diagnosis decreased with increasing obesity
  - weight status (at the time of the first slip) was known for 1337 children - 51.5% were obese (body weight >95th percentile), 11.7% were overweight (body weight in 90th to 95th percentile

Blount's Disease

- Orthopedic condition with severe bowing (varus deformity) of the legs
  - Thought to result from increased and uneven stress on the growth plate caused by excess weight leading to irregular growth and deformity.
    - Probably preceded by physiologic varus in the child combined with overweight
  - Infantile and adolescent types (both uncommon, reported at less than 1%)
  - Usual presenting complaint is the progressive deformity, rather than pain
  - Treatment can consist of leg braces or orthotics in younger patients and with less severe deformities.
  - Surgery is required in older patients and those with more severe deformities.
    - Complications can include malunion, gross deformity, infection, delayed healing, recurrence
    - Surgery is more difficult in obese patients and a higher risk of complicationsis reported.


Radiographic features include varus at epiphyseal/metaphyseal junction
- Widened irregular medial physis
- Medial sloping of epiphysis
- Beaking of medial metaphysis

Blount's disease - Relationship to obesity

- Obesity has been linked with the prevalence and degree of angulation of the deformity in infantile Blount disease
- Dietz WH, Gross WL, Kirkpatrick JA. Blount disease (tibia vara): another skeletal disorder associated with childhood obesity. *J Pediatr*. 1982;101:735–737
  - Retrospective study of 18 cases of children with Blount disease. Of these, 16 had infantile Blount disease, and all the patients described as obese (>120% of ideal body weight) had infantile Blount
    - the relationship of the onset of obesity and the onset of the Blount disease could not be determined
- More than 90% of the reported cases of adolescent Blount's disease have been in black males who are morbidly obese
- Henderson RC, Kemp GJ, Hayes PRL. Prevalence of late-onset tibia vara. *J Pediatr Orthop*. 1993;13:255–258.
  - Studied all boys area high-school football teams who weighed >210 lb
    - (210 lb - 95th percentile for 18-year-old males - National Center for Health Statistics)
  - Of the 1117 boys, 140 boys (80 black and 60 white) met the weight criteria
  - Radiographs of the seven boys who clinically screened positive showed that two boys had adolescent Blount disease, resulting prevalence was 2.5% (two of 80 boys) in the adolescent black male population described as obese

Perthes disease – relationship to childhood obesity

- Loss of blood supply to femoral head leading to necrosis
  - typically occurs in children who are between 4 and 10 years old. Boys 5:1 girls. 10% to 15% bilateral.
  - 4 stages: necrosis, fragmentation, re-ossification, healed -can take years
  - All require prolonged bracing or traction and some require surgery.
  - Increased risk of hip osteoarthritis later in life

- **Prevalence of Obesity in Patients With Legg-Calvé-Perthes Disease.**
  - Neal DC, et al. J Am Acad Orthop Surg. 2016.
  - Retrospective, 150 patients
  - 16% overweight and 32% obese
  - Obese with 2.8 times likelihood of requiring bony operation
  - Obesity common in Perthes patients and associated with a later stage of disease presentation

Various musculoskeletal complaints

- Orthopedic specialists commonly see overweight children complaining of hip, back, knee and foot pain.
- **Overweight and obesity are associated with musculoskeletal complaints as early as childhood: a systematic review.**
  - Review article Paulis WD, et al. Obes Rev. 2014.
  - 40 articles included
  - Concluded that "overweight and obesity are associated with musculoskeletal pain, injuries and fractures as early as childhood"
    - More high quality prospective core studies are needed.
- Krul, M et al, Ann Fam Med Jul-Aug 2009). Musculoskeletal problems in overweight and obese children.
  - Overweight/obese children with more musculoskeletal, lower extremity and ankle and foot problems versus normal weight

Fractures/Sprains and Related Complications

- Obese/overweight children may have a higher risk for fractures
  - Increased forces with falls
  - Awkwardness, decreased coordination?
  - Possibly relatively weaker bones secondary to inactivity
- Treatment of fractures can be complicated/compromised
  - traditional metal implants more likely to fail –
    - Guidelines for use of elastic nails for femur fractures versus IM rods etc.
    - Weiss et al 2008- Increased risk complications flexible nails with increasing BMI - wound infections, nonunion , skin ulcers, nerve palsy, re-fracture
  - crutches may be difficult to use –
    - mobilization of lower extremity fractures complicated (Hayashi, 2009)
  - Cast/splint immobilization may be more difficult and inadequate
    - E.g. hip spica cast not effective for fatter kids
    - Trouble controlling fx alignment with extremity casts -soft tissue envelope
- Timm NL, et al. Arch Pediatr Adolesc Med. 2005. **Chronic ankle morbidity in obese children following an acute ankle injury. Arch Ped Adolesc Med 2005 -**Overweight children increased Sx 6 mo post ankle sprain

Multiple studies showing increased frequency or severity of fractures with childhood obesity

- Seeley MA, et al. Obesity and its effects on pediatrics supracondylar humeral fractures. JBJS 96A (3), Feb 2014
  - 354 patients
  - Obesity was associated with more complex fractures, preoperative and postoperative nerve palsies, and postoperative complications
  - Obese patients were more likely to sustain complex fractures from a simple fall on outstretched hand.
- Goulding A, Jones IE, Taylor RW, et al. More broken bones: 4-yr double cohort study of young girls with and without distal forearm fractures. *J Bone Miner Res*. 2000;15:2011–2018
  - girls, aged 3 to 15 years
  - 100 who had each recently traumatically fractured a forearm was compared with a group of 100 who were fracture free.
  - previous fractures, low total body area bone mineral density (g/cm^2), and high body weight each independently increased the risk of new fractures in growing children.
  - Also, spinal volumetric bone mineral apparent density (g/cm^3) was a predictor of new fractures.
  - Fracture group- 8 to 19 year olds 4.7 kg (~10 lb) heavier

Impairments in mobility and balance associated with obesity?

- McGraw B, McClenaghan BA, Williams HG, et al. Gait and postural stability in obese and nonobese prepubertal boys. *Arch Phys Med Rehabil*. 2000;81:484–489.
  - Boys aged 8 to 10 years who were obese spent a greater percentage of the gait cycle in dual stance and had diminished dynamic stability.
- A study of 93 boys aged 10 to 21 years supported that adolescents who are overweight have poorer balance than those of healthy weight
  - Increased risk of falling
  - Difficulty halting forward progress when they began the fall
  - Increased force applied to bones with fall.
- Taylor MS III found that overweight children report a significant impairment in mobility compared to non overweight children.
- Developmental coordination disorder (DCD)?

Back and Spine problems with childhood obesity

- Samartzis D, et al. A population-based study of juvenile distant generation and its association with overweight and obesity, low back pain…. JBJS 2011
  - Obesity increases the risk of degenerative disc disease by 14 times.
- A review of 65 epidemiologic studies of low back pain did report that 32% of the 65 reviewed studies showed a statistically positive link between weight and low back pain
- Milbrandt, TA – Increased complication rates following scoliosis surgery in adolescent girls
  - Overweight and obese patients had 70% complication rate.
  - Most common complication was persistent wound drainage.
  - heavier girls had significantly longer surgical times and hospital stay.
- Difficult bracing for scoliosis etc.

Other –foot pain, etc with childhood obesity

- Foot pain in the obese child is not uncommon.
  - Contributing to fatigue and exercise tolerance
- Overweight -increased foot length/width, decreased navicular height, lower medial arch height, and higher plantar pressure
- a rigid idiopathic flat foot that is negative for any type of coalition or other cause has been described in obese children.
  - Could be sequelae of obesity and increased pressure on the foot with midfoot collapse and tight Achilles tendon

The Cure:

- Parents must embrace their responsibility to raise a healthy child
  - Set a good example
  - Be supportive
  - Create a healthy environment
    - Healthy food, exercise, family time/outings
    - Limit TV, video games, computer
      - **NO TV in child's bedroom !**
    - Adequate rest (8-9 hrs min)
  - ACTIVE ; hike, swim, bike, camp, wash car, chores, sports,etc

The Cure:

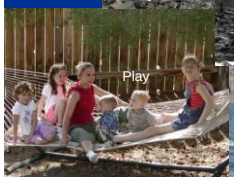
- Schools
  - PE – daily, emphasize personal fitness/cardio
  - "School-age youth should participate daily in 60 minutes or more of moderate to vigorous physical activity that is developmentally appropriate, enjoyable, and involves a variety of activities. (J Pediatr 2005; 146:732-7)
  - Youth strength training
    - Safe and effective
    - OK with ACSM, AAP, NSCA
    - As early as 9-10 yrs
    - Not = adults; emphasize
      - Safety, form, technique, lifetime fitness, FUN
      - Lighter wts/ more reps
      - Core, balance

  - cafeterias – nutritious choices
  - Vending machines – healthy snacks, no sodas

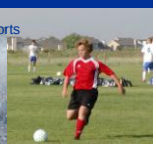
The Cure - Exercise

Hiking

SCUBA



Play

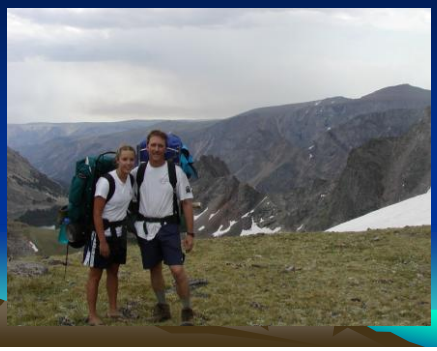


Sports

Additional Resources

- www.supersizedkids.com
  - Super Sized Kids. Larimore MD, et al.
- www.nih.gov
- www.cdc.gov
- Am Obesity Assoc (www.obesity.org)
- US Preventative Services Task Force (USPSTF)

The End

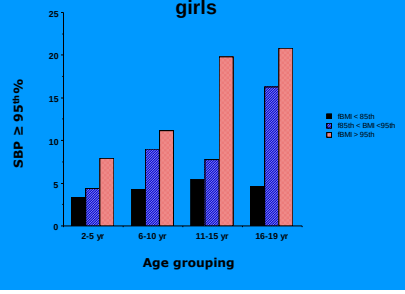


OBESITY RELATED HYPERTENSION IN CHILDREN

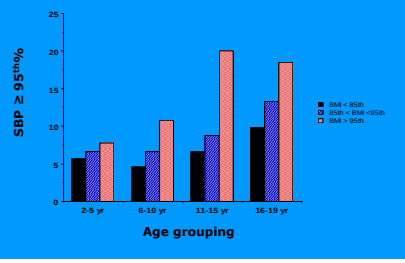
Bonita Falkner, MD
Thomas Jefferson University
Philadelphia

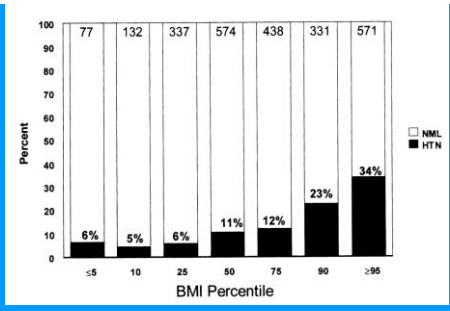
- Disclosures: None

Prevalence of systolic hypertension - girls



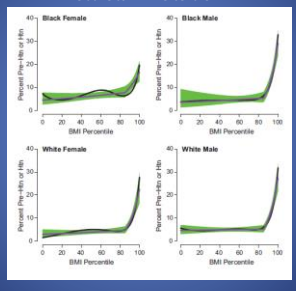
Prevalence of systolic hypertension - boys





Sorof J, Daniels S. Obesity hypertension in children. Hypertension 40:441-55, 2004

Estimated Prevalance of Prehypertension-Hypertension in childhood Relative to BMI Percentile



Tu et al; Hypertension 2011

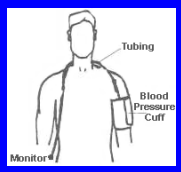
Blood Pressure Levels for Boys by Age and Height Percentile

Age	BP	Systolic BP (mmHg)							Diastolic BP (mmHg)						
		Percentile of Height							Percentile of Height						
(Year)	Percentile	5th	10th	25th	50th	75th	90th	95th	5th	10th	25th	50th	75th	90th	95th
12	50th	102	103	104	105	107	108	109	61	61	61	62	63	64	64
	90th	116	116	117	119	120	121	122	75	75	75	76	77	78	78
	95th	119	120	121	123	124	125	126	79	79	79	80	81	82	82
	99th	127	127	128	130	131	132	133	86	86	87	88	88	89	90

The fourth report; Pediatrics 2004

Ambulatory Blood Pressure Monitoring

- Patient wears lightweight BP monitor that takes BP at regular intervals for 24 hr
- Readings are recorded by monitor and later downloaded to a personal computer
- Study is analyzed by comparing the patient's BP to a set threshold value
- Equipment available for use in children
- Validity confirmed in children



Metabolic Syndrome

(dysmetabolic syndrome)

Diagnosis (ICD-9 code 277.7) requires 3 or more of the following:

Obesity (BMI >95th %)

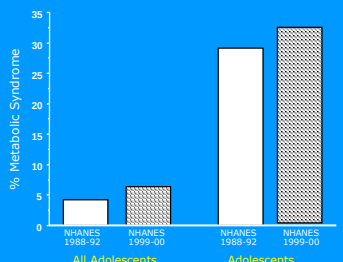
Elevated BP (systolic and/or diastolic >90th %)

Abnormal blood lipids (HDL-C < 40 mg/dl, and/or Triglycerides > 150mg/dl)

Impaired glucose tolerance (fasting glucose >100 mg/dl, 2 hr glucose >140, or any glucose > 200 mg/dl)

(*source: modified for youth from JAMA 2002;287:356-359)

Metabolic Syndrome in Adolescents



Duncan et al, Diabetes Care 2004

Effects of Obesity and High BP On left ventricular mass in adolescents

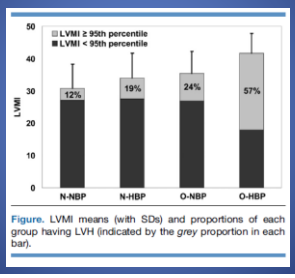
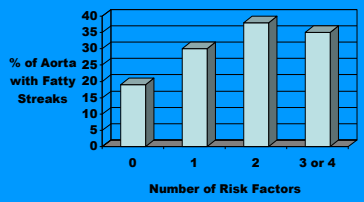


Figure. LVMI means (with SDs) and proportions of each group having LVH (indicated by the *grey* proportion in each bar).

Falkner J Peds 2013

Association of Risk Factors with Vessel Pathology



Berenson et al, N Engl J Med 1998

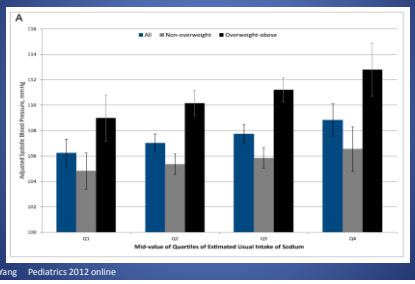
Causes of Obesity Associated Hypertension

Increased sympathetic nervous system activity

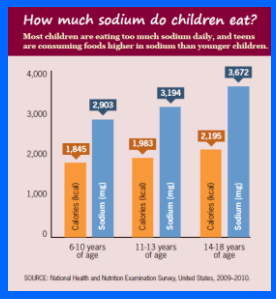
Blood pressure sensitivity to sodium intake

Microvascular injury

What About Sodium?



Yang Pediatrics 2012 online

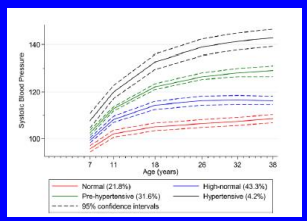


Classification of HTN in Children & Adolescents, With Therapy Recommendations

	Pharmacologic Therapy
Normal	—
Prehypertension	None unless compelling indications such as CKD, diabetes mellitus, heart failure, LVH
Stage 1 hypertension	Initiate therapy based on indications or if compelling indications as above
Stage 2 hypertension	Initiate therapy

The fourth report; Pediatrics 2004

Systolic Blood Pressure Trajectories from Childhood to Early Adulthood.



Theodore et al, Hypertension, 2015

Number to Remember

- 120/80 mm Hg