Mechanical loading regime and its relationship to bone mineral density in children

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ABSTRACT

GRIMSTON, S. K., N. D. WILLOWS, and D. A. HANLEY. Mechanical loading regime and its relationship to bone mineral density in children. *Med. Sci. Sports Exerc.*, Vol. 25, No. 11, pp. 1203–1210, 1993. This study tested the hypothesis that differences in mechanical loading regime was important when evaluating the potential role of physical activity on bone density in children. Seventeen children competing regularly in weight-bearing sports producing loads of at least 3 times body weight (Impact Load) were matched for race, gender, stage of puberty, body weight, and average daily training time with children involved in competitive swimming (Active Load). Bone mineral density (BMD) was measured using dual photon absorptiometry at the lumbar spine (L2–L4) and femoral neck (FN), Tanner staging was used to assess puberty, diet was evaluated based on 3-d dietary records from two occasions, and a questionnaire assessed average daily nonweight-bearing hours. There were no significant differences in age (13.2 ± 0.4 and 12.6 ± 0.4), height (154.9 ± 2.9 and 157.6 ± 3.0), or weight (43.6 ± 2.7 and 44.5 ± 2.2) between Impact and Active Load groups. Impact Load children had significantly greater FN BMD (0.78 ± 0.02) than Active Load children (0.72 ± 0.02) and a tendency for greater BMD L2–L4; 0.70 ± 0.03 and 0.66 ± 0.03, respectively. These data indicate that children involved in sports producing significant impact loading on the skeleton had greater femoral neck bone density and a trend for greater spinal bone density, than children in sports producing loads to bone primarily through muscular contraction.

MECHANICAL LOAD, PUBERTY, BONE DENSITY

Maximizing adult peak bone mass has been proposed as a means of minimizing the future risk for significant osteopenia and/or osteoporotic fracture (10,30). Studies of bone growth and development have therefore been initiated to monitor changes in bone mineral density, bone mineral content, and longitudinal bone growth in immature subjects to determine what factors, if any, are important for optimal skeletal maturation (1,3,4,11,12,14–16,26,28). One factor of particular interest has been the influence of childhood physical activity patterns on skeletal maturation. However, there is a paucity of information regarding the relative potential for specific activities, i.e., specific mechanical loading regimes, to influence bone mineral density accretion.

During skeletal maturation two distinct skeletal processes occur (7). First is the process of bone growth, which functions to increase the tissue's volume, thereby achieving adult body size. The second important skeletal process of maturation is modeling. Modeling, under the influence of local factors, such as mechanical load, may alter a specific growth pattern and its organization of tissue components to produce macroarchitectural features. Bone modeling may add bone mass but may never result in a reduction in bone mass (7). To maximize bone mass during skeletal maturation, the modeling process must be optimized. Appropriate mechanical load during the critical period of rapid skeletal growth and modeling in children would therefore appear important for skeletal health.

One recent study of children has demonstrated a significant positive association between the level of physical activity and bone mineral density, as measured by dual photon absorptiometry (28). However, it is not possible from the information available to predict if a specific kind of activity could optimize bone density gains during childhood, and thereby increase adult peak bone mineral density. Weight-bearing activities (in the presence of gravitational forces) have generally been considered to have a positive influence on bone health. In particular, activities such as running and landing from a jump which generate external loads on the human body of between 3–5 times body weight (5,6,23) and 7–10 times body weight (18,22,23) at impact respectively, might be expected to stimulate the modeling process. However, nonweight-bearing activities, which actively load the skeleton through muscular contraction on bone mass, have not had an established influence on bone mass. In particular, results have been conflicting with respect to the possible skeletal benefits to be derived by children from participation in swimming.

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Children who have responded to questionnaires and indicated that of all their activities swimming was the dominant form of exercise, have been shown to have lower bone density measures than children indicating various forms of weight-bearing activities as their dominant exercise pattern. These results suggest swimming may not potentiate gains in bone mass compared with other weight-bearing activities such as running (21,28). In contrast, controlled animal studies have shown swimming to significantly increase longitudinal bone growth, bone mineral density, and the mechanical competence of bones in growing rats compared with non-swimming rats (31). The apparent discrepancy between results of these studies may be explained by differences in the quantity and intensity of the swimming involvement of the rats compared with the children interviewed, differences in the bone sites measured, and the limitations associated with extrapolating from an animal model to a human condition. In addition, both studies failed to control for differences in body weight of subjects when evaluating the possible effect of swimming on bone growth and bone mass. It is therefore unclear as to the possible influence of swimming involvement on bone growth and/or bone mass on the immature skeleton.

The purpose of this study was to compare the bone mineral density of children dedicating a significant proportion of their physical activity time to high impact weight-bearing sports, to that of children similarly engaged in the nonweight-bearing, active mechanical loading sport of swimming. It was hypothesized that in children matched for the important skeletal factors of race, gender, body weight, and stage of puberty, those training in sports requiring significant impact loading to the skeleton would have greater bone mineral density measures than children training in swimming.

METHODS

Seventeen children (eight males and nine females) involved in competitive sports requiring significant impact loading to the skeleton (Impact Load), aged between 10 and 16 yr, were recruited from the Calgary region for this study. In this study, impact loading sports were defined as those sports producing ground reaction forces at landing of greater than or equal to 3 times body weight. On the basis of this definition, sports included were running ($N = 3$), gymnastics ($N = 5$), tumbling ($N = 7$), and dance ($N = 2$). Competitive involvement was defined on the basis of total time commitment, which included a minimum of three 60-min specific training sessions per week, and regular competition at both the local and provincial levels. All children were Caucasian and had no medical history of disorders affecting skeletal metabolism, eating disorders, growth, and/or development. Informed written consent was obtained from the parents of all participants prior to testing, in accordance with protocols defined by the University of Calgary Conjoint Medical Bioethics Committee, and the policy statements of the American College of Sports Medicine.

Stage of puberty was assessed by physicians during a complete medical examination using Tanner staging (19,20). The general health of each child was confirmed and basic anthropometric assessment of height and weight were made during the medical examination. Regional bone mineral density (BMD) measurements from the lumbar spine (L2–L4) and femoral neck (FN) were taken using Dual Photon Absorptiometry (BMC-LAB 22a, Novo Diagnostic Systems). Procedures for the measurement of lumbar and femoral neck BMD have been described in detail previously (17). The coefficient of variability using this technique in our laboratory is 2–3%.

Children and parents were instructed on how to complete a comprehensive dietary record by the registered dietitian in our laboratory. Subjects recorded all ingested items over two 3-d periods, which included 2 weekend days and 4 weekdays. Interviews with parents and children during and immediately after the diet record-keeping periods were conducted by the dietitian to clarify any inconsistencies and resolve potential inaccuracies. Issues such as time taken to eat meals, location of meals, and activity level during meals (e.g. sitting down vs eating "on the run") were addressed during the interview. The final 6 d of diet records for each child were coded and analyzed using the commercially available computer package, Nutritionist III (N-Squared Computing, Oregon). Dietary analyses included quantification of average energy ($\text{kcal}\cdot\text{d}^{-1}$), protein ($\text{g}\cdot\text{d}^{-1}$), fat ($\text{g}\cdot\text{d}^{-1}$), carbohydrate ($\text{g}\cdot\text{d}^{-1}$) and calcium ($\text{mg}\cdot\text{d}^{-1}$). Derivation of percent of total energy intake from carbohydrate and fat, protein intake per kilogram body weight ($\text{g}\cdot\text{kg}^{-1}$), and calcium density ($\text{mg}\cdot\text{kcal}^{-1}$) were also included in the analysis.

An activity questionnaire was developed for use in this study that was modified from questionnaires previously reported in the literature (Appendix; 27,28,32) Questions assessed year-round activity patterns, with additional questions regarding the average hours per day spent in nonweight-bearing activities such as sleeping, watching television, doing homework, and taking transportation to and from school and/or training venues emphasized. Weekends were distinguished from weekdays for all questions and subjects were directed to distinguish between activities engaged in during the competitive and off-seasons. Specific information regarding training times, days, and months each year were included and responses confirmed with parents and coaches. Testing for an estimate of questionnaire reliability was conducted prior to the study by administration of the questionnaire to 21 similar age-group athletes who were not part of the current study on two occasions, 6 months apart. Each child was asked to complete the activity profile questionnaire in collaboration with their parents. Completed questionnaires were returned and responses reviewed and clarified with each child. Parents were consulted if further inconsistencies persisted.

In children a 6-month interval between test sessions may not be considered a true test of questionnaire reliability. Nevertheless, results of dependent *t*-test comparisons of results from both test sessions indicated good consistency in questionnaire responses (Table 1). On the basis of these results, the 17 Impact Load subjects were asked to complete the questionnaire, using the previously detailed procedures.

Each Impact Load child was then matched for race, gender, stage of puberty, and body weight with a competitive swimmer (Active Load) who was already part of a larger longitudinal study of bone growth and development in 120 children. In contrast with the other sports, swimming generates active mechanical loads (through muscular contraction) in the absence of additional loads imposed by gravitational forces. To be considered as an appropriate match with respect to activity level, we selected swimmers who participated in a minimum of three training sessions each week, and competed regularly at the provincial level. Additional matching criteria for the older children included similar duration since menarche (females) and similar duration since reaching Tanner stage 5 (males). The matching criterion for body weight required body weights within 2 kg of the impact loaded subject. All procedures documented for the Impact Load children were similarly conducted for the Active Load children.

Student's *t*-tests for independent groups were used to compare variables between Impact Load and Active Load subjects, and between males and females of each group. Due to the potential for small differences in chronological age and/or years in training accounting for a significant proportion of any observed differences in BMD, analyses of covariance adjusting for these variables were also run. Significant associations between relevant variables were tested using Pearson product moment correlations. A limitation of this study was a lack of statistical power due to the relatively low number of children that could be matched on all criteria. Statistical significance was concluded at the $P \leq 0.05$ level of significance.

TABLE 1. Test-retest comparison between baseline and 6 month administrations of activity questionnaires (mean ± SEM).

Question Topic	Test	Retest	*P*
Years train (yr)	6.5 ± 0.3	6.6 ± 0.3	0.16
Hours train ($hr \cdot d^{-1}$)	2.7 ± 0.1	2.8 ± 0.1	0.72
Months train ($months \cdot yr^{-1}$)	10.2 ± 0.2	10.1 ± 0.3	0.78
Hours sleep ($hr \cdot d^{-1}$)	8.5 ± 0.2	8.7 ± 0.2	0.35
Hours TV ($hr \cdot d^{-1}$)	1.2 ± 0.3	1.0 ± 0.1	0.32
Hours Study ($hr \cdot d^{-1}$)	1.6 ± 0.3	1.4 ± 0.2	0.38
Phys. Ed. ($min \cdot wk^{-1}$)	162 ± 22	132 ± 27	0.06
Other sports	2.8 ± 0.1	2.7 ± 0.2	0.33

RESULTS

Chronological age, height, years training, and average training time per day were not included as matching criteria in this study. Nevertheless, comparison of all subjects in the Active and Impact groups showed no significant differences between groups for these variables (Table 2). Weight training was considered a distinct activity from hours spent in specific training and was included in the assessment of total weight-bearing hours. Of the 34 subjects studied, five swimmers (three Tanner stage 5 and two Tanner stage 4) participated in a moderate high resistance weight-training program. The remaining athletes reported variable programs of low resistance, high-repetition weight training, typically in the off-season months. There were no significant dietary differences noted between groups (Table 3).

At the femoral neck BMD measurements were significantly greater for children involved in sports producing significant impact loads to the skeleton (Impact Load), whereas the differences noted for BMD at the lumbar spine did not reach statistical significance (Fig. 1). The significant difference in femoral neck BMD persisted when adjustments for differences in age were made ($P = 0.028$). Differences in years training between groups was not a significant covariate ($P = 0.12$). Active Load

TABLE 2. Comparison of descriptive results between children involved in Active Load and Impact Load sports.

	Impact Load ($N = 17$)	Active Load ($N = 17$)
Age (yr)	13.2 ± 0.4	12.6 ± 0.4
Height (cm)	154.9 ± 2.9	157.6 ± 3.0
Weight (kg)	43.6 ± 2.7	44.5 ± 2.2
Time training ($hr \cdot d^{-1}$)	2.0 ± 0.2	2.1 ± 0.2
Years training (yr)	6.8 ± 0.7	5.8 ± 0.5
Weight bearing ($hr \cdot d^{-1}$)	8.0 ± 0.2*	5.3 ± 0.3
Sleep ($hr \cdot d^{-1}$)	9.1 ± 0.2	9.5 ± 0.2*

Results are expressed as mean ± SE.

* Significantly greater; $P < 0.05$.

TABLE 3. Nutritional comparisons between children involved in Active Load and Impact Load sports.

Nutrient Intake (per day)	Impact Load ($N = 17$)	Active Load ($N = 17$)
Energy (kcal)	2392 ± 137	2443 ± 111
Carbohydrate (g)	316 ± 20	338 ± 16
Carbohydrate (%)	52.4 ± 1.6	54.7 ± 1.8
Protein (g)	88.7 ± 4.5	93.9 ± 6.3
Protein ($g \cdot kg^{-1}$ wt)	2.0 ± 0.1	2.2 ± 0.2
Protein (%)	15.2 ± 0.6	14.9 ± 0.6
Fat (g)	89.7 ± 7.1	83.5 ± 5.7
Fat (%)	33.6 ± 1.3	30.2 ± 1.5
Calcium (mg)	1253 ± 100	1289 ± 82
Calcium density ($mg \cdot kcal^{-1}$)	0.53 ± 0.03	0.53 ± 0.03

Results are expressed as mean ± SE.

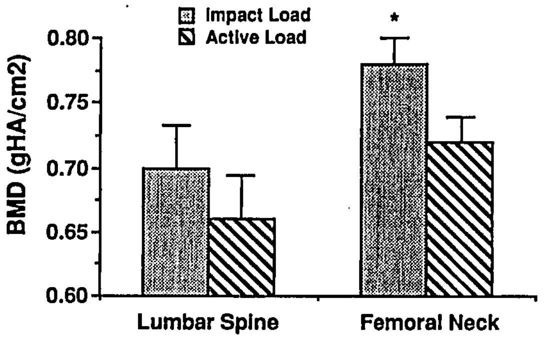

Figure 1—Bone mineral density comparisons between Impact Load and Active Load children males and females within each group combined. Results are mean values with SEM indicated. * Significantly greater; $P < 0.05$.

subjects reported spending significantly less time each day in weight-bearing physical activities than subjects in the Impact Load group (Table 2). When the association between weight-bearing hours and bone density was tested there were no significant correlations between average daily weight-bearing hours and spinal BMD (r = 0.04) or femoral neck BMD (r = 0.14).

Comparisons between groups for each gender were consistent, with both male (Table 4) and female (Table 5) Impact Load children reporting significantly more time in weight-bearing activities than their respective Active Load comparative group. There were no significant differences in BMD at either site between female Impact Load and Active Load subjects (Fig. 2), whereas in contrast, male Impact Load subjects had significantly greater spinal BMD than male Active Load children (Fig. 3). This difference persisted when adjustments for differences in age and years in training were made. Femoral neck BMD was greater in the Impact Load group but failed to reach statistical significance for both males ($P = 0.061$) and females ($P = 0.057$). There were no significant dietary differences between groups within each gender (data not shown).

TABLE 4. Comparison of descriptive results between females involved in Active Load and Impact Load sports.

	Impact Load ($N = 9$)	Active Load ($N = 9$)
Age (yr)	13.4 ± 0.4	13.0 ± 0.5
Height (cm)	158.6 ± 2.7	158.7 ± 3.2
Weight (kg)	44.3 ± 3.1	46.3 ± 2.9
Time training (hr·d^{-1})	1.8 ± 0.2	2.1 ± 0.2
Years training (yr)	7.1 ± 1.1	6.3 ± 0.7
Weight bearing (hr·d^{-1})	7.6 ± 0.3*	5.3 ± 0.3
Sleep (hr·d^{-1})	9.1 ± 0.3	9.3 ± 0.2

Results are expressed as mean ± SE.
* Significantly greater; $P < 0.05$.

TABLE 5. Comparison of descriptive results between males involved in Active Load and Impact Load sports.

	Impact Load ($N = 8$)	Active Load ($N = 8$)
Age (yr)	13.0 ± 0.8	12.1 ± 0.5
Height (cm)	150.7 ± 5.3	156.5 ± 5.5
Weight (kg)	42.7 ± 4.8	42.5 ± 3.5
Time training (hr·d^{-1})	2.2 ± 0.2	2.1 ± 0.3
Years training (yr)	6.4 ± 1.0	5.3 ± 0.7
Weight bearing (hr·d^{-1})	8.4 ± 0.2*	5.3 ± 0.4
Sleep (rh·d^{-1})	8.9 ± 0.3	9.7 ± 0.3*

Results are expressed as mean ± SE.
* Significantly greater; $P < 0.05$.

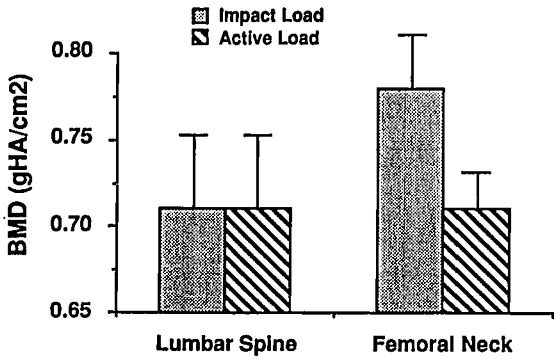

Figure 2—Bone mineral density comparisons between female Impact Load and Active Load groups. Results are mean values with SEM indicated.

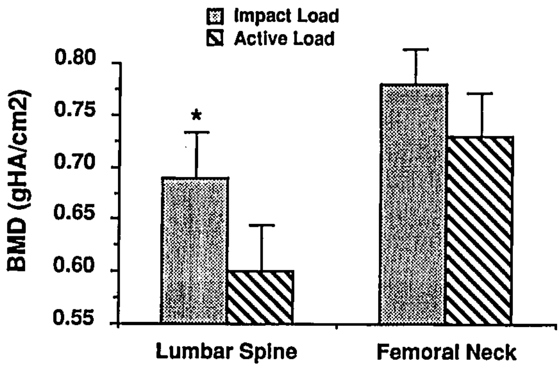

Figure 3—Bone mineral density comparisons between male Impact Load and Active Load groups. Results are mean values with SEM indicated. * Significantly greater; $P < 0.05$.

DISCUSSION

The quality and quantity of bone in adult years is believed to depend in part on the characteristics of these properties developed during childhood and early adulthood (1,10,29). Any measure that may effectively increase these bone properties during childhood may therefore improve overall bone health in later adult years. Physical activity under the influence of gravitational forces has been recognized since before the 20th century as having an important influence on bone mass and architecture (34). In recent years, human studies of mechanical influences on bone have focused almost exclusively on adult and elderly populations (2,25,29). Typically, subjects have been either osteopenic or osteoporotic individuals, with the objective generally being to prevent further bone mass loss. Little attention has been focused on the role of various forms of physical activity (mechanical load) for increasing the quantity and/or quality of bone in the immature skeletons of children. This cross-sectional study was designed to determine the possible differences in BMD of children engaged in two contrasting forms of mechanical loading, impact loading and active loading sports.

The results of this study demonstrated significant differences in bone mineral density measures between children matched for race, gender, stage of puberty, and body weight, as a function of mechanical loading regime (Fig. 1). Specifically, children competitively involved in sports producing impact loads to the skeleton of greater than or equal to 3 times body weight had significantly greater femoral neck BMD (0.78 ± 0.02 $gHA \cdot cm^{-2}$) than children involved in the nonweight-bearing (Active Load) sport of swimming (0.72 ± 0.02 $gHA \cdot cm^{-2}$). The difference in FN BMD persisted when differences in chronological age were adjusted for. In addition, the Impact Load children also reported significantly more time spent each day in weight-bearing activities (8.0 ± 0.2 $h \cdot d^{-1}$) than Active Load children (5.3 ± 0.3 $h \cdot d^{-1}$). Part of this difference can be attributed to the 2.1 ± 0.2 of these weight-bearing hours spent in training for their impact sports (Table 1). The remaining difference was due primarily to the significant difference noted for the average number of sleeping hours reported (Table 2). The Impact Load children reported participating in training for their respective sport specialties longer than Active Load athletes (Table 2). This difference did not reach significance and did not account for a significant proportion of the differences in BMD at either site.

The differences in lumbar spine BMD (L2–L4) between Active Load (0.66 ± 0.03 $gHA \cdot cm^{-2}$) and Impact Load (0.70 ± 0.03 $gHA \cdot cm^{-2}$) children did not reach statistical significance when results for both males and females were combined (Fig. 1). However, males involved in impact sports were found to have significantly greater spinal BMD (0.69 ± 0.04 $gHA \cdot cm^{-2}$) than male Active Load (0.60 ± 0.04 $gHA \cdot cm^{-2}$) children (Fig. 3). No differences in bone density between groups was noted for female subjects (Fig. 2). The explanation for the apparent gender specificity of the response of spinal bone to different mechanical loading regimes is not clear from these data but may be related to the low subject numbers in this study. Additional data documenting longitudinal growth rate vs the rate of bone mineral density accretion may afford some insight into this finding.

Despite the significant differences between groups noted for BMD of the femoral neck and weight-bearing hours, there were no direct relationships between total weight-bearing hours and BMD measured at either site. This finding was in contrast to previous results derived through questionnaire administration to 59 pairs of monozygotic twins in which a significant correlation of 0.37 ($P < 0.01$) was established between total weight-bearing hours and femoral neck bone density (28). Although recruitment of a larger number of subjects in the present study might have yielded a similar relationship between total weight-bearing hours and femoral neck BMD similar to that found in earlier studies, part of the difference may be related to the subject populations studied. Children in the present study were successful competitive athletes who, in 71% of cases (24 of 34 children) participated in no sport other than their sport specialty, on a regular consistent basis. In contrast, children previously studied were reported to engage in a variety of sporting activities and were not competitively training in any specific sport. Thus, the frequency, duration, and magnitude of skeletal loading patterns may be quite different between studies. In all other respects, however, our results were consistent with those of previous studies suggesting weight-bearing activities may confer a greater skeletal benefit in children than nonweight-bearing activities (21,28).

The important feature of the present study design was the grouping of children on the basis of sport specialties that differ in the magnitude and nature of forces generated on bones of the skeleton. Our hypothesis, that sports producing significant impact loads (and therefore a large compressive stress) to the skeleton would result in significantly greater bone density when compared with the BMD of children experiencing forces imposed through active muscular contraction, was based on the current understanding of bones' response to mechanical load. It has been shown that the response of bone to mechanical usage is dependent on some "... time-averaged value of the mechanical forces on bone, (which) assign disproportionately more weight to large than to small loads, no matter how frequent the latter" (8; pg. 430). Thus, the average 2.00 ± 0.2 $h \cdot d^{-1}$ spent in sports generating impact forces on the skeleton were hypothesized to significantly influence bone density in these athletes. The finding of significant differences in femoral neck bone density points to the local influence of mechanical load on bone. The possibility of impact loading sports potentiating gains in bone mineral density during childhood warrants further prospective study.

Frost's theory of the "Mechanostat" requires that some minimum effective strain (MES_m) be exceeded in order to initiate the modeling process and thus potentiate an increase in bone mass (8,9). Therefore, based on this theory, if a particular physical activity/sport is to have greater potential for maximizing bone mineral density in children than another, it should require movements that produce strains on bones that exceed the MES_m at any given time. Unfortunately, MES data for growing children have not been documented. However, since strain is defined as the deformation in a material due to an applied load, and stress is the force applied to a body per unit area, an indication of the strains required to stimulate modeling in growing bones may be indirectly derived from force data.

Biomechanical studies utilizing force plates have provided for the measurement of external ground reaction forces in humans arising as a consequence of various forms of physical activity. Previous studies in our laboratory of able-bodied children of the same age range as those in the present study, have shown the vertical ground reaction force due to the impact at touchdown of the support leg during running to average approximately 3 times body weight (5,6). These results are similar to those obtained from adults (13,23,24). These external loads have been calculated to represent the transmission of internal forces to the tibia of somewhere between 6–12 times body weight (33). Similar testing of the external ground reaction forces imposed by landing from a jump, such as would be expected to occur during gymnastics, tumbling, and dance routines, have been determined to reach values as high as 10 times body weight (18,22,23). The transmission of these forces to bones of the skeleton would be expected to exceed the forces generated through muscular contraction in a nonweight-bearing activity such as swimming, and may be of sufficient magnitude to exceed the current MES_m and therefore potentiate the modeling process in growing children.

A limitation to this study design was our inability to recruit sedentary control children who matched the athletic children on all criteria. Bone density measures of such a group would have allowed for conclusions to be drawn regarding the bone mineral density of both groups of athletes relative to sedentary children. However, comparison with data collected on normal children from other laboratories, and expressed as z-scores to control for differences in equipment used, suggest that the swimmers in the present study did not have bone density measures outside the normal range (1,3,4,11,12,14–16,26,28). It may not be concluded therefore that the activity of swimming effectively reduces bone mass, nor do the data suggest that swimming retards the growth process, since there were no differences in height between groups (Table 2). More importantly, the absence of longitudinal data on these children prohibits conclusions regarding the dynamics of bone density changes as a function of mechanical load. Prospective analysis of subjects through to approximately 25–30 yr of age would be required to establish the possible advantage in terms of peak adult bone density impact loading activities during childhood might represent.

The results of this study indicate that children engaged in active mechanical loading sports such as swimming had significantly lower femoral neck bone density compared with children in weight-bearing sports requiring impact loads of greater than or equal to 3 times body weight. This trend was also evidenced for lumbar spine BMD, but was not significant. Further studies are required to determine the ramifications to overall bone health these results represent.

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Appendix

ACTIVITY QUESTIONNAIRE

ACTIVITY

- HOW MANY HOURS PER DAY, ON AVERAGE, DO YOU;

Sleep	(weekdays)	☐☐	(weekends)	☐☐
Watch Television	(weekdays)	☐☐	(weekends)	☐☐
Study or do Homework	(weekdays)	☐☐	(weekends)	☐☐
Just "Sit Around"	(weekdays)	☐☐	(weekends)	☐☐

TRANSPORTATION

- DO YOU WALK TO SCHOOL?

☐ Yes → • HOW LONG DOES IT TAKE YOU TO WALK TO SCHOOL? ________

• DO YOU WALK HOME FOR LUNCH? ________

• WHAT DO YOU NORMALLY DO AT LUNCH TIME (besides eat)?

____

☐ No ↓

- HOW DO YOU GET TO SCHOOL?
  - ☐ Bike
  - ☐ Parents
  - ☐ Bus
  - ☐ Other

SCHOOL

- WHAT DO YOU NORMALLY DO AT RECESS? ________________
- DO YOU TAKE PHYSICAL EDUCATION CLASSES?

☐ Yes → • HOW MANY TIMES A WEEK DO YOU HAVE PHYSICAL EDUCATION CLASSES? ☐☐

☐ No

• HOW LONG ARE YOUR PHYSICAL EDUCATION CLASSES? ☐☐

• WHAT DO YOU NORMALLY DO IN PHYSICAL EDUCATION CLASSES? ________________

____

SPORTS

- DO YOU PLAY ANY OTHER SPORTS?

☐ Yes → • WHICH SPORTS DO YOU PLAY "IN SEASON"?

____

☐ No

• HOW OFTEN DO YOU PLAY OR PRACTISE THESE SPORTS PER WEEK? ________

____

• HOW LONG ARE THESE SESSION? ________

____

- DO YOU PLAY ANY OTHER SPORTS?

☐ Yes → • WHICH SPORTS DO YOU PLAY "OFF SEASON"?

____

☐ No

• HOW OFTEN DO YOU PLAY OR PRACTISE THESE SPORTS PER WEEK? ________

____

• HOW LONG ARE THESE SESSION? ________

____

WEEKENDS

- DO YOU DO ACTIVITIES ON THE WEEKENDS? (e.g. bike, swim, dance, ski, run)

☐ Yes → SATURDAY

☐ No

ACTIVITIES	TIME SPENT
________	________
________	________
________	________
________	________

☐ Yes → SUNDAY

☐ No

ACTIVITIES	TIME SPENT
________	________
________	________
________	________
________	________

GENERAL TRAINING QUESTIONS

- WHEN DID YOU START PARTICIPATING IN YOUR SPORT?

Year ☐☐ Month ☐☐

- HOW DID YOU GET INVOLVED?

☐ friends
☐ family
☐ school
☐ other (specify)

- WHERE DO YOU DO YOUR ACTIVITY?

☐ school
☐ public facility (specify) ____________
☐ home
☐ other (specify)

- HOW DO YOU GET TO YOUR SPORT?

☐ parents
☐ bus
☐ walk
☐ bike
☐ drive yourself

- HOW MANY HOURS A DAY DO YOU TRAIN?

☐☐

- HOW OLD WERE YOU WHEN YOU STARTED?

☐☐

- WHEN DID YOU FIRST COMPETE?

☐☐

- HOW MANY MONTHS A YEAR DO YOU TRAIN?

☐☐

- HOW LONG DOES A TYPICAL WORKOUT TAKE YOU? __________

- HOW MANY WORKOUTS DO YOU HAVE A DAY ☐☐ WEEK? ☐☐

- WHAT IS YOUR DAILY MILEAGE (AVE.) ________ WEEKLY? ________

- DO YOU SPEND THE SAME AMOUNT OF TIME PRACTISING EACH EVENT ?

☐ Yes
☐ No → • IF NOT, HOW MUCH TIME IS SPENT ON EACH EVENT PER WORKOUT? (please list and give time in minutes).

____
____
____
____

- ARE YOU A DISTANCE ATHLETE OR SPRINTER ? ______________

- WHAT IS YOUR FAVORITE EVENT? ______________

- WHAT EVENT DO YOU COMPETE IN REGULARLY?

____
____
____
____

- HOW MANY MEETS DID YOU COMPETE IN THIS SEASON? ______________