Summer 7-2013

Physical Education in West Virginia Schools: Are We Doing Enough to Generate Peak Bone Mass and Promote Skeletal Health?

Franklin D. Shuler MD, PhD
Marshall University, shulerf@marshall.edu

Dana Lycans

Thomas Gill MD

Ali Oliashirazi MD
Marshall University, oliashirazi@marshall.edu

Recommended Citation
Shuler FD, Lycans D, Gill T, Oliashirazi A. Physical education in West Virginia schools: Are we doing enough to generate peak bone mass and promote skeletal health? West Virginia Medical Journal (Special CME Issue). July/Aug 2013;109(4):66-70.

Physical Education in West Virginia Schools: Are We Doing Enough to Generate Peak Bone Mass and Promote Skeletal Health?

Franklin D. Shuler, MD, PhD
Associate Professor, Orthopaedic Trauma; Vice Chairman, Orthopaedic Research; Medical Director, Senior Fracture Program, Dept. of Orthopaedic Surgery, Marshall University, Huntington, WV

Dana Lycans, MD
Orthopaedic Resident (PGY I), Dept. of Orthopaedic Surgery, Marshall University, Huntington, WV

Thomas Gill, MD
Orthopaedic Resident (PGY II), Dept. of Orthopaedic Surgery, Marshall University, Huntington, WV

Ali Oliashirazi, MD
Professor and Chairman; Program Director; Dept. of Orthopaedic Surgery, Marshall University, Huntington, WV

Corresponding author: Franklin D. Shuler, MD, PhD, Marshall University, Dept. of Orthopaedic Surgery, 1600 Medical Center Dr., Ste. G-500, Huntington, WV 25701; shulerf@marshall.edu.

Abstract

Peak bone mass (PBM) is attained at 25-35 years of age, followed by a lifelong decline in bone strength. The most rapid increase in bone mass occurs between the ages of 12-17. Daily school physical education (PE) programs have been shown to produce measurable increases in PBM, but are not federally mandated. Increases in PBM can decrease the lifelong risk of osteoporosis and fractures; critical for West Virginia prevention programs. Nationally only 1 in 6 schools require PE three days per week, with 4% of elementary schools, 8% of middle schools and 2% of high schools providing daily PE. In 2005, West Virginia passed the Healthy Lifestyles Act that returned physical education to the K-12 curriculum. This law requires only one credit of PE from grades 9-12 and provides only 35% of the recommended PE for grades K-12. This article highlights the relationship of PE to PBM and discusses the potential impact on West Virginia skeletal health.

Introduction

Skeletal development, peak bone mass and osteoporosis

Throughout life, there is a constant turnover of bone through a process called remodeling that involves both the formation and absorption of bone. During the growing years, there is a net positive balance toward bone formation. The amount of bone accrued during this critical time contributes to our peak bone mass (PBM) and is a major determinant in the reduction of fracture risk later in life.[1-3] The greatest increases in bone mass are obtained between the ages of 12-15 years in girls and 14-17 years in boys, with PBM occurring at 25-35 years of age.[2,4,5] (**Figure 1**) After peak bone mass is achieved, a neutral or negative balance occurs throughout life favoring bone loss and increasing the risk of osteoporosis and fracture.

An individual's PBM is influenced primarily by genetics.[6-10] The remaining variance in bone density is affected by nutrition and physical activity.[4,11,12] Increases in PBM by 10% would reduce the fracture risk by 50% and delay the onset of osteoporosis by 13 years, placing critical emphasis on school nutrition and exercise programs.[13-15] (**Figure 1, lines A and B**) Strategies to prevent osteoporosis development later in life should therefore focus on the establishment of behaviors at a young age that maximize PBM, avoid exposure to risk factors like alcohol and smoking, and slow the bone loss associated with aging.[14,16]

For avoidance of risk factors, we have one of the nation's top rates for smoking (28.2%), heavy alcohol use, and physical inactivity (33.2%). The Centers for Disease Control documented that 17.3% of adolescents reported having no physical activity during a 7 day time period, with only 24% attending daily physical education classes.[17,18] Additionally, our aging population (WV is second nationally for percent population ≥ 65 years of age) and predominant 94.4% Caucasian ethnicity (ethnicity with the greatest risk of osteoporosis and fracture) present non-modifiable risk factors that dramatically impact the state's skeletal health.[19,20] Thus, our current state mandates should try to maximize PMB through the development of school age prevention programs. Current law requires only 1 credit of physical education after 8th grade following the passage of House Bill 2816 – the Healthy Lifestyles Act – that returned physical education to the K-12 curriculum.[17,18] (Table 1)

Objectives

This article highlights that current West Virginia state law limits the amount of physical education (PE) required at the most critical time for the development of peak bone mass. The PE mandates are currently below national organization recommendations. Introduction of dynamic, load-bearing exercises, in addition to increasing the quantity of exercise, can lessen the burden chronic diseases like osteoporosis, obesity, and heart disease.

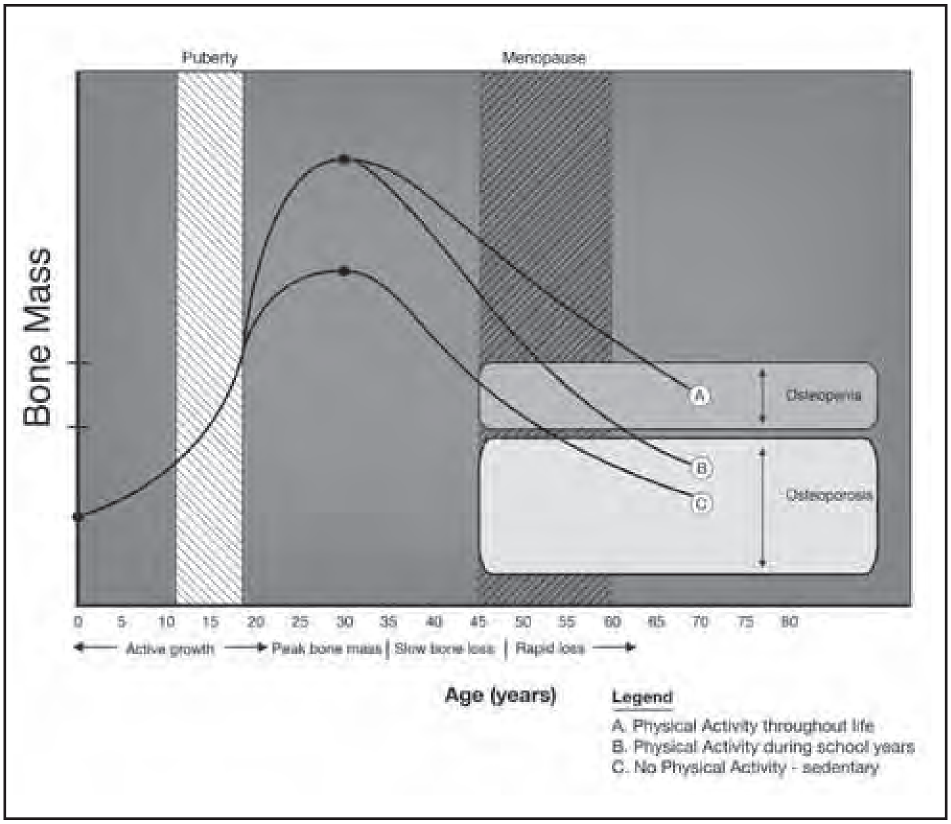

Figure 1: Physical activity alters PBM and shifts the risk of development of osteoporosis. *Lines A and B represent the generation of PBM following NASPE and American Heart Association recommendations. Line A illustrates the impact of continuing active lifestyle behaviors throughout adulthood, and line B illustrates the progressive bone loss due to a more sedentary lifestyle, with 33.2% of WV adults reporting no physical activity during the past month. Line C should be avoided and represents our current state mandates for PE that will not generate PBM and do not encourage the development of active lifestyle behaviors generating a greater risk of osteoporosis and greater risk of fracture. Adapted from*[13,14,18,20,46,47]

Physical Education and Evidence for Increased Bone Mineral Density

There are few studies that have failed to show a significant difference in bone mineral density (BMD) following exercise protocols; confounding variables for these studies include insufficient intervention time, insufficient follow up, differences in exercise programs, or other factors.[21-26] On the other hand, there are a large number of studies demonstrating how exercise interventions, particularly load-bearing exercises, can increase BMD and bone mineral content (BMC).

Increases in BMD are associated with increases in children's weight-bearing physical activities.[2,27] A Canadian study following children over seven years showed that the group of children in the highest quartile of physical activity developed up to a 17% increase in BMC during the years of peak BMD accumulation compared to those in the lowest quartile.[3] In another 8 month study, prepubertal boys were randomized into a control or intervention group which had three 30 minute sessions of moderate physical activity per week. The intervention group developed higher BMC in the femoral shaft versus the control group.[28] It is not known which physical activity was responsible for the increased BMC in this study.[29] Dynamic axial loading exercises, like jumping, have the greatest effect on BMD and BMC of the femoral neck and lumbar spine.[30-33] As mentioned previously, the type of activity is critical because short duration exercise with high loads and dynamic loading (e.g. jumping) is more important than the total duration of exercise or endurance training for skeletal strength.[23,30,31,33-36] In a randomized-controlled jumping protocol in prepubescent children, a 2 foot step up exercise followed by a jump off the boxes generated an eight-fold increase in body weight force during the exercise producing a significant increase in the BMC of the femoral neck and lumbar spine at seven months.[33] In another 2 year intervention trial, prepubertal girls engaged in 10 to 12 minutes of diverse weight bearing exercises, such as circuits of jumping during regular PE classes produced roughly a 2% increase in BMC per school year.[37] They reported a 3.7% increase in BMC at the lumbar spine and a 4.6% increase at the femoral neck over the 2 year period, which they equated to offsetting approximately 3 to 5 years of postmenopausal bone loss. It is also important to note that the child's developmental stage affects the rate of BMC accrual. In a jumping program consisting of 10 minute intervals 3 times per week, no differences in BMC were noted for girls in tanner stage 1, but significant changes were noted in girls in tanner stages 2 and 3.[32] These changes were evident in the femoral neck (2.6% higher) and intertrochanteric regions (1.7% higher) when compared to controls. They also noted an increased bone diameter at the femoral neck. A similar increase in BMC accrual and increase in bone size was reported by the Pediatric Osteoporosis Study that examined girls aged 7-9 years who participated in 200 minutes/

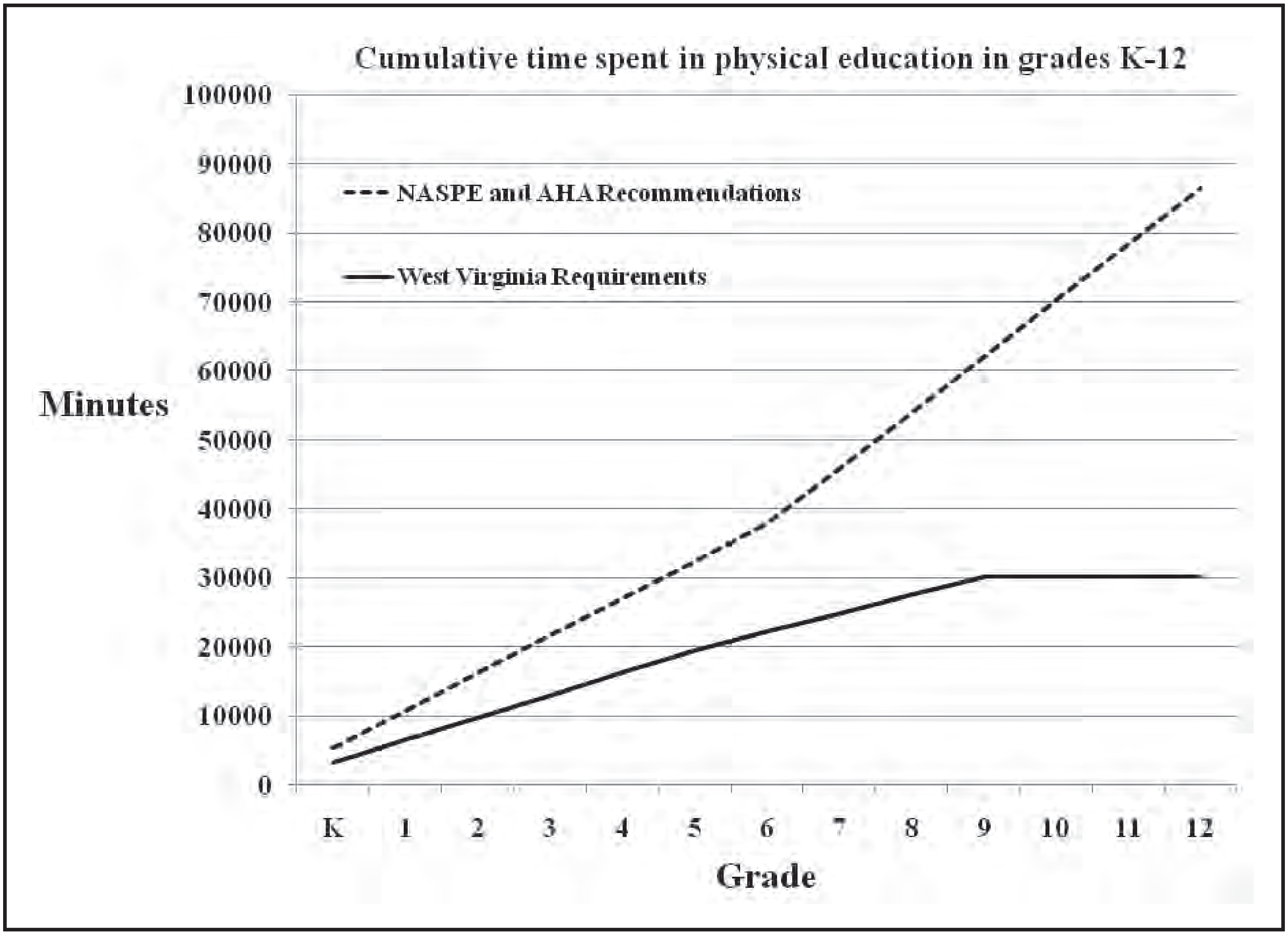

Figure 2: WV PE requirements for K-12 compared to NASPE and American Heart Association recommendations. *Our state's PE mandates provide only 35% of the recommended physical educational recommendations in grades K-12 and should not be considered optimal to generate behaviors that emphasize the development of an active lifestyle throughout adulthood.*

week of general physical activity versus a less active control group.[38,39]

Physical Activity in Childhood

Historically, childhood has been a very active time in peoples' lives. More recently, however, playing tag at recess and school-yard basketball has been replaced with playing video games and watching television. A distinct reference for the exact timing of this change was not noted, but President Kennedy stated in 1961 that "*we are becoming a nation of spectators, ones who ride instead of walk, watch instead of play*."[40] Many reasons exist for the erosion of physical activity that include, but are not limited to, the ubiquity of video games and multimedia, child safety concerns with many parents afraid to send their kids out for unsupervised play, budgetary restrictions impacting state PE programs, and substitution of other academic requirements like computer training. It should be emphasized that there is no federal mandate for physical education, with individual states deciding the amount of PE required. This lack of national policy has resulted in only one state (Illinois) having a daily requirement for physical education for K-12 children. In addition, only 1 in 6 schools nationally require PE 3 days per week with only 4% of elementary schools, 8% of middle schools and 2% of high schools providing daily PE.[40] As a result, childhood obesity rates are the highest in US history with 16.9% of children obese.[41-43] For West Virginia, 67.4% of our adult population has a body mass index (BMI) of ≥ 25; 32.5% with BMI ≥ 30 and 14.2% of our adolescents are obese (≥ 95th percentile BMI by age and sex).[18] Physical activity in childhood is important for skeletal health because

Table 1. West Virginia requirements for physical education compared to NASPE and American Heart Association recommendations.

Grade levels	West Virginia Requirements*	NASPE/AHA recommendations
K-5	90 min per week	150 min per week
6-12th grade	6-8th grade = 75 min per week* 9-12th grade = 18.75 min per week*	6th grade = 150 min per week 7-12th grade = 225 min per week
Totals K-12	30240 TOTAL minutes PE	86400 TOTAL minutes PE

**Please note that the table uses minutes/week to compare to NASPE/AHA recommendations with WV requirements averaged.*

mechanical loading results in an accelerated growth response in bone mineral content and structure when compared to an adult.[23,44] The type of activity is also important because short duration exercise with high loads (e.g. jumping) is more important than the total duration of exercise or endurance training for skeletal strength.[23,31,33-36]

Physical Education Requirements and House Bill 2816

The National Association of Sport and Physical Education (NASPE) has documented the state mandated PE requirements across the US.[45] West Virginia mandates at least 90 minutes of PE per week K-6 with one credit of PE required in grades 9-12. This report does differ from the language in WV House Bill 2816 that returned physical education to the K-12 curriculum. It is therefore worth noting the directives covered in this bill. WV House Bill 2816 mandates the following:

K-5 – PE for 30 minutes three days per week = 90 min/week;

6-8th grade – PE 1 period per day for 1 semester (about 90 instructional days)

9-12th grade – PE for 1 course credit required for graduation.

West Virginia also mandates the following: a daily recess is not required in elementary schools. There is no minimum weekly requirement for physical activity time for middle school, junior high, or high school students and physical activity can be withheld for disciplinary reasons.

As shown in **Table 1 and Figure 2**, WV is currently providing only 35% of the recommended physical educational requirements demonstrated to help prevent the burden of chronic diseases like obesity, heart disease and osteoporosis.[45]

Conclusions

Osteoporosis-associated fragility fractures are a significant cause of morbidity in the aging US and WV population. West Virginia's PE mandates provide only 35% of the recommended physical educational recommendations in grades K-12 and should not be considered optimal to generate behaviors that emphasize the development of an active lifestyle throughout adulthood. Since peak bone mineral density is a key determinant in the onset of osteoporosis, we believe that our state would greatly benefit from improvements in its PE system to both increase the quantity of exercise to NASPE and American Heart Association recommendations and also to improve the quality of exercise. Changing current PE protocols to include dynamic, load-bearing exercises like jumping to optimize PBM generation can lessen the burden of osteoporosis for our state.

References

1. Krall EA, Dawson-Hughes B. Heritable and life-style determinants of bone mineral density. *Journal of bone and mineral research : the official journal of the American Society for Bone and Mineral Research.* Jan 1993;8(1):1-9.
2. Bonjour JP, Theintz G, Law F, Slosman D, Rizzoli R. Peak bone mass. *Osteoporosis international : a journal established as result of cooperation between the European Foundation for Osteoporosis and the National Osteoporosis Foundation of the USA.* 1994;4 Suppl 1:7-13.
3. Bailey DA, McKay HA, Mirwald RL, Crocker PR, Faulkner RA. A six-year longitudinal study of the relationship of physical activity to bone mineral accrual in growing children: the university of Saskatchewan bone mineral accrual study. *Journal of bone and mineral research : the official journal of the American Society for Bone and Mineral Research.* Oct 1999;14(10):1672-1679.
4. Heaney RP, Abrams S, Dawson-Hughes B, et al. Peak bone mass. Osteoporosis international : a journal established as result of cooperation *between the European Foundation for Osteoporosis and the National Osteoporosis Foundation of the USA.* 2000;11(12):985-1009.
5. Theintz G, Buchs B, Rizzoli R, et al. Longitudinal monitoring of bone mass accumulation in healthy adolescents: evidence for a marked reduction after 16 years of age at the levels of lumbar spine and femoral neck in female subjects. *The Journal of clinical endocrinology and metabolism.* Oct 1992;75(4):1060-1065.
6. Gueguen R, Jouanny P, Guillemin F, Kuntz C, Pourel J, Siest G. Segregation analysis and variance components analysis of bone mineral density in healthy families. *Journal of bone and mineral research : the official journal of the American Society for Bone and Mineral Research.* Dec 1995;10(12):2017-2022.
7. Ralston SH, Uitterlinden AG. Genetics of osteoporosis. *Endocrine reviews.* Oct 2010;31(5):629-662.
8. Ralston SH. Genetics of osteoporosis. *The Proceedings of the Nutrition Society.* May 2007;66(2):158-165.
9. Ralston SH. Genetics of osteoporosis. *Reviews in endocrine & metabolic disorders.* Jan 2001;2(1):13-21.
10. Ralston SH. The genetics of osteoporosis. *QJM : monthly journal of the Association of Physicians.* Apr 1997;90(4):247-251.
11. Recker RR, Davies KM, Hinders SM, Heaney RP, Stegman MR, Kimmel DB. Bone gain in young adult women. *JAMA : the journal of the American Medical Association.* Nov 4 1992;268(17):2403-2408.
12. Heaney RP. Weight-bearing activity during youth is a more important factor for peak bone mass than calcium intake. *Journal of bone and mineral research : the official journal of the American Society for Bone and Mineral Research.* Jan 1995;10(1):172-173.
13. Bonjour JP, Chevalley T, Ferrari S, Rizzoli R. The importance and relevance of peak bone mass in the prevalence of osteoporosis. *Salud publica de Mexico.* 2009;51 Suppl 1:S5-17.
14. Bonjour JP, Chevalley T, Rizzoli R, Ferrari S. Gene-environment interactions in the skeletal response to nutrition and exercise during growth. *Medicine and sport science.* 2007;51:64-80.
15. WHO Study Group on Assessment of Fracture Risk and its Application to Screening for Postmenopausal Osteoporosis. *Assessment of fracture risk and its application to screening for postmenopausal osteoporosis.* Geneva: World Health Organization; 1994.

16. Karlsson MK. Physical activity, skeletal health and fractures in a long term perspective. *Journal of musculoskeletal & neuronal interactions.* Mar 2004;4(1):12-21.
17. Shuler FD, Conjeski J. Defining bone health and fracture risk in West Virginia: the World Health Organization FRAX assessment tool. *The West Virginia medical journal.* Sep-Oct 2011;107(5):12-17.
18. Promotion NCfCDPaH. West Virginia: State Nutrition, Physical Activity, and Obesity Profile. 2012. Accessed Accessed January 30, 2013.
19. Shuler FD, Lycans D, Salloum E. Extraskeletal effects of vitamin D: potential impact on WV disease morbidity and mortality. *The West Virginia medical journal.* May-Jun 2012;108(3):56-62.
20. Shuler FD, Conjeski J, Kendall D, Salava J. Understanding the burden of osteoporosis and use of the World Health Organization FRAX. *Orthopedics.* Sep 2012;35(9):798-805.
21. Van Langendonck L, Claessens AL, Vlietinck R, Derom C, Beunen G. Influence of weight-bearing exercises on bone acquisition in prepubertal monozygotic female twins: a randomized controlled prospective study. *Calcified tissue international.* Jun 2003;72(6):666-674.
22. Witzke KA, Snow CM. Effects of plyometric jump training on bone mass in adolescent girls. *Medicine and science in sports and exercise.* Jun 2000;32(6):1051-1057.
23. Alwis G, Linden C, Stenevi-Lundgren S, et al. A school-curriculum-based exercise intervention program for two years in pre-pubertal girls does not influence hip structure. *Dynamic medicine : DM.* 2008;7:8.
24. Alwis G, Linden C, Stenevi-Lundgren S, et al. A one-year exercise intervention program in pre-pubertal girls does not influence hip structure. *BMC musculoskeletal disorders.* 2008;9:9.
25. Jarvinen TL, Kannus P, Sievanen H. Have the DXA-based exercise studies seriously underestimated the effects of mechanical loading on bone? *Journal of bone and mineral research : the official journal of the American Society for Bone and Mineral Research.* Sep 1999;14(9):1634-1635.
26. Daly RM. The effect of exercise on bone mass and structural geometry during growth. *Medicine and sport science.* 2007;51:33-49.
27. Slemenda CW, Miller JZ, Hui SL, Reister TK, Johnston CC, Jr. Role of physical activity in the development of skeletal mass in children. *Journal of bone and mineral research : the official journal of the American Society for Bone and Mineral Research.* Nov 1991;6(11):1227-1233.
28. Bradney M, Pearce G, Naughton G, et al. Moderate exercise during growth in prepubertal boys: changes in bone mass, size, volumetric density, and bone strength: a controlled prospective study. *Journal of bone and mineral research : the official journal of the American Society for Bone and Mineral Research.* Dec 1998;13(12):1814-1821.
29. Davies JH, Evans BA, Gregory JW. Bone mass acquisition in healthy children. *Archives of disease in childhood.* Apr 2005;90(4):373-378.
30. Lanyon LE. Control of bone architecture by functional load bearing. *Journal of bone and mineral research : the official journal of the American Society for Bone and Mineral Research.* Dec 1992;7 Suppl 2:S369-375.
31. Rubin CT, Lanyon LE. Regulation of bone formation by applied dynamic loads. *The Journal of bone and joint surgery. American volume.* Mar 1984;66(3):397-402.
32. Petit MA, McKay HA, MacKelvie KJ, Heinonen A, Khan KM, Beck TJ. A randomized school-based jumping intervention confers site and maturity-specific benefits on bone structural properties in girls: a hip structural analysis study. *Journal of bone and mineral research : the official journal of the American Society for Bone and Mineral Research.* Mar 2002;17(3):363-372.
33. Fuchs RK, Bauer JJ, Snow CM. Jumping improves hip and lumbar spine bone mass in prepubescent children: a randomized controlled trial. *Journal of bone and mineral research : the official journal of the American Society for Bone and Mineral Research.* Jan 2001;16(1):148-156.
34. Robling AG, Hinant FM, Burr DB, Turner CH. Improved bone structure and strength after long-term mechanical loading is greatest if loading is separated into short bouts. *Journal of bone and mineral research : the official journal of the American Society for Bone and Mineral Research.* Aug 2002;17(8):1545-1554.
35. Robling AG, Hinant FM, Burr DB, Turner CH. Shorter, more frequent mechanical loading sessions enhance bone mass. *Medicine and science in sports and exercise.* Feb 2002;34(2):196-202.
36. Turner CH, Robling AG. Exercises for improving bone strength. *British journal of sports medicine.* Apr 2005;39(4):188-189.
37. Mackelvie KJ, McKay HA, Khan KM, Crocker PR. A school-based exercise intervention augments bone mineral accrual in early pubertal girls. *The Journal of pediatrics.* Oct 2001;139(4):501-508.
38. Linden C, Alwis G, Ahlborg H, et al. Exercise, bone mass and bone size in prepubertal boys: one-year data from the pediatric osteoporosis prevention study. *Scandinavian journal of medicine & science in sports.* Aug 2007;17(4):340-347.
39. Linden C, Ahlborg HG, Besjakov J, Gardsell P, Karlsson MK. A school curriculum-based exercise program increases bone mineral accrual and bone size in prepubertal girls: two-year data from the pediatric osteoporosis prevention (POP) study. *Journal of bone and mineral research : the official journal of the American Society for Bone and Mineral Research.* Jun 2006;21(6):829-835.
40. *Weight of a Nation: Children in Crisis 2012.*
41. Ogden CL, Carroll MD, Kit BK, Flegal KM. Prevalence of obesity in the United States, 2009-2010. *NCHS data brief.* Jan 2012(82):1-8.
42. Ogden CL, Carroll MD, Kit BK, Flegal KM. Prevalence of obesity and trends in body mass index among US children and adolescents, 1999-2010. *JAMA : the journal of the American Medical Association.* Feb 1 2012;307(5):483-490.
43. Flegal KM, Carroll MD, Kit BK, Ogden CL. Prevalence of obesity and trends in the distribution of body mass index among US adults, 1999-2010. *JAMA : the journal of the American Medical Association.* Feb 1 2012;307(5):491-497.
44. Bass SL, Saxon L, Daly RM, et al. The effect of mechanical loading on the size and shape of bone in pre-, peri-, and postpubertal girls: a study in tennis players. *Journal of bone and mineral research : the official journal of the American Society for Bone and Mineral Research.* Dec 2002;17(12):2274-2280.
45. National Association for Sport and Physical Education., American Heart Association., American Stroke Association. Shape of the nation 2006 shape of the nation report : status of physical education in the USA. Reston, VA.: National Association for Sport and Physical Education; 2006: HTML version: http://www.aahperd.org/naspe/ShapeOfTheNation/PDF version: http://www.aahperd.org/naspe/ShapeOfTheNation/PDF/ShapeOfTheNation.pdf.
46. Assessment of fracture risk and its application to screening for postmenopausal osteoporosis. Report of a WHO Study Group. *World Health Organization technical report series.* 1994;843:1-129.
47. Melton LJ, 3rd, Atkinson EJ, Khosla S, Oberg AL, Riggs BL. Evaluation of a prediction model for long-term fracture risk. *Journal of bone and mineral research : the official journal of the American Society for Bone and Mineral Research.* Apr 2005;20(4):551-556.

CME Post-Test

28. The amount of time spent in physical education in schools is determined by which entity?

a. The state
b. The federal government
c. The play 60 program from the National Football League
d. A combination of both state and federal mandates

29. The most rapid rate of gain of bone mass occurs at ages 12-17. When is peak bone mass realized?

a. In childhood
b. At 20 years of age
c. Between 25-35 years of age

30. What percent of our adolescents in West Virginia attend daily physical education in school?

a. <10%
b. Between 10-20 %
c. 24%
d. >25%