Bone Density in Competitive Figure Skaters

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Objectives: To compare the bone mineral density (BMD) of competitive female teenage figure skaters with a history of fracture with the BMD of skaters without fracture and to compare each group to age-matched, nonathletic controls.

Design: Retrospective age-matched cohort.

Setting: Tertiary care medical center and 3 local skating clubs.

Participants: Thirty-six adolescent female competitive skaters (10 with fracture, 26 without fracture) to 22 age-matched controls.

Interventions: Not applicable.

Main Outcome Measures: BMD was estimated by quantitative ultrasound.

Results: Skaters who had suffered stress fractures had BMD values comparable with those of healthy nonathletic controls. However, skaters who had not suffered stress fractures had calcaneal BMD values 15% to 24% greater than either the controls or skaters with fractures. Among the skaters without fracture, there was a 14% to 19% higher calcaneal BMD in skaters who executed triple jumps relative to skaters who performed only double jumps. Furthermore, there was 7% to 11% greater BMD in the landing foot of the skaters relative to the takeoff foot.

Conclusions: Stress fractures in adolescent skaters are not caused by low bone mass but may result from excessive forces placed on a normal skeleton. Our findings also support the hypothesis that higher peak forces are applied to the landing foot relative to the takeoff foot.

Key Words: Bone density; Exercise; Fractures, stress; Rehabilitation; Skating; Ultrasonography; Weight bearing.

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STRESS FRACTURES are defined as microbreaks within the bony matrix or osteon resulting from tensile or compressive forces that exceed the remodeling and rebuilding capacity of the bone-forming osteoblastic cells. The effect of weight-bearing exercise on bone mineral density (BMD) has been extensively studied in women of child-bearing age, as well as in postmenopausal women. Few studies have evaluated the influence of exercise on BMD in children and adolescents because it may be that this population is not at high risk of imminent osteoporosis and fractures resulting from this disease. However, it is this population that would benefit most from critical preventive measures designed to reduce fracture risk in later years because the majority of bone mass is acquired between the ages of 11 and 19 years. Although there may be some gain in bone mass up to age 30, its largest increase in girls is believed to occur between the ages of 11 and 14 years.

Physical activity, particularly the jumping required in sports such as gymnastics and figure skating, is known to promote bone deposition. Slemenda et al showed in athletic prepubertal children a 4% to 7% higher rate of bone mineralization relative to nonathletic children. All weight-bearing forms of exercise are apparently not equivalent in their effects on bone mass. In a study by Robinson et al, gymnasts exhibited a greater lumbar, femur, and whole body BMD than did runners, despite a greater prevalence of menstrual abnormalities among the gymnasts. The osteogenic stimuli experienced by the gymnasts was sufficient to mitigate the adverse effects of abnormal menstruation and delayed menarche. However, in a study with ballet dancers, Pearce et al showed that weight-bearing exercise did not compensate for the detrimental effects of hormonal irregularities on the skeleton.

Another major consideration in the determination of BMD in young women and teenagers is the amount of their calcium and vitamin D consumption. Lack of these nutrients may serve as the basis for stress fractures. It is unclear which age range, if any, is best served by greater than normal amounts of these nutrients or is most negatively impacted by insufficient amounts.

Numerous studies have examined how different sports influence BMD and stress fracture risk, but many of these studies have focused on runners, gymnasts, swimmers, and ballet dancers. Only 2 investigations in recent years have concentrated exclusively on competitive figure skaters. Slemenda and Johnson compared skaters from 11 to 23 years of age with age-matched controls. They concluded that the BMD in the femur and pelvis areas were 4% and 14% greater in the skaters. Pecina et al found a 22% lifetime prevalence of stress fractures among world-class figure skaters. Although Pecina did not estimate densities per se, the study’s results reiterated the strong prevalence of stress fractures among elite skaters, including those with access to superior training facilities and medical care.

The calcaneus was chosen as the evaluation site because it is easily accessible, the flat bones make it easy to manipulate for measurement, and because the heel is largely comprised of trabecular bone. This form of bone is also found in the hip and to a lesser degree in the spine.

Hans et al evaluated 5662 elderly women for osteoporosis by both calcaneal ultrasound and traditional dual energy x-ray absorptiometry (DEXA) scans and found that the 2 modalities predicted with similar accuracy an increased risk of hip fracture. In fact, the authors suggested that ultrasound might be a more sensitive predictor of osteoporosis because it provides information about the microarchitecture and elasticity of bone, as well as its density. Traditional DEXA scans, although precise, provide information only about bone density, yet weak bones are believed to be a function of all 3 properties—architecture, elasticity, and density. A second study compared the precision and discriminatory ability of 5 different

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modes of bone density examination, including quantitative ultrasound (QUS) and DEXA. The authors determined that the correlation among the 5 modalities for calcaneal bone density was strong at 0.8 to 0.91. Furthermore, the correlation specifically between QUS and DEXA measurements of the calcaneus was 0.8; of the femoral neck, 0.71; and of the spine, 0.65.

The purpose of this study was to determine whether female skaters who experience stress fractures have low BMD, compared with skaters who do not have fractures and with nonathletic, age-matched controls. In addition, we compared any BMD differences between skaters with and without fractures in terms of menstrual cycle, calcium intake, and body mass index (BMI). Because many studies have shown that weight-bearing exercise increases BMD, we hypothesized that there would be differences in the BMD of skaters who were able to complete only double jumps versus skaters who could complete triple jumps. We also hypothesized that there are differences in BMD between an individual’s takeoff foot and the landing foot. The greater height attained by a skater in a triple jump results in a more forceful impact on landing.

METHODS

Forty competitive female figure skaters between the ages of 14 and 20 years were recruited from 3 skating clubs in Massachusetts. Four skaters were excluded because they used medications that affected bone metabolism, resulting in a study group of 36. Twenty-two age-matched subjects, recruited from 2 private high schools and 1 junior college in Worcester County, MA, served as the control population. The protocol was approved by the Human Subjects Committee of the University of Massachusetts Medical Center, Worcester, MA.

Information about exercise levels, calcium intake, family history of fractures, personal history of fractures (from both skating and unrelated causes), and menstrual history was obtained through questionnaires completed by the participants. Exercise factor was the product of the number of years of competitive skating times the number of hours spent skating per week. The number of hours per week is influenced by the skater’s proficiency level, objectively determined by the number of skating tests that the skater has passed in the structured curriculum of the United States Figure Skating Association. The time each skater spent at a given test level was available from the databases of their sponsoring skating clubs; the data were then incorporated into the value for exercise factor. Exercise was calculated for the control subjects by the number of hours of activity during each quarter of the school year (which varied according to the sports offered seasonally) and during the summer. In both skaters and controls, adjustments were made for seasonal differences in training intensity by weighting the school year activity by three quarters and the summer activity by one quarter. Skaters were asked about nonskating athletic endeavors. None of the subjects participated in gymnastics or running. Fewer than 10% attended a weekly ballet class that lasted 90 minutes or less.

Skaters who had experienced stress fractures were asked for information about the site of fracture, their age and skating ability at the time of fracture, the time required to recover, and the incidence of additional fractures. Two individuals had experienced complete fractures at a young age (1 in a motor vehicle crash, 1 from a playground fall). They were not included in the fracture category with girls whose stress fractures were incurred while skating. Because their injuries occurred before they began skating and were caused by a traumatic event, they were classified as skaters without fracture.

Estimated daily calcium intake was computed for each subject and was based on the National Osteoporosis Foundation’s formula:

\[
\text{Dairy calcium + 250mg (nondairy sources)} = \text{estimated calcium intake.}
\]

Any additional high calcium sources, either in pill form or from food items supplemented with large amounts of calcium (eg, certain brands of orange juice), were added to this estimate. Girls whose calcium intake fell below the minimum recommended 1200mg/d were advised to increase their calcium intake either through mineral supplements or diet. This advice was given regardless of the eventual BMD outcome.

Weight and height were measured on the same scale for all subjects and the data were converted to BMI.

Data regarding each subject’s proficiency in figure skating, both at the time of testing and in earlier years, were gathered by questionnaire and interview. If the skater and parent could not recall the skater’s proficiency level at earlier ages, the skater’s coach at that time was interviewed. In some cases, the skating club’s records of achievement and videos were consulted. The skaters were asked 4 questions about their training history: (1) At what age did you begin skating seriously (defined as 10 or more practice sessions per week and at least 1 private lesson per week)? (2) At what age had you mastered your single jumps, not including an axel? (3) How many months or years did it take you to learn your first double jump, after having mastered your single jumps? and (4) How old were you when you began 10 or more practice sessions of jumping per week? (Hours on the ice that did not involve jumping were excluded.)

BMD was estimated at the calcaneus with the Sahara Clinical Bone Sonometer. This new, portable ultrasound instrument measures transmission of sound through the soft tissue and bone and is limited to examination of the calcaneus. The machine measures both the speed of sound and broadband ultrasound attenuation. These values are combined into a single measurement called the Quantitative Ultrasound Index (QUI). The QUI is then converted into an estimated BMD, based on the correlation between QUI and the calcaneus BMD. Quality assurance phantom scans were performed daily on the Sahara instrument.

Statistics

The 36 skaters were separated into subsets of 10 girls who had experienced stress fractures and 26 who had not suffered fractures. The 26 girls without fracture were further separated into 2 groups—those who had mastered most or all of the double jumps but not the triple jumps (n = 13) and those who had mastered at least 1 triple jump (n = 13). We were unable to do a similar calculation on the group with stress fractures because only 1 girl had mastered triple jumps.

Statistics were generated on an IBM-compatible computer network with the SPSS software. Tests of significance used analysis of variance allowed by the Scheffé test. In addition, independent samples t tests were performed. Correlations used Pearson’s product-moment correlation coefficient. Significance for P values was defined as alpha equal to .05.

RESULTS

Of the 10 skaters who had experienced stress fractures, 6 had suffered more than 1 fracture. Subjects were asked about their stress fracture history. Clinical suspicion of fracture was confirmed by plain films, magnetic resonance imaging, or bone scan. The bones affected included the metatarsal, talus, tibial shaft, and lumbar vertebrae. Three skaters who had stress...
fractures in the lower extremities or the spine had also experienced complete fractures in the upper extremities, most commonly in the wrist. In all 3 cases, the upper extremity fractures were the result of falls during attempted double or triple jumps. Table 1 lists the physiologic characteristics of the 3 groups of girls. There were no differences in age among the groups. BMI was significantly lower in skaters without fracture relative to controls \((P = .006)\). There were no differences in BMI between controls and skaters with fracture, nor were there differences between the 2 groups of skaters. No significant differences in menstrual cycles among the 3 groups. In addition, there were no significant differences in the age of menarche. The calcium intake of controls and skaters without fracture was comparable, but calcium intake was substantially higher in skaters with fracture \((P = .002)\).

The exercise factor differed substantially between controls and skaters without fracture \((P = .003)\) and reached borderline significance between controls and skaters with fracture \((P = .057)\). The girls with fracture, on average, exercised slightly less than girls without fracture, not because of the deliberate exercise limitation in the fracture group but because of the girls’ training preferences and number of years in the sport.

Figure 1 shows the mean BMD of each heel for the 3 groups of subjects. There was no significant difference between the estimated heel BMD values of controls and skaters with fracture, whereas skaters without fracture had substantially greater bone mass in both heels. In the right heel, the estimated BMD of skaters without fracture was 22% greater than that of the skaters with fracture \((P = .001)\) and 24% greater than that of controls \((P < .001)\). For the left heel, the estimated BMD of skaters without fractures was 15% greater than that of skaters with fractures \((P = .035)\) and 17% greater than that of controls \((P = .001)\).

BMD values of left and right heels of control subjects were comparable, as were BMD values in each heel of skaters with fracture. In skaters without fracture, the right heel had a 7.5% greater BMD than the left \((.80 \text{ vs } .72 \text{ gm/cm}^2, P = .004)\). In a BMD comparison between landing and takeoff feet of only the skaters without fracture, there was a 10% difference \((.80 \text{ vs } .72 \text{ gm/cm}^2, P = .004)\).

The estimated BMD for 13 skaters able to complete double but not triple jumps is compared in figure 2 with the estimated BMD of 13 skaters able to perform triples consistently. Triple jumpers had a 14% greater bone density than double jumpers in the right heel \((P = .021)\) and a 19% greater density in the left heel \((P < .001)\).

Correlations relating estimated BMD to the ages of the skaters as they mastered certain jumps are shown in table 2. The younger the skaters were when they mastered their first double jump, the higher their bone density. The younger the skaters were when they mastered their first double jump, the higher their bone density \((left \text{ foot significant at } P = .019; right \text{ foot borderline significance at } P = .056)\). Negative correlations were also observed for estimated BMD of skaters and the age when their training time reached 10 or more hours of jumping per week. However, no correlation could be found for esti-

### Table 1: Physiologic Characteristics of Skaters and Control Subjects

<table>
<thead>
<tr>
<th></th>
<th>Control ((n = 22))</th>
<th>Skaters With Fracture History ((n = 10))</th>
<th>Skaters With No Fracture History ((n = 26))</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (yr)</strong></td>
<td>16.8 ± 1.7</td>
<td>15.7 ± 1.5</td>
<td>16.3 ± 1.9</td>
</tr>
<tr>
<td><strong>Calcium intake (mg/d)</strong></td>
<td>929.5 ± 246.7</td>
<td>1410* ± 478.3</td>
<td>988.5* ± 386.9</td>
</tr>
<tr>
<td><strong>BMI (lb/in²)</strong></td>
<td>2.1 ± 0.3</td>
<td>2.0 ± 0.1</td>
<td>1.9* ± 0.2</td>
</tr>
<tr>
<td><strong>Months menstruating</strong></td>
<td>46.8 ± 27.3</td>
<td>33.5 ± 18.8</td>
<td>35.3 ± 24.2</td>
</tr>
<tr>
<td><strong>Age at menarche (yr)</strong></td>
<td>12.66 ± 1.24</td>
<td>13.05 ± 1.3</td>
<td>13.29 ± 1.3</td>
</tr>
<tr>
<td><strong>Exercise factor</strong></td>
<td>30.9 ± 21.5</td>
<td>80.0* ± 43.9</td>
<td>89.2 ± 58.4</td>
</tr>
</tbody>
</table>

NOTE. Values represent the mean ± standard deviation (SD).  
* Scheffé’s multiple comparison test revealed significant differences \(P < .05\) between skaters with fracture history and controls; and between skaters with and without fracture history.  
† Scheffé’s multiple comparison test revealed significant differences \(P < .05\) between the control group and skaters with no fracture history and marginally significant differences \(P = .057\) between the control group and skaters with fracture history.  
‡ Scheffé’s multiple comparison test revealed a significant difference \(P < .05\) between the control group and skaters with no fracture history.
mated BMD and the number of months before the point when the skater’s schedule reached an intensity of 10 or more hours per week of jump training. Thus, estimated BMD was higher in girls who were jumping 10 or more hours a week by age 8 or 9, whether they had taken up the sport 6 years or 6 months earlier.

Table 3 shows the differences in training history of skaters with and without fractures. There was no significant difference in the ages at which each group began competitive skating, defined as at least 4 practice sessions per week with private instruction, and with the goal of mastering certain elements for competition purposes. There was also no significant difference in the ages at which the girls mastered single jumps in the fracture and nonfracture groups. However, girls in the fracture group executed their first double jump at an average age of 11.5 years, whereas the nonfracture group reached this proficiency level before age 10 (borderline significance at \( P = .06 \)). In other words, it took the skaters with fracture an average of 2.5 years to master their first double jump from the time their singles were mastered. In contrast, the skaters without fracture took only about 9 months to progress from single to double jumps. These differences were significant (\( P = .017 \)). Only 1 of the fracture subjects suffered a break before the age of 12, thus time off because of the injury should not have delayed the learning process. There were no differences in the age when training time exceeded 10 hours a week, nor in the number of months of skating before training exceeded 10 hours a week.

**DISCUSSION**

We have shown that skaters who have suffered stress fractures do not have, on average, abnormally low BMD. Their estimated BMD values are comparable with those of healthy, nonathletic, age-matched controls, yet apparently are not high enough to sustain the force of jumping. In contrast, the estimated BMD values of the skaters with fracture are significantly lower than those of skaters without fractures.

The reason is unclear as to why some girls experience a physiologic increase in bone density in response to exercise, whereas other girls remain at the same level as nonathletes. Studies centered on similar types of athletes, such as gymnasts and ballet dancers, have suggested as reasons for decreased BMD low BMI, inadequate calcium intake, and menstrual disturbances. Research has shown that a low BMI is associated with lower BMD. In our study, the skaters with fractures did not significantly differ from the nonfracture group in terms of BMI. Similarly, neither age nor months since menarche could explain the disparity in estimated BMD between the 2 groups of skaters.

Calcium intake in both the control and nonfracture groups was below the recommended daily allowance of 1200 to 1500mg/d for teenage girls (table 1). The fracture group had a substantially higher calcium intake of 1400mg/d, relative to both the controls (\( P = .004 \)) and the nonfracture group (\( P = .01 \)). Many of the girls with fractures had been instructed by their physicians to take calcium supplements or to increase calcium in their diet after their initial injuries. Because their intake does not reflect the amount of calcium they consumed at the time of the fractures, it is difficult to draw any conclusions about the interaction of calcium consumption and BMD.

Zeigler et al analyzed the vitamin and mineral intake of a group of nationally ranked skaters from the United States. Her results also showed that calcium and vitamin D intake were well below the recommended daily allowance for teenage girls. Although all participants in our study were able to provide recent dietary histories, they were unable to recall precise details from several years earlier, which might have permitted a more accurate comparison.

The retrospective dietary data both for current food intake and for nutritional status years earlier is a source of uncertainty in our comparisons. Training time estimates represent a second source of error. Although club records of ice sessions purchased were consulted as an estimate of years that a skater had trained, skaters sometimes practice additional sessions at other rinks. Those sessions would not have been reflected in the individual club records.

The skaters without fracture exercised considerably more hours per week for a greater number of years than the age-matched controls (\( P = .003 \)). The skaters with fracture also exercised more hours than controls, but this finding was not statistically significant (\( P = .058 \)). Hence, our study supports a relation between hours of exercise and BMD in athletes who do not incur a fracture. Nickols-Richardson et al examined female child gymnasts through DEXA. Over a 1-year growth period, both the gymnasts and age-matched controls increased

### Table 2: Correlations Between Skating History and Estimated BMD for All Skaters

<table>
<thead>
<tr>
<th>Skating History</th>
<th>Right Heel BMD</th>
<th>Left Heel BMD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age when single jumps mastered</td>
<td>(-.405 .014)</td>
<td>(-.347 .038)</td>
</tr>
<tr>
<td>Age when first double jump mastered</td>
<td>(-.321 .056)</td>
<td>(-.388 .019)</td>
</tr>
<tr>
<td>Months skated before first double jump mastered</td>
<td>(-.337 .045)</td>
<td>(-.362 .03)</td>
</tr>
<tr>
<td>Age when jump training time exceeded 10hr/wk</td>
<td>(-.388 .019)</td>
<td>(-.368 .027)</td>
</tr>
<tr>
<td>Months skated when jump training exceeded 10hr/wk</td>
<td>(-.204 .232)</td>
<td>(-.149 .385)</td>
</tr>
</tbody>
</table>

### Table 3: Skate Training History as a Function of Fracture History

<table>
<thead>
<tr>
<th>Fracture History (N = 10)</th>
<th>No Fracture History (N = 26)</th>
<th>Group Total (N = 36)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age when started serious skating</td>
<td>7.6 ± 1.6</td>
<td>7.7 ± 1.6</td>
</tr>
<tr>
<td>Age when single jumps mastered</td>
<td>9.0 ± 1.5</td>
<td>9.0 ± 1.9</td>
</tr>
<tr>
<td>Months skating before single jumps mastered</td>
<td>16.8 ± 12.6</td>
<td>15.6 ± 10.3</td>
</tr>
<tr>
<td>Age when first double jump mastered</td>
<td>11.5 ± 1.5</td>
<td>9.8 ± 2.8</td>
</tr>
<tr>
<td>Months skating before first double jump mastered</td>
<td>46.2 ± 20.6</td>
<td>31.0 ± 14.2</td>
</tr>
<tr>
<td>Age when training time exceeded 10hr/wk</td>
<td>11.5 ± 1.4</td>
<td>10.9 ± 1.8</td>
</tr>
<tr>
<td>Months skating when training time exceeded 10hr/wk</td>
<td>46.8 ± 22.4</td>
<td>39.2 ± 18.6</td>
</tr>
</tbody>
</table>

**NOTE.** Values represent the mean ± SD.

* Significant difference between groups, \( t = 2.522, P < .05 \).
their bone density, but the gymnasts did so to a greater extent. Nickols-Richardson’s findings are consistent with an earlier report by Sleemenda et al,6 which found an association between physical activity and more rapid mineralization of bone in prepubertal active children. The active children were compared with other children who were participating in nonathletic activities or in non–weight-bearing athletic sports, such as swimming.

We believe a possible explanation for the differences in fracture incidence in the 2 groups of skaters may be found in their training histories. Both groups began skating at approximately the same age, 7.3 and 7.6 years respectively, and both groups mastered single jumps at the average age of 9 years. Yet, the skaters without fracture mastered their first double jump by the average age of 9.8 years, whereas the skaters with fracture were unable to execute this skill until they were nearly 11.5 years of age. It may be that the osteogenic stimulus experienced by those skaters without fracture in their daily practice of these demanding jumps contributed to the higher estimated BMD. Furthermore, there may be a critical time during childhood and adolescence when such an osteogenic stimulus is most advantageous. Skaters who mastered their initial double jumps at a later age, whether they started skating early and progressed slowly, or whether they simply began training after the age of 10 or 11, may not be able to achieve the full benefit of the osteogenic stimulus of jumping.

We did not find a correlation between estimated BMD and the number of years spent in training less than 10 hours a week. Thus, no benefit in BMD was evident for skaters who started slowly and, after several years, increased training intensity to a rate above 10 hours weekly. Nor was there any significance between estimated BMD and age when training began to exceed 10 hours a week. In contrast, the difficulty of the particular elements being practiced, as opposed to the number of hours a day spent training, had a far greater impact on estimated BMD.

In an independent samples test, we compared the dominant and nondominant heel densities in controls and also in skaters without fractures. In 75% of all these subjects, the right heel was dominant. No difference between heels was observed in controls, but in the skaters the dominant heel had a 6.8% greater BMD (P = .005). In all but a few skaters, the dominant foot serves as the landing foot for jumping and is under considerably greater stress than the nondominant foot. Direct comparison of takeoff and landing in skaters without fracture indicated that the landing foot had a 10% greater estimated BMD (P < .004). Krahl et al34 found that former soccer players in Sweden, Duppe et al34 found that former soccer players at the average age of 40 had significantly higher BMD than controls half their age. If such data also prove true for figure skaters, one would expect a protective effect for future fracture risk.

The extent to which the estimated BMD advantage gained by the skaters can be maintained after they retire from the sport remains to be determined. In their study of female soccer players in Sweden, Duppe et al34 found that former soccer players at the average age of 40 had significantly higher BMD than age-matched controls, actually equaling the BMD of controls half their age. If such data also prove true for figure skaters, one would expect a protective effect for future fracture risk.

In addition to the potential sources of error in the dietary and exercise histories mentioned earlier, we must emphasize that the number of study subjects was limited, as are the interpretations of QUS. Ayers et al35 have suggested that while QUS can be useful in demonstrating differences between groups of able-bodied and osteoporotic women, there can be challenges for the individual patient. In an effort to maintain high sensitivity for bone loss, the specificity decreases and thus the rate of false positives increases. The authors also found that the sensitivity is far better in the 0 to −1 range than it is below −2.
The authors agreed that QUS is a significant predictor of fracture and serves as a viable initial screening test, but they caution that patients whose tests result in the high negative values should obtain a DEXA scan to confirm the results before initiating medical treatment.

This investigation has 2 major rehabilitation implications in terms of injury prevention. First, coaches and trainers must recognize that training of skaters who start to learn double jumps after the age of 10 or 11 should proceed slowly, because the body is less able to adapt to the impact of jumping. Figure skating coaches may want to place a greater emphasis on strengthening the lower extremity musculature and bone density of the takeoff foot, which is more susceptible to injuries. Trainers should focus not only on general cross training but also on specific exercises to strengthen the takeoff foot. Ideally, such exercises should begin when the skater is first introduced to double jumps.

CONCLUSION

We have shown that skaters without fracture have significantly greater estimated BMD, compared with skaters with fracture and to age-matched nonathletic controls. There were no differences between estimated BMD in skaters with fracture and controls. These findings suggest that skaters who fracture do not have abnormally low BMD but rather experience fractures because of excessive forces placed on a skeleton of normal BMD. The length of time needed to master double jumps and, indirectly, the age at which this goal was reached were associated with estimated BMD. Furthermore, the landing foot in skaters without fracture was found to have a significantly greater estimated BMD than the takeoff foot for jumping. The data suggest that weight-bearing exercise at a critical developmental age may have a profound impact on BMD, thereby reducing an individual’s future fracture risk.

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References


Suppliers
a. Hologic Inc, 35 Crosby Dr, Bedford, MA 01730.
b. SPSS Inc, 233 S Wacker Dr, 11th Fl, Chicago, IL 60606.