Pediatric Bone Health from Bench to Bedside

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Division of Orthopaedics and Sports Medicine
Children's National Medical Center

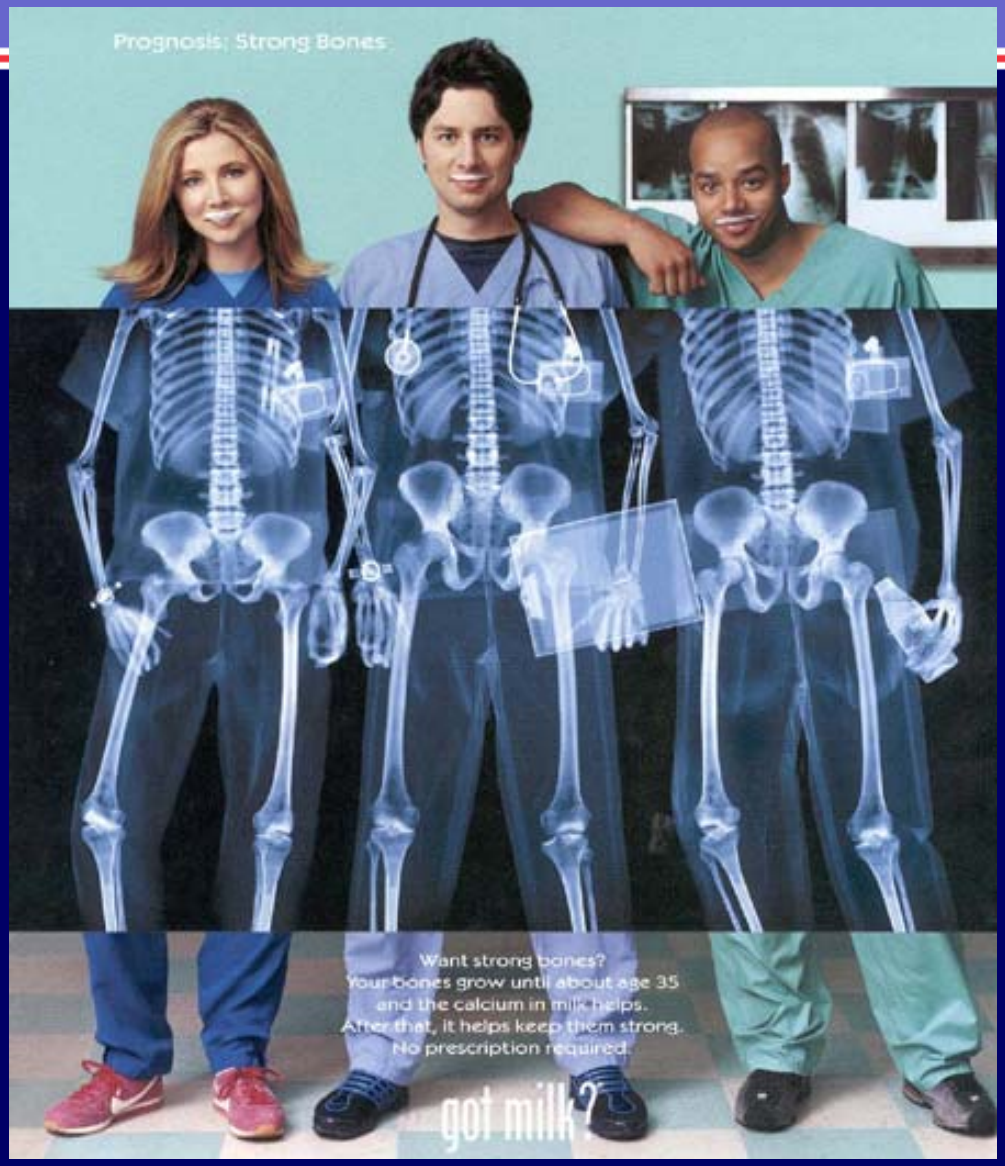
Disclosures

- Merck – research funding
- KCI - consultant

Learning Objectives

- Recognize critical importance of enhancing “bone quality” across the life span.
- Review ongoing research seeking to identify genetic influences on bone size, a critical element of bone quality
- Discuss scientific updates and ongoing research investigating the relationship between bone health and childhood forearm fractures.
- Identify initiatives designed to explore or enhance bone quality in individuals with recognized skeletal disorders
- Recognize Bone Health Program initiatives to improve bone health literacy in the DC community

Bone is Unique



Structure & protection

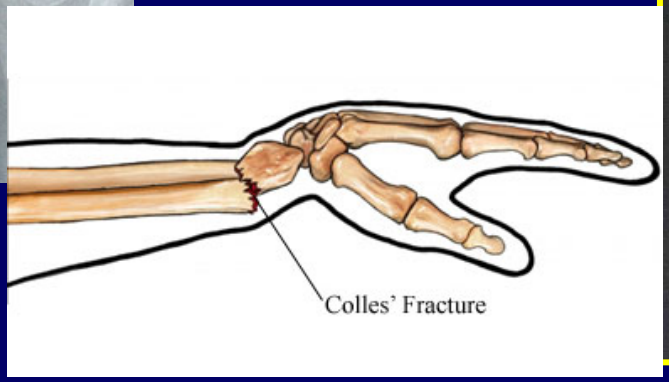
Primary storehouse for calcium in body

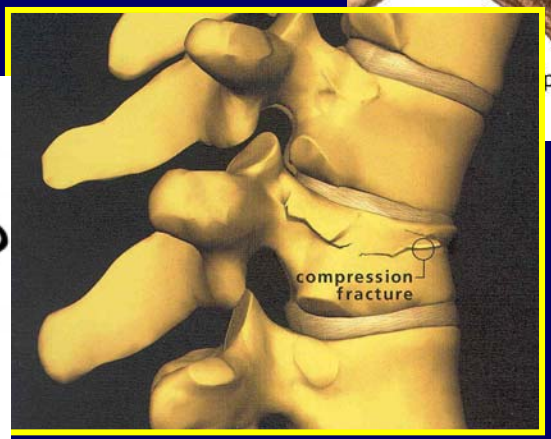
Only organ able to heal w/o scarring

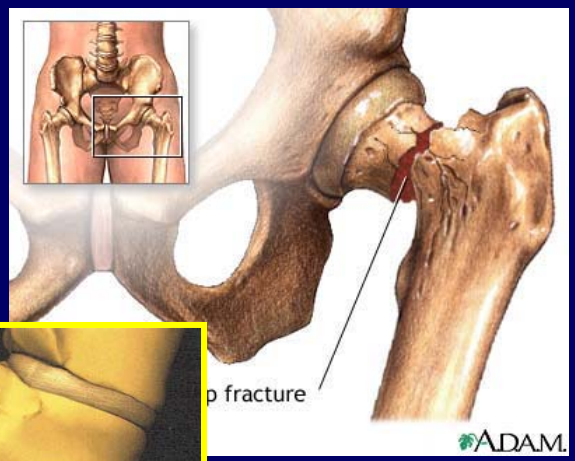

DREW BARRYMORE
ANJELICA HUSTON
EVER AFTER

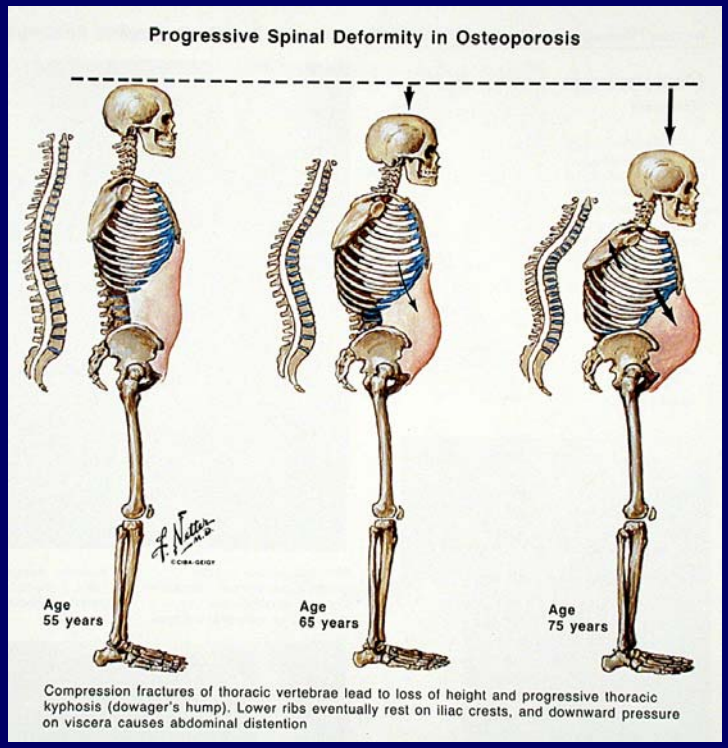
The worry

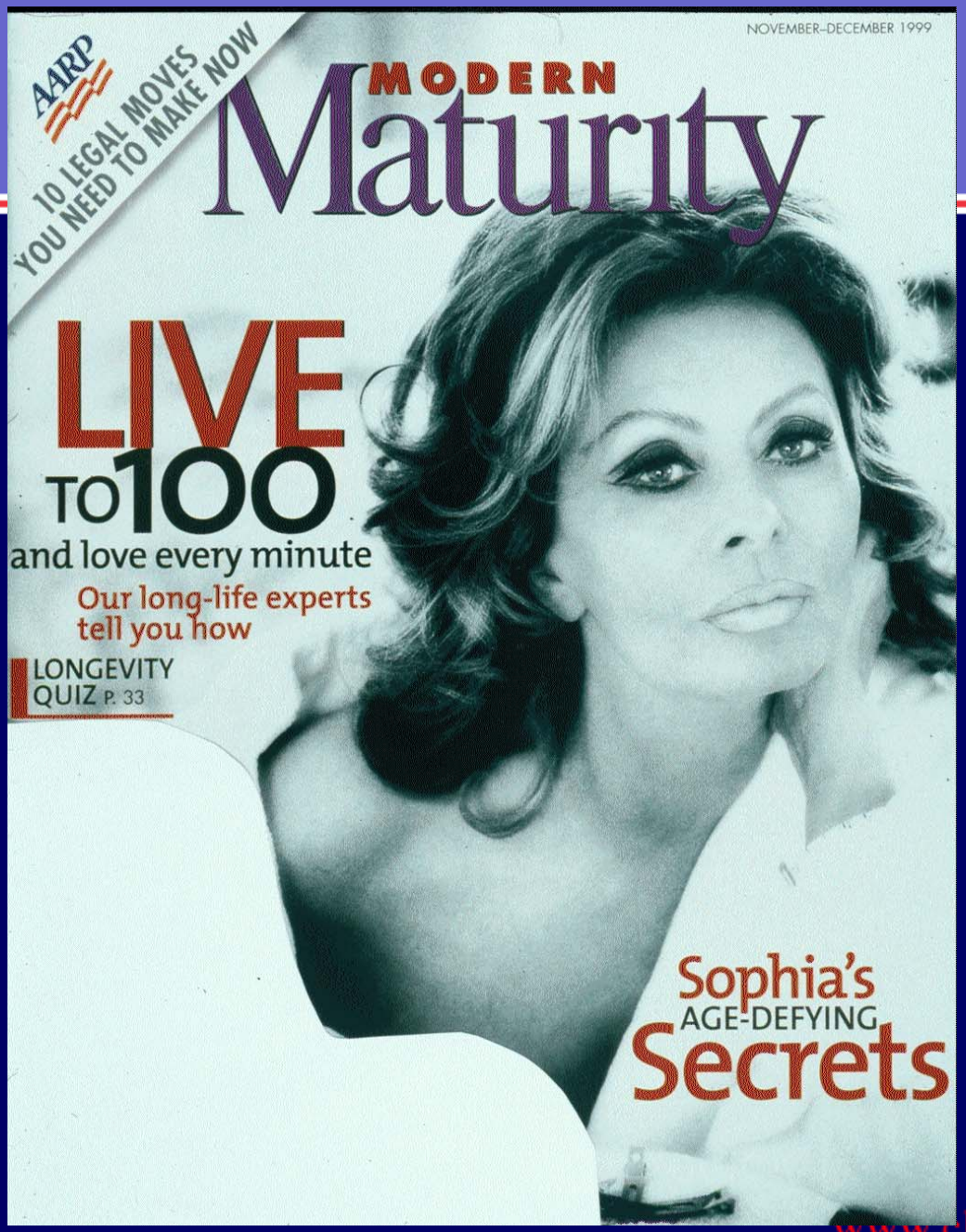
Low energy fracture: fracture that occurs following fall from a standing height or less








Progressive Spinal Deformity in Osteoporosis
Age
55 years
Age
65 years
Age
75 years
Compression fractures of thoracic vertebrae lead to loss of height and progressive thoracic kyphosis (dowager's hump). Lower ribs eventually rest on iliac crests, and downward pressure on viscera causes abdominal distention



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PEAK BONE MASS

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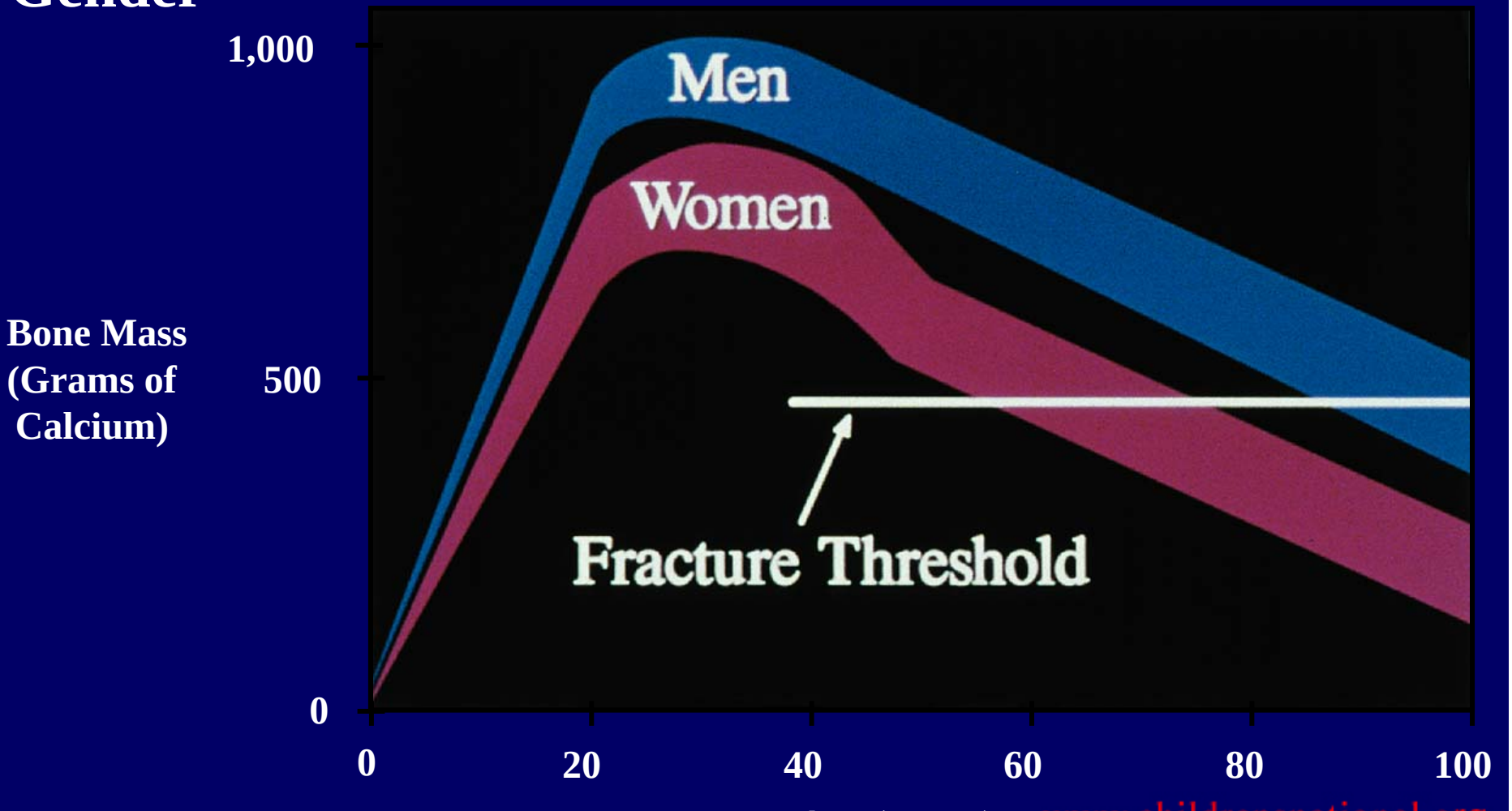
Gender



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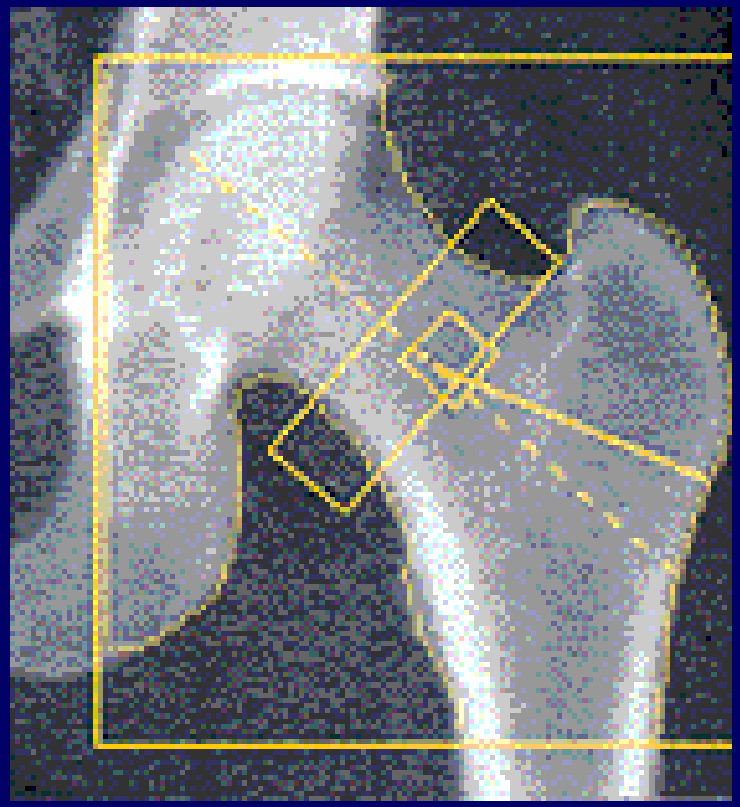
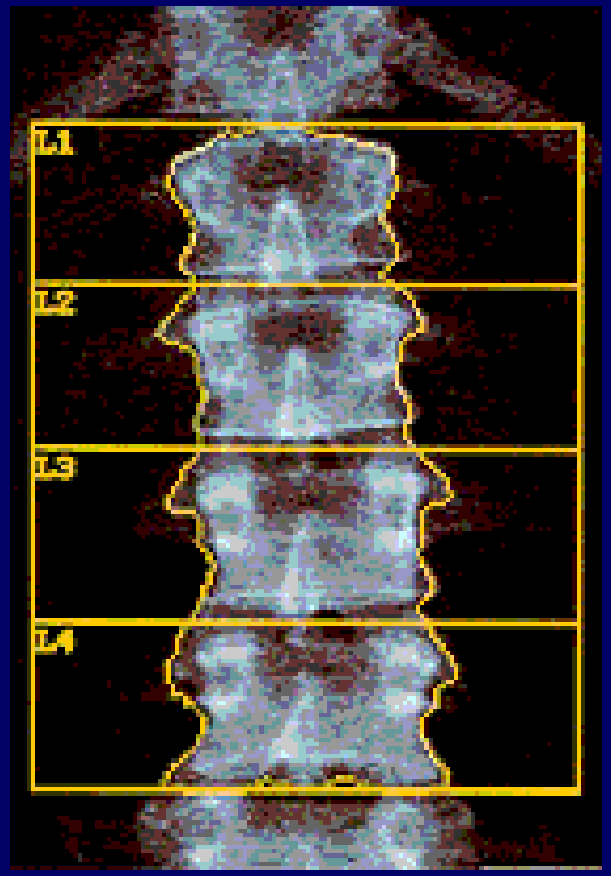
Key Determinants of Bone Health in Children

- Genetics
- Presence of secondary conditions
- Exercise
- Vitamin D
- Calcium

Old think: bone density explains bone strength

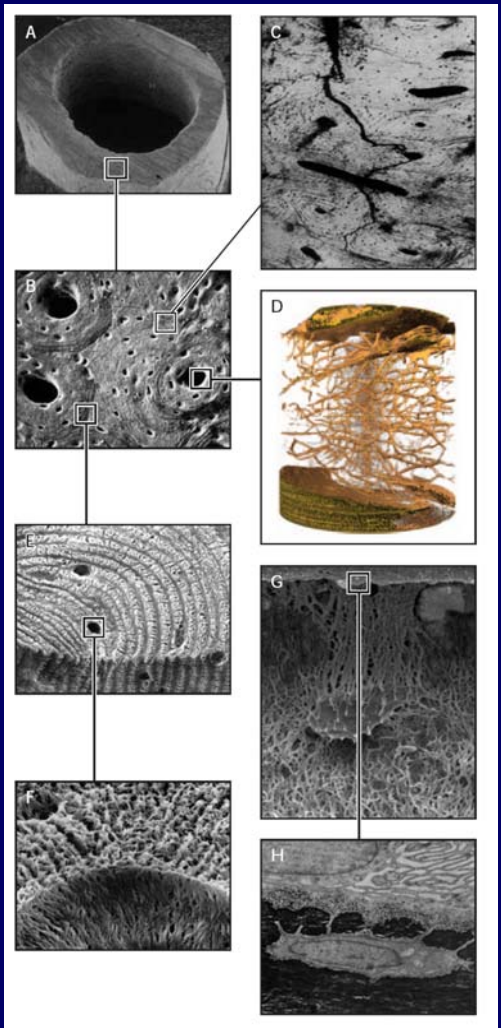


DXA image of the hip



DXA image of the lumbar spine

New Think on What Makes Bone Strong



Seeman & Delmas NEJM 2006

Bone Quality:

Macrostructure
Microstructure
Matrix Properties
Cellular Composition
and activity

Bone Health Program Goal:

Ensure that each and every child achieves the best bone quality possible

Childhood forearm fractures and bone health

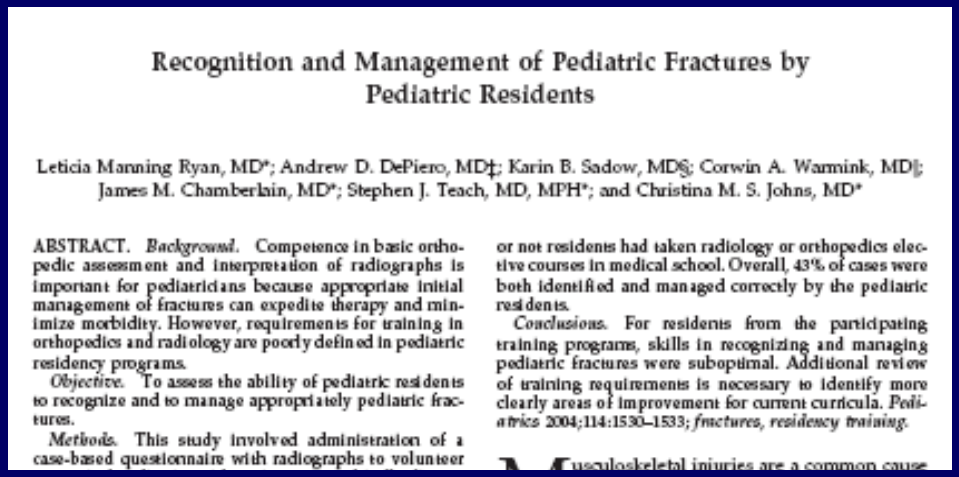
Bench to bedside

Leticia Manning Ryan, MD
Division of Emergency Medicine
Center for Clinical and Community Research

Learning objective

- To discuss scientific updates and ongoing research investigating the relationship between bone health and childhood forearm fractures

Bone health: the emergency medicine perspective



Recognition and Management of Pediatric Fractures by Pediatric Residents

Leticia Manning Ryan, MD*; Andrew D. DePiero, MD‡; Karin B. Sadow, MD§; Corwin A. Warmink, MD‖; James M. Chamberlain, MD*; Stephen J. Teach, MD, MPH*; and Christina M. S. Johns, MD*

ABSTRACT. *Background.* Competence in basic orthopedic assessment and interpretation of radiographs is important for pediatricians because appropriate initial management of fractures can expedite therapy and minimize morbidity. However, requirements for training in orthopedics and radiology are poorly defined in pediatric residency programs.

Objective. To assess the ability of pediatric residents to recognize and to manage appropriately pediatric fractures.

Methods. This study involved administration of a case-based questionnaire with radiographs to volunteer

or not residents had taken radiology or orthopedics elective courses in medical school. Overall, 43% of cases were both identified and managed correctly by the pediatric residents.

Conclusions. For residents from the participating training programs, skills in recognizing and managing pediatric fractures were suboptimal. Additional review of training requirements is necessary to identify more clearly areas of improvement for current curricula. *Pediatrics* 2004;114:1530–1533; *fractures, residency training.*

Musculoskeletal injuries are a common cause

Pediatrics 2004: 114 (6): 1530-1533.

- REACH project
- Case-based questionnaire on fracture recognition and management
- Administered to pediatric residents and pediatric emergency attendings at three training programs

Bone health:
the emergency medicine perspective

Bone health:
the emergency medicine perspective

- DIAGNOSIS 1:
  femur fracture

Bone health:
the emergency medicine perspective

- **DIAGNOSIS 1:**
  femur fracture

- **DIAGNOSIS 2:**
  rickets

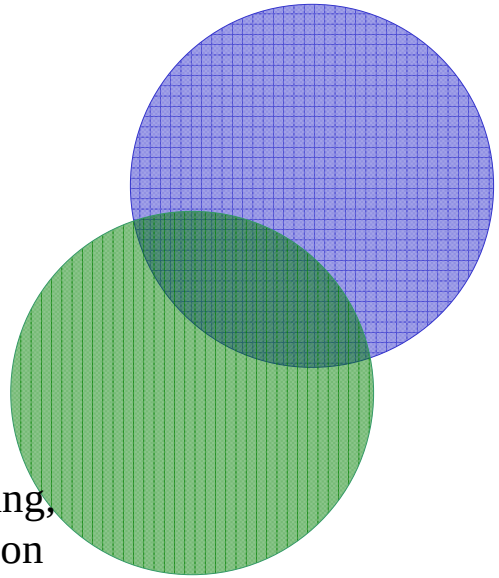
  - osteopenia
  - slight bowing
  - metaphyseal fraying

Bone health:
the emergency medicine perspective

- Forearm fractures are a common and costly pediatric injury
- Forearm fracture rates are <u>increasing</u>
- Why do some patients fracture and others don't?

Bedside:
Components of forearm fracture risk

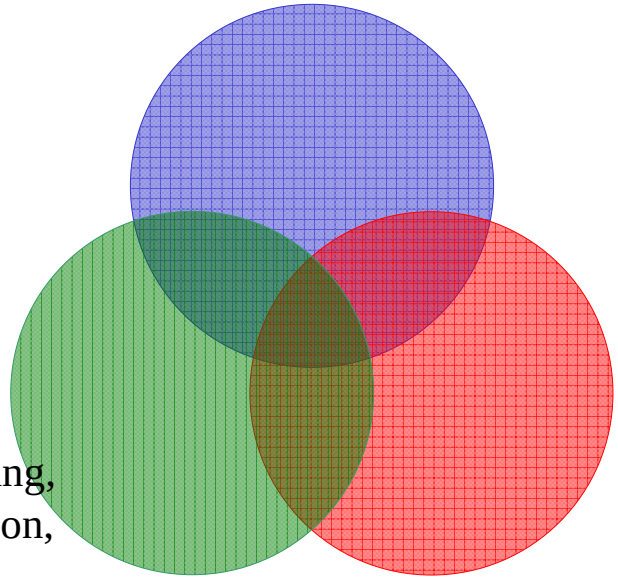
MECHANISM:
force, angle, weight



EXPOSURE:
INDIVIDUAL: risk taking, hyperactivity, coordination
COMMUNITY: neighborhood deprivation, supervision

Bedside:
Components of forearm fracture risk

MECHANISM:
force, angle, weight

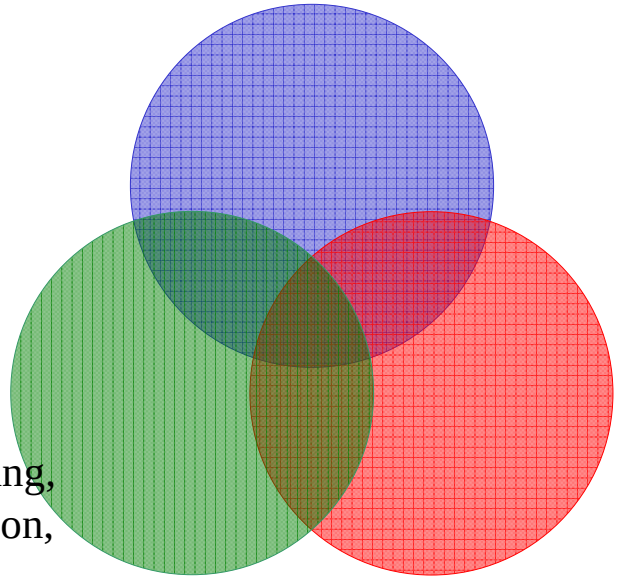


EXPOSURE:
INDIVIDUAL: risk taking, hyperactivity, coordination, supervision
COMMUNITY: neighborhood deprivation, safety

BONE HEALTH

Bedside:
Components of forearm fracture risk

MECHANISM:
force, angle, weight



EXPOSURE:
INDIVIDUAL: risk taking, hyperactivity, coordination, supervision
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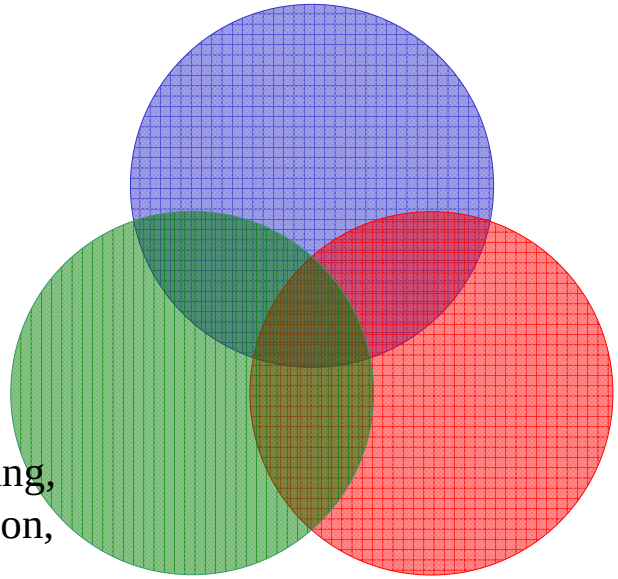
BONE HEALTH:
bone mineral density
nutrition

Bedside:
Components of forearm fracture risk

MECHANISM:
force, angle, weight



EXPOSURE:
INDIVIDUAL: risk taking, hyperactivity, coordination, supervision
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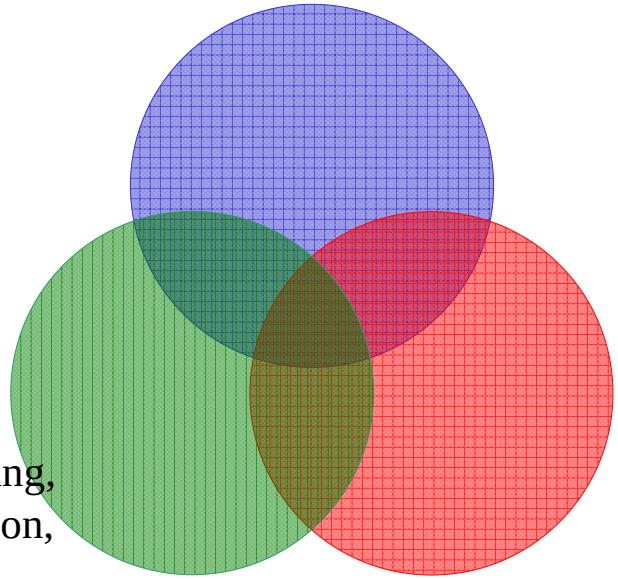
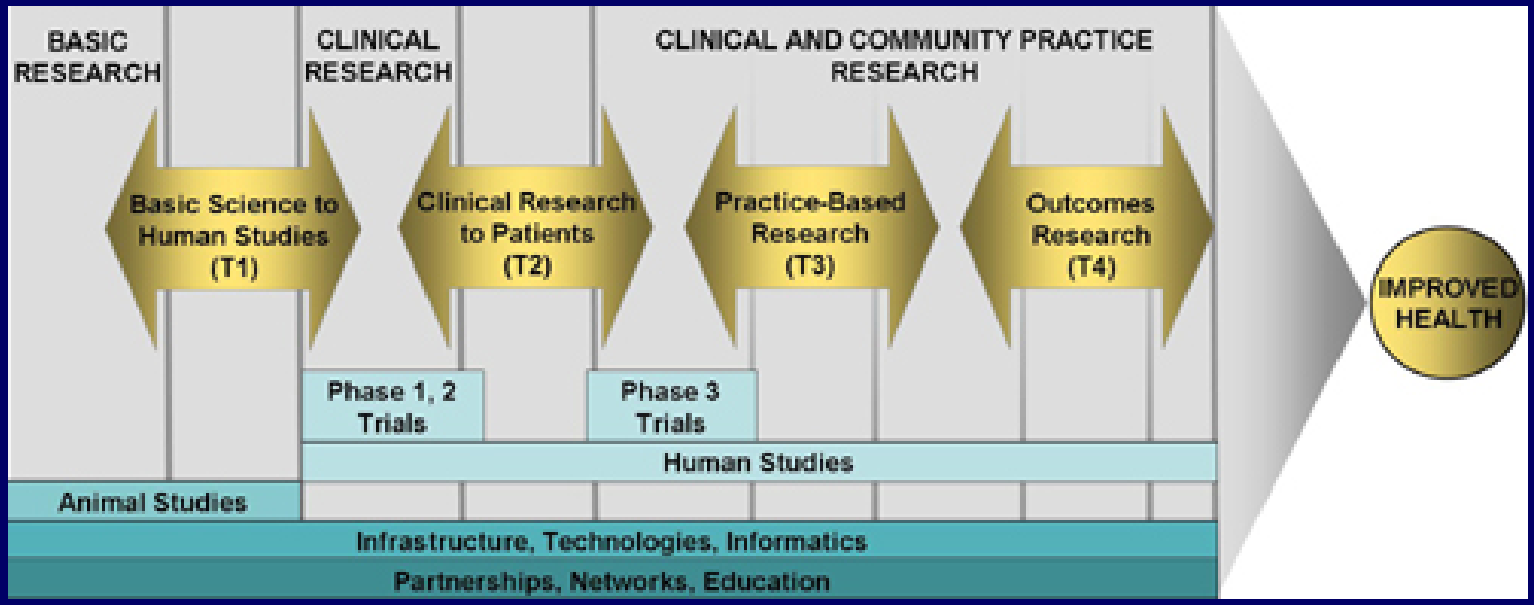


EXPOSURE:
INDIVIDUAL: risk taking, hyperactivity, coordination, supervision
COMMUNITY: neighborhood deprivation, safety

BONE HEALTH:
bone mineral density
nutrition
obesity
vitamin D status

Forearm fractures in children
Bedside to bench to bedside



(Original figure adapted from NCRR Strategic Plan 2009-2013.)

T1/Bench research

- Study Design: Case-control study

- Sample:
  65 cases: African American children, 5-9 years of age, with an isolated forearm fracture
  65 controls: race/age-matched children without history of fracture

- Analysis: Vitamin D level, body mass index, dietary intake, bone mineral density, genetic analysis

T1/Bench research

- Team science:

  Division of Emergency Medicine
  Division of Orthopaedics and Sports Medicine
  Division of Diagnostic Imaging and Radiology
  Center for Clinical and Community Research
    Bionutrition Research
    Biostatistics and Informatics
  Center for Genetic Medicine Research
  General Clinical Research Center
  National Institutes of Health

T1/Bench research

Preliminary results			
Variable	**Cases**	**Controls**	**p value**
Mean bone mineral density z-score per DXA scan	0.69 (n=44)	1.02 (n=55)	p=0.1
Odds ratio of vitamin D level ≤ 20 mg/dl	1.4 (95% CI 0.7-3.2)	ref	p=0.4
Odds ratio of body mass index ≥ 85%	2.2 (95% CI 1.0-4.9)	ref	p=0.05

T1/Bench research

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Variable	**Fall from standing height**	**Controls**	**p value**
Mean bone mineral density z-score per DXA scan	0.55 (n=8)	1.02 (n=55)	p=0.2
Odds ratio of vitamin D level ≤ 20 mg/dl	3.4 (95% CI 0.8-15.2)	ref	p=0.1
Odds ratio of body mass index ≥ 85%	2.0 (95% CI 0.4-8.6)	ref	p=0.5

T1/Bench research

- **Future analysis to incorporate:**
  - Dietary intake: calcium, vitamin D, protein, dairy products
  - Physical activity
  - Sun exposure
  - Genetic analyses

T2/Clinical research

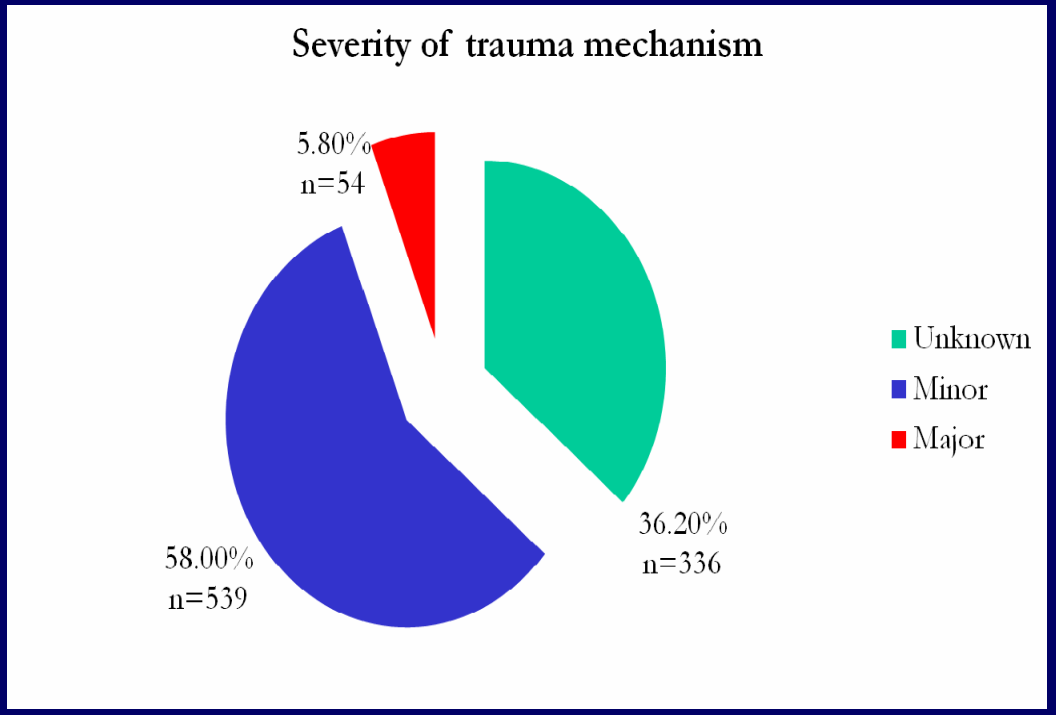
- Study design:
  Retrospective analysis of a consecutive case series from 2003-2006

- Sample:
  929 Washington DC children with CNMC ED visits for isolated forearm fractures

- Analysis: Descriptive

T2/Clinical research

- **Demographics of forearm fracture cases**
  - Proportion male: 63.4%
  - Proportion African American: 80.1%
  - Mean age ± SD= 8.3 ± 3.9 years



T2/Clinical research

Variable	Minor trauma (n=539)	Fall from standing height (n=226)
Odds ratio of weight for age/sex percentile $\geq$ 95th percentile in comparison to major trauma cases	2.1 (95% CI: 0.9-4.7)	2.4 (95% CI: 1.1-5.4)

Weight for age/gender $\geq$ 95th percentile has a high specificity (96%) and reasonable positive predictive value (80%) in identifying obese children (body mass index $\geq$ 95th percentile). *Stettler et al, Obesity 2007.*

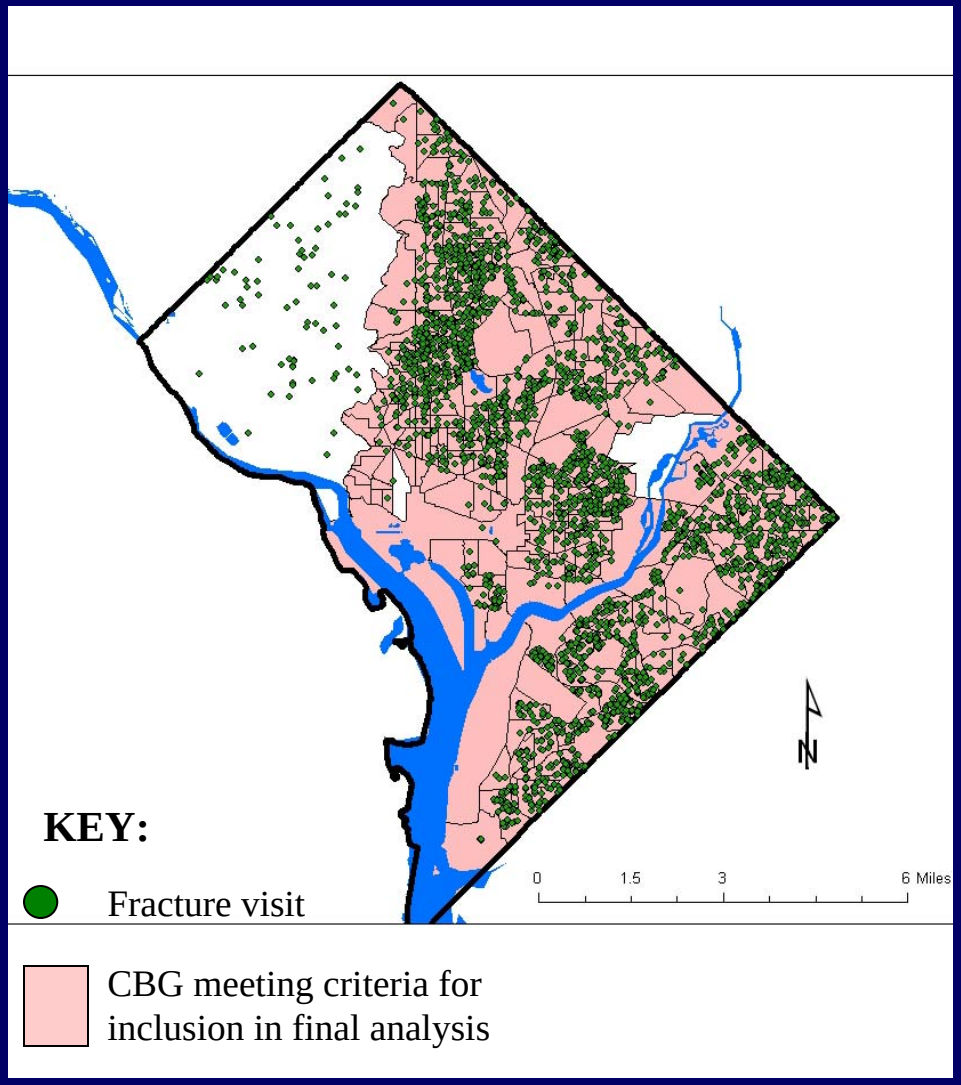
T3/Community research

- Study design:
  Retrospective cohort study of CNMC ED visits for bone fractures from 2003-2006

- Sample:
  3674 ED visits in Washington DC children residing in census block groups with > 80% catchment

- Analysis:
  Fracture rates for census block group, geospatial analysis, factor analysis, regression analysis

T3/Community research

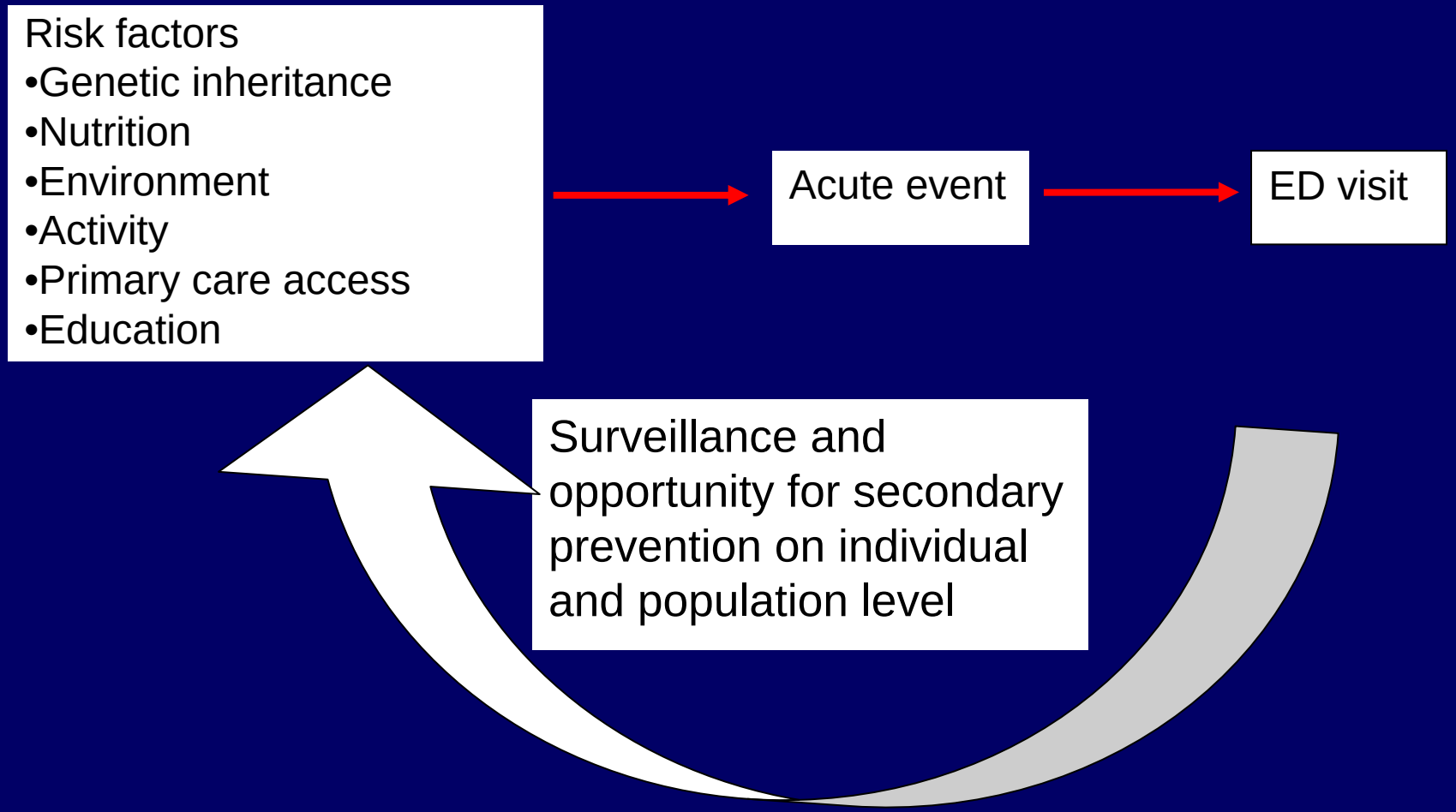


Geographic distribution of fracture visits to CNMC 2003-2006

T3/Community research

NEIGHBORHOOD FACTOR	ODDS RATIO	95% CONFIDENCE INTERVAL
F1- RACE/EDUCATION	1.271	1.139-1.418
F2- UNEMPLOY/POVERTY	0.947	0.891-1.007
F3- IMMIGRANTS	0.957	0.900-1.018
F4- RENTALS	1.021	0.968-1.077
F5- LARGE FAMILIES	1.114	1.056-1.176
F6- CROWDING	1.040	0.976-1.109
F7- SENIORS	0.907	0.856-0.963

Next steps: Returning to the bedside



Next steps: Returning to the bedside

- **Use proactive screening to identify children with forearm fracture related to suboptimal bone health and/or modifiable risk factors**
  - Comparable to CNMC ED efforts in asthma, HIV, obesity
- **Design and implement appropriate intervention to prevent future fracture**

Acknowledgements

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James Chamberlain, MD
Division Chief, Division of Emergency Medicine

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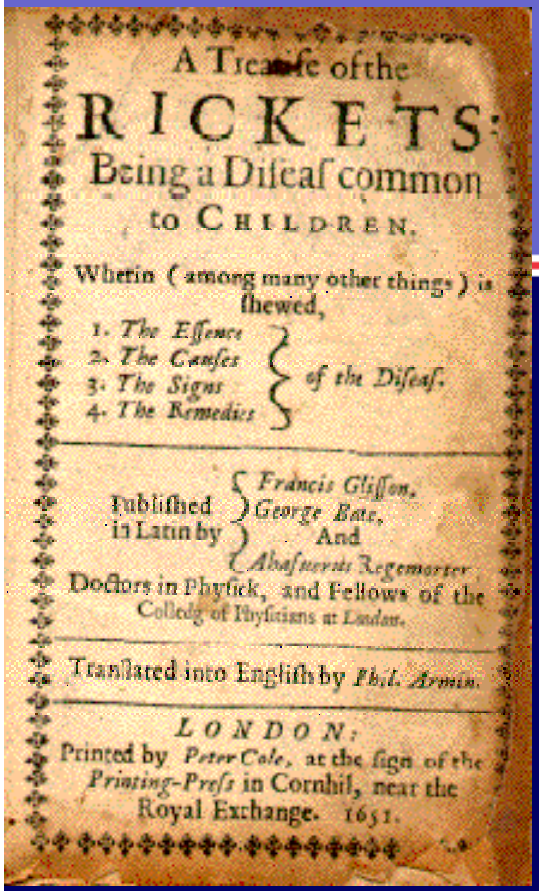
- National Institutes of Health National Center for Research Resources (1K23 RR024467-01)
- Children's Research Institute Children's National Medical Center Research Advisory Council Grant
- Children's National Medical Center Board of Visitors
- DC-Baltimore Research Center on Child Health Disparities
- Children's National Medical Center General Clinical Research Center
- Children's National Medical Center Bone Health Program

Back to the Bedside……

So, who does a Bone Health Clinic actually see?



A Treatise of the
RICKETS:
Being a Disease common
to CHILDREN.

Wherin (among many other things) is shewed,

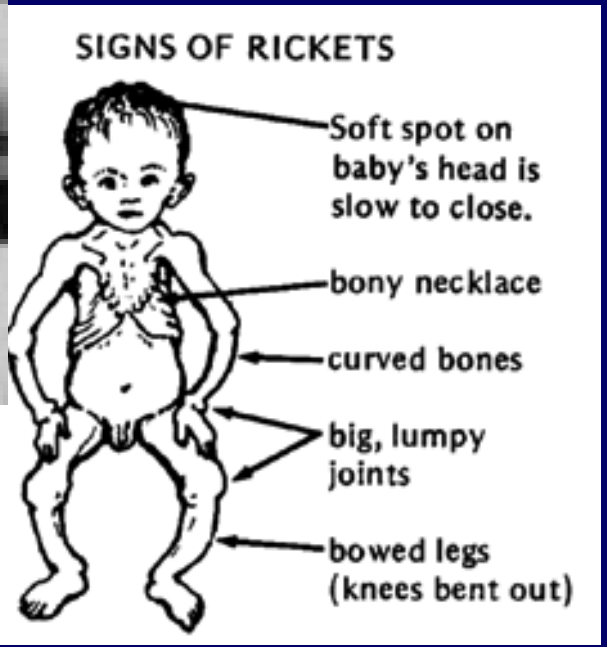
1. The Essence
2. The Causes
3. The Signs
4. The Remedies

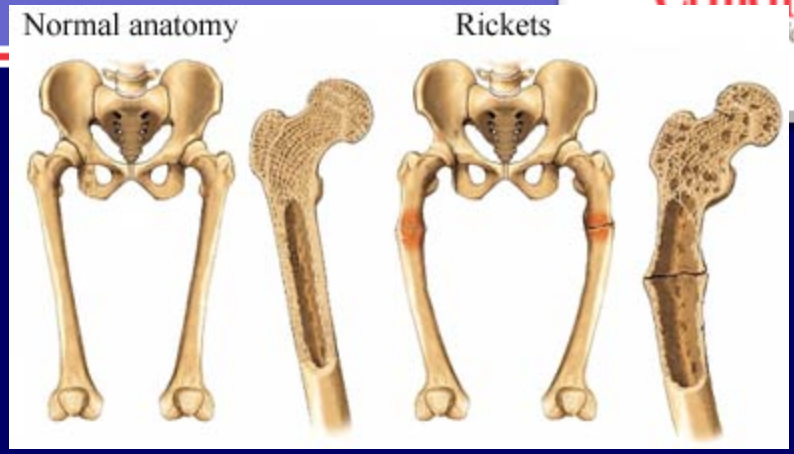
} of the Disease.

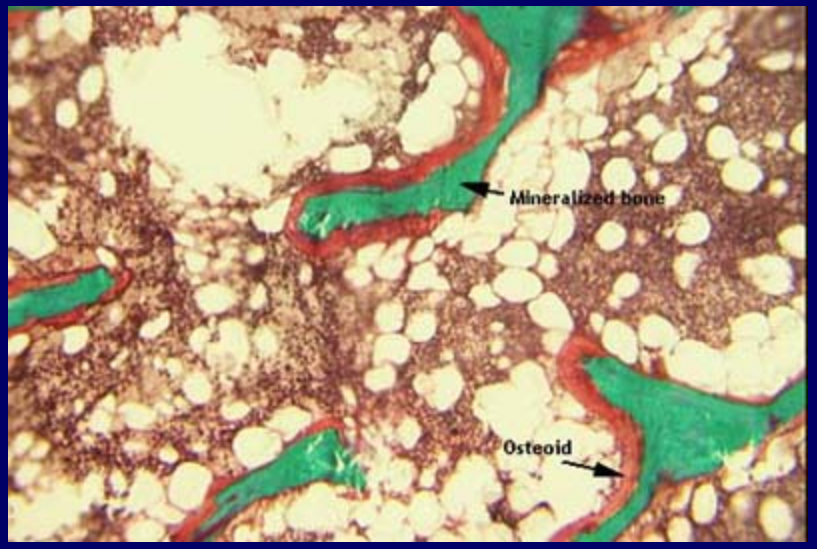
Published in Latin by Francis Glisson, George Bate, And Abasuerus Regemorter Doctors in Physick, and Fellows of the College of Physicians at London.

Translated into English by Phil. Armin.

LONDON:
Printed by Peter Cole, at the sign of the Printing-Press in Cornhil, near the Royal Exchange. 1651.







Osteomalacia NOT

Osteoporosis

As Teen Girls Drink More Soda Their Calcium Intake Declines

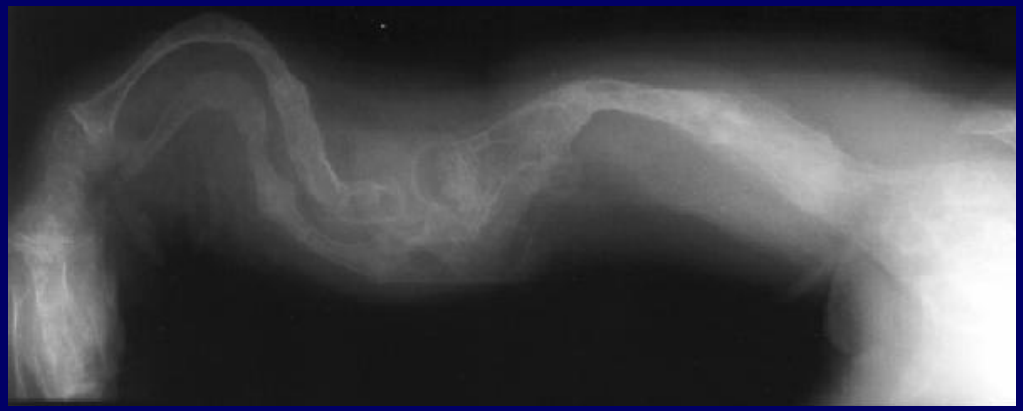
	Regular Soda	Milk
White 9 yr olds	4.7 oz	12.3 oz
White 18 yr olds	13.2 oz	8.4 oz
Black 9 yr olds	4.0 oz	8.5 oz
Black 18 yr olds	11.8 oz	5.0 oz

Researchers found that as soda intake increased, calcium intake decreased and body-mass index (BMI) increased.

Beverages associated with poor nutrient profiles were: regular sodas, fruit-flavored drinks, coffee and teas.

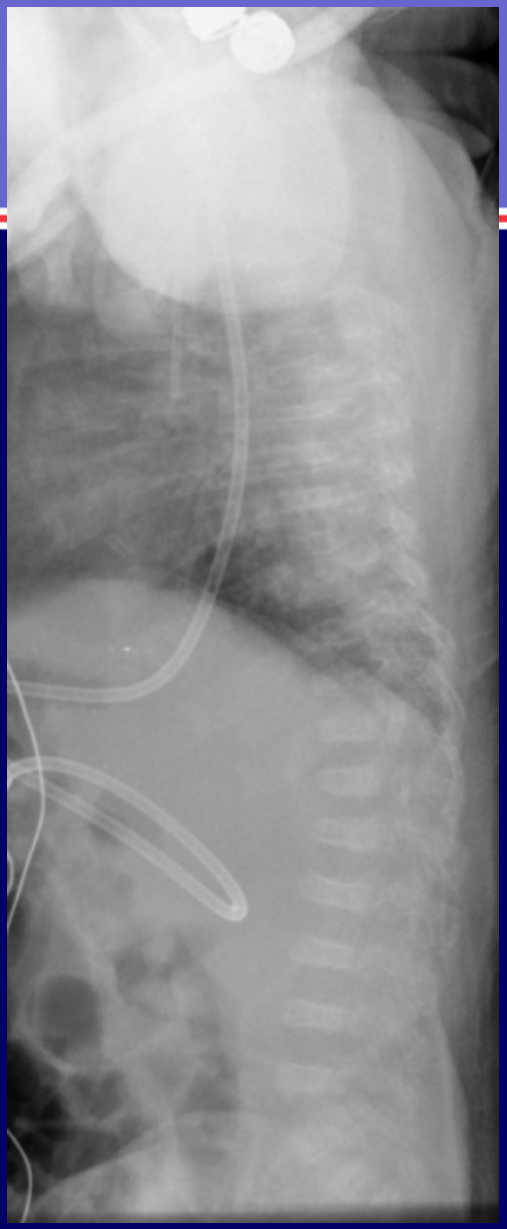
The Journal of Pediatrics, Volume 148, Issue 2, February 2006

Osteogenesis Imperfecta a.k.a. brittle bone disease



Pamidronate infusion program

Partnership with Dina Zand - Genetics, the Hospitalist team, and Pharmacy

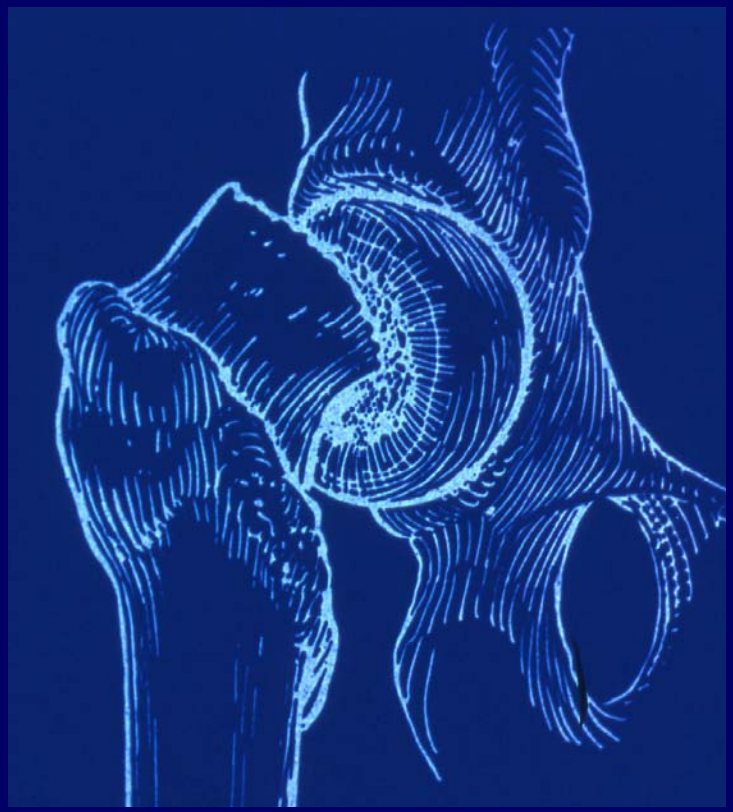


Infant

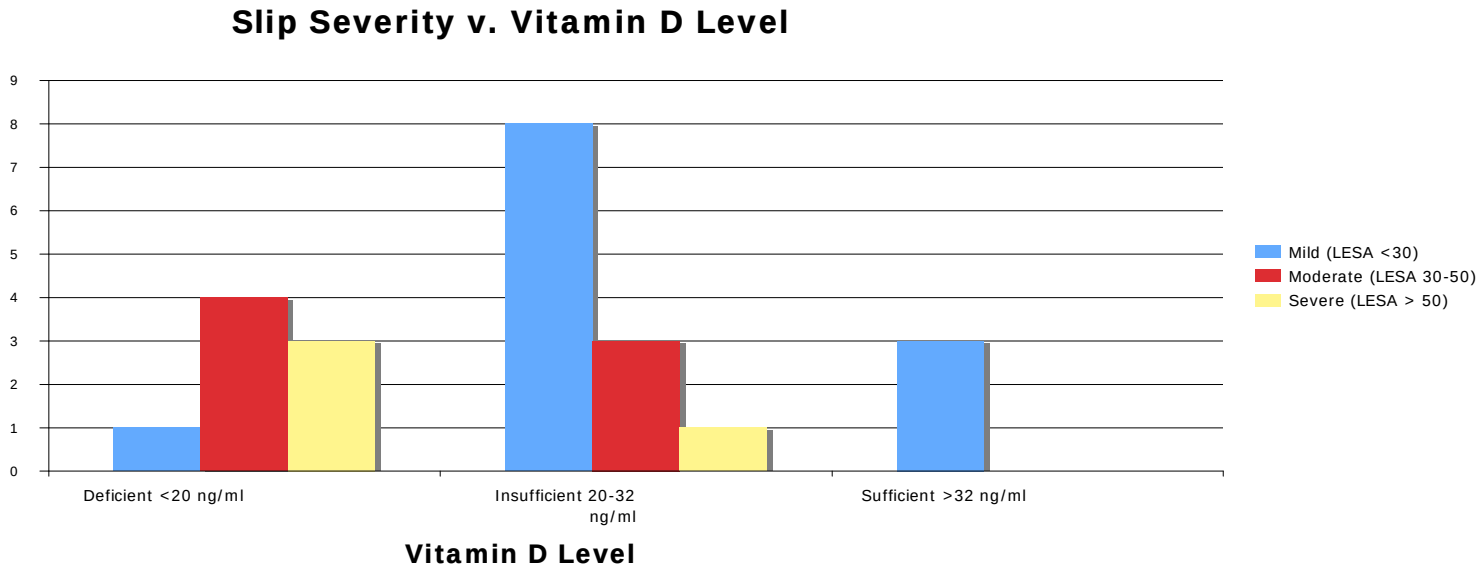
15 months later

Slipped Capital Femoral Epiphysis

- Boys
- Peripubertal
- Afro-American
- Overweight/Obese



CNMC Study

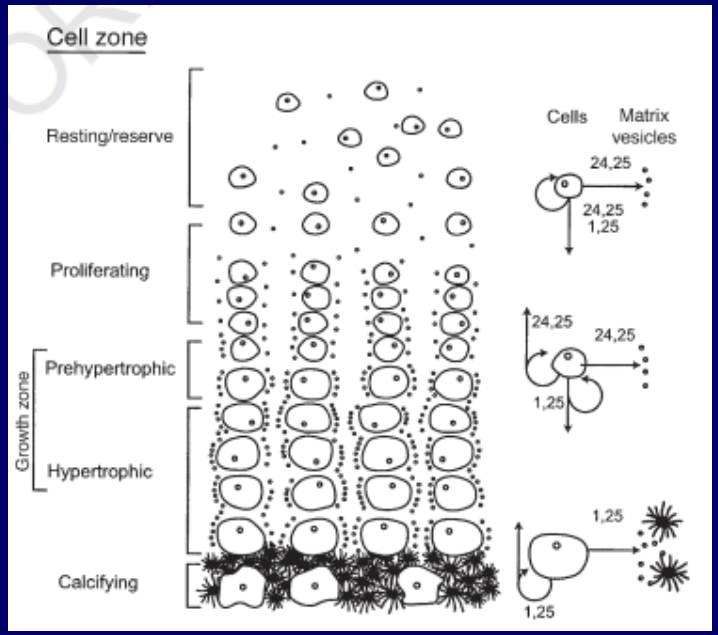


Children with severe SCFE much more likely to have moderate to severe vitamin D deficiency

Vitamin D Receptor Expression in Individuals Undergoing Surgical Repair of a Slipped Capital Femoral Epiphysis (SCFE)

Partnership with

Georgia Tech



Why do some people have multiple fractures?

Protocol:

Identification of Potential Genetic Polymorphisms Leading to Multiple Fractures

Partnership:

Meg Bradbury and Joe Devaney, CRI

and

Hospital for Special Surgery, NY

Advocacy Partnerships

US Department of Health and Human Services

Health and Fitness Expo 2010

Mid-Atlantic Dairy Council

www.childrensnational.org

Always Remember…….

Thank You

www.childrensnational.org