Freestyle skiing is associated with similar proximal femur and lumbar spine adaptations and lower body mass index compared to skiers in nonfreestyle events

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Purpose

Investigate the differences in areal bone mineral density (aBMD), bone mineral composition (BMC), bone area, and body composition in freestyle skiers and nonfreestyle skiing controls.

Introduction

What is known about the subject

Previous studies have shown that high volumes of endurance, short-lived impact physical training (e.g. cycling, swimming, and running) can lead to decreased bone mineral density (aBMD) whereas impact and rotational sports (e.g. gymnastics, tennis, hockey, and long-jump) can lead to increased aBMD.[2] Nonetheless, this list neglects the many extreme sports that fall into a category that encompasses elements of three major categories of training: endurance, impact, and torsion. Some studies have looked at the aBMD of other winter sport athletes and found a significant increase in the femoral neck aBMD in alpine skiers when compared to non-skiing control athletes and in Olympic level female winter sports athletes compared to normally active controls.[1-6,8] However, the results of these studies are limited by exclusively evaluating females or failing to account for differences within the types of skiing.[5] This is noteworthy because each subset of skiing: alpine speed, alpine technical, speed, mogul, slopestyle, half pipe, superpipe, big air, and big mountain requires a technique enhancing and emphasizing different muscle groups and potentially leading to event specific adaptations in bone architecture.

Adds to existing knowledge

This study is novel in that it specifically differentiates freestyle skiers from skiing control subjects which has not been done before. We hope to provide additional insight into exactly what movement patterns contribute to bone and body remodeling. Additionally, it emphasizes a group of athletes that remain understudied.

Methods

18 freestyle skiers (14M 4F, [27.56 ± 5.22 years]) and 15 controls (7M 8F, [26.93 ± 3.54 years]) were measured with dual energy X-ray absorptiometry (DXA) to determine total body composition, hip, and lumbar spine aBMD and bone mineral composition (BMC). Height and weight were measured with an in-office stadiometer and scale. Questionnaires were used to determine physical activity and medical history. Between-group variations were analyzed with an analysis of variance (ANOVA) and stratified by sex.

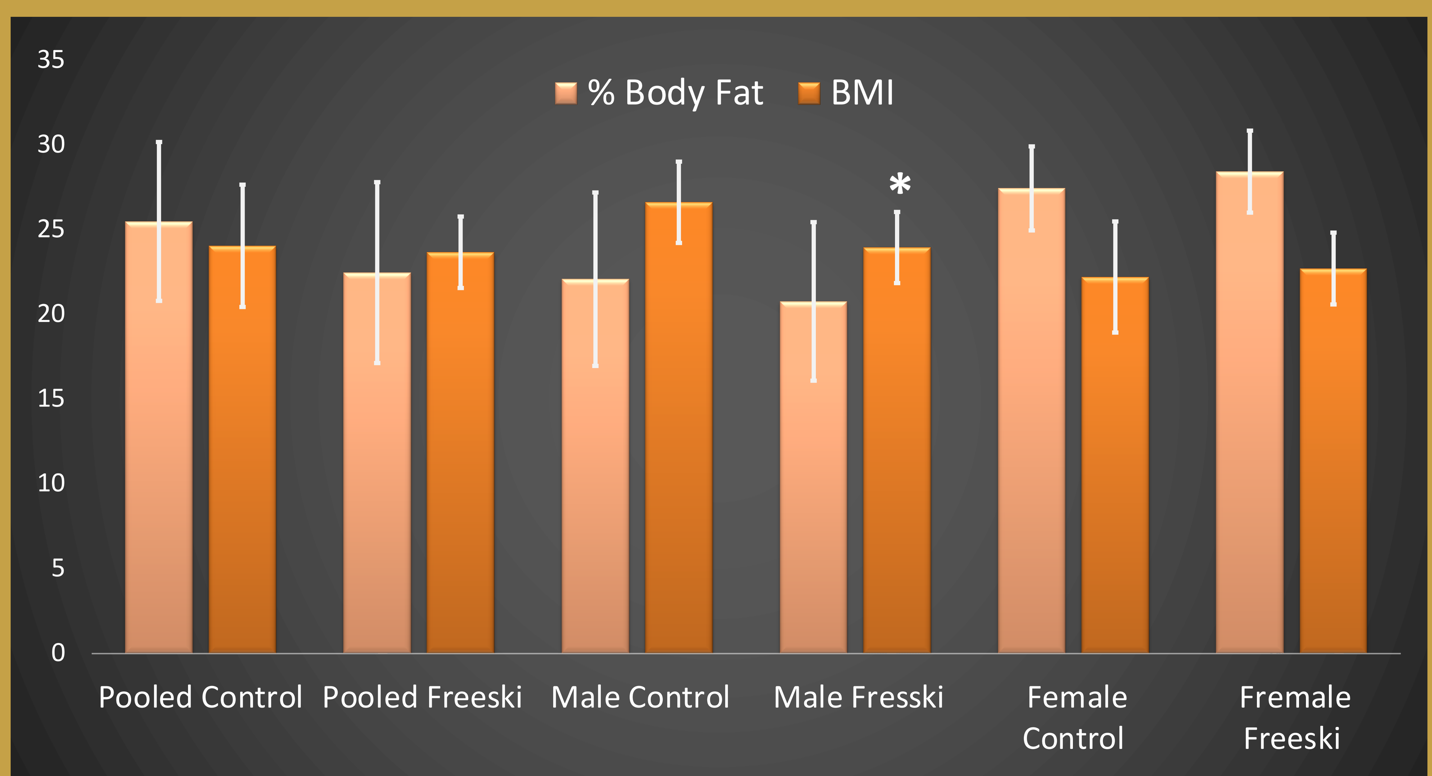
Exclusion Criteria

Injury within the past 6 months or preexisting systemic endocrine or metabolic disease that could impact aBMD or the weight bearing capacity of the structures being investigated; current or recent (within the past 6 months) use of any substances or drugs known to influence bone metabolism including: corticosteroids, antidepressants, anticonvulsants, anticoagulants, and tobacco. If female, highly irregular menses. Females on hormonal contraceptives were considered eligible.

Results

Percent fat, hip, and lumbar spine aBMD, BMC, and area were all similar between freeski and nonfreeski athletes (p>0.05 for all). BMI was significantly lower in male freeski athletes (23.97kg/m², 95% CI [22.75-25.18]) when compared to other control skiing athletes (26.64kg/m², 95% CI [24.43-28.86]) (p=0.03). Male freestyle skiers also had less body fat than control athletes (controls 26.64%, 95% CI [24.43-28.86], freeski 23.97%, 95% CI [22.75-25.18]) (p=0.09).

Figure 1: Percent body fat and BMI (kg/m²) of pooled (male and female) freeski and nonfreeski athletes. Bars denote standard deviations. Star (*) denotes statistical significance.



Conclusion & Clinical Relevance

Conclusions

Freestyle skiers maintain aBMD despite a low BMI. This study shows that bone density can be conserved independent of body mass with movement patterns emphasizing multidirectional movements and weighted jumps and landings.

Clinical Relevance

Skiers endure a variety of intense physical forces yet remain understudied despite high orthopedic injury rates. This study serves as a pilot to broaden the current sports health literature and better understand the relationship between winter sports and musculoskeletal health.

Table 1. Demographics of freestyle skiers and nonfreestyle skiers pooled or separated by sex (mean, SD). *C= control athletes, SD= standard deviation, N=number, Yrs= years, Ht= height, BMC= Bone Mineral Composition.*

	All athletes				Male				Female			
Group	C	SD	Freeski	SD	C	SD	Freeski	SD	C	SD	Freeski	SD
N	15		18		7		14		8		4	
Age	26.9	3.5	27.6	5.2	25.7	2.3	27.9	5.9	27.9	4.1	26.3	1.0
Yrs Skied	18.9	4.9	19.2	9.7	17.3	4.0	20.4	9.7	19.4	5.9	14.8	9.5
Ht (cm)	173.4	9.4	176.5	8.0	181.4	5.5	179.2	5.1	167.1	5.6	167.1	10.1
Body Mass (kg)	73.3	17.4	74.2	11.0	87.7	9.4	77.2	9.7	62.5	13.3	63.8	9.5
BMC (g)	2703.9	522.4	2874.3	428.2	3148.8	268.4	3032.3	327.2	2369.9	384.3	2321.2	225.2
Fat Mass (g)	18303.5	5804.1	20025.1	18776.6	19367.0	6644.3	20640.8	21348.1	16940.0	4814.7	17870.0	3873.0
Lean Mass (g)	53129.4	15929.2	54545.4	7698.1	63785.2	4725.1	56726.7	7260.6	45629.1	17454.5	46910.9	2729.6

Table 2: Proximal femur and lumbar spine bone traits and adjusted group differences (95% confidence interval) between and sex separated freestyle and non-freestyle control groups. Area reported in cm². *L= Left, R= Right.*

Male					
Group	C	95% CI	Freeski	95% CI	P Value
Lumbar spine (cm²)	73.3	69.8-76.8	70.4	66.6-74.2	0.2
Lumbar Spine BMD (g/cm²)	1.1	1.0-1.2	1.1	1.0-1.2	0.4
Female					
Group	C	95% CI	Freeski	95% CI	P Value
Lumbar spine (cm²)	63.9	61.0-66.8	67.1	52.6-81.5	0.6
Lumbar Spine BMD (g/cm²)	1.1	1.0-1.1	1.0	0.9-1.1	0.2
Male					
Group	C	95% CI	Freeski	95% CI	P Value
R Femur Neck (cm²)	5.8	5.3-6.3	5.5	5.3-5.8	0.3
R Femur Neck BMD (g/cm²)	1.0	0.9-1.1	1.0	0.9-1.0	0.9
L Femur Neck (cm²)	5.9	5.5-6.2	5.6	5.4-5.8	0.2
L Femur Neck BMD (g/cm²)	1.0	0.9-1.1	1.0	0.9-1.0	0.7
Female					
Group	C	95% CI	Freeski	95% CI	P Value
R Femur Neck (cm²)	5.1	4.9-5.3	5.1	4.6-5.6	0.8
R Femur Neck BMD (g/cm²)	0.9	0.8-1.0	0.9	0.8-1.0	0.6
L Femur Neck (cm²)	5.2	4.9-5.5	4.9	4.3-5.5	0.2
L Femur Neck BMD (g/cm²)	0.9	0.7-1.0	0.9	0.7-1.0	1.0

Table 3. Body composition (percent body fat and BMI) and adjusted group differences (95% confidence interval) between the pooled (male and female) and sex separated freestyle and the nonfreestyle groups.

All athletes					
Group	C	95% CI	Freeski	95% CI	P Value
% Body Fat	25.5	23.0-28.0	22.5	19.8-25.2	0.09
BMI (kg/m²)	24.1	22.0-26.2	23.7	22.6-24.7	0.73
Male					
Group	C	95% CI	Freeski	95% CI	P Value
% Body Fat	22.1	17.4-26.8	20.8	18.1-23.5	0.58
BMI (kg/m²)	26.6	24.4-28.9	24.0	22.8-25.2	0.03
Female					
Group	C	95% CI	Freeski	95% CI	P Value
% Body Fat	27.5	25.4-29.5	28.5	24.6-32.3	0.53
BMI (kg/m²)	22.2	19.5-25.0	22.7	19.4-26.1	0.76

Discussion

There is minimal difference in bone and body characteristics among freestyle and nonfreestyle skiers except in males; freestyle skiers had a significantly lower BMI than controls while still maintaining no statistically different BMD in the lumbar spine (L1-L4) and femoral neck. aBMD is influenced by external factors (diet and nutraceuticals), the role of different forms of activity has been well-established as either increasing or decreasing density.[2-4] Overall stress endured by the bone as a function of vector direction and duration is critical to development and maintenance of bone density.

Repetitive, high-impact, short duration stresses affect the bone in individuals who partake in nonconventional activities, especially freestyle skiers and snowboarders. In previous studies, H. Sievänen et al. reported significant differences in aBMD in all but forearm measurements between alpine skiers and non-skiers.[8] This, along with our study, sheds a light on the role of multidimensional loading forces, not just weight bearing forces, as a means of achieving and maintaining increased bone mineral density. DXA remains an underutilized technology in sports medicine, especially winter sports athletes, and may improve identification of athletes at risk for osteopenia, bone fracture, endocrine disorders, and nutritional deficiencies.[1,6-7] Additionally, it is worth considering that many winter sports athletes, given the nature of their training, have very little direct sun exposure impacting the ability to synthesize vitamin D— a substance crucial for bone health further making the high aBMD of skiers worthy of investigation.[2-3]

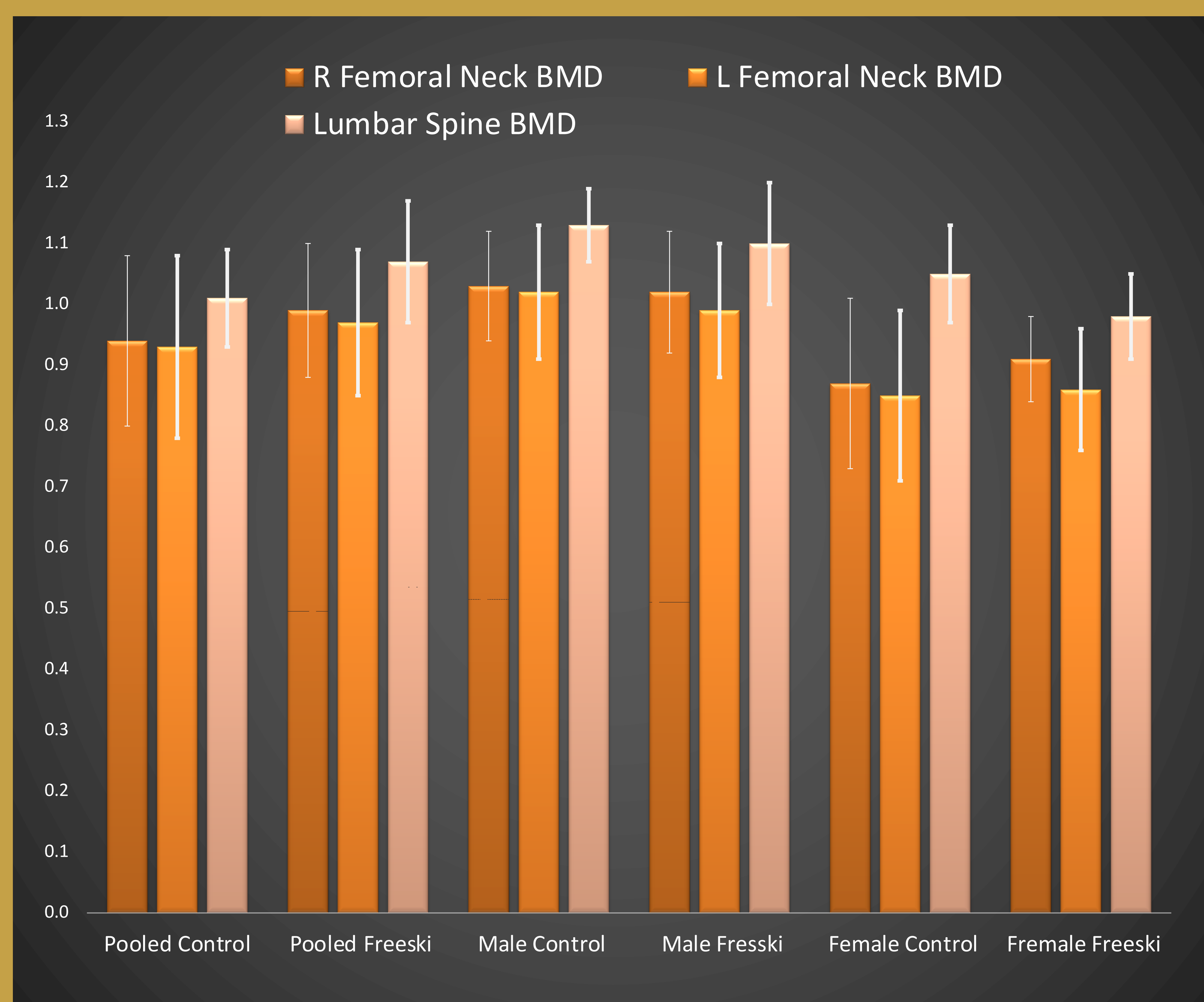
Limitations

A small study sample size (n=33) can lead to underestimation of clinically relevant associations. Selection bias plays a role given that skiing is not a common sport subsequently leading to demographic restrictions and further reducing the number of eligible participants. It is also impossible to completely isolate the role of skiing independent of any other activity on bone and body composition since all individuals in this study partook in multiple cross-training activities such as endurance and weight or resistance training. Despite DXA being the most common test to assess bone health it only measures areal aBMD, it fails to provide information on bone quality therefore missing valuable insight into bone microarchitecture.

Future Directions

The strengths of this study lay in its novelty. To date, there is minimal literature on winter sport athletes, especially extreme winter sport athletes, and the amount of data obtained concurrently looking at body composition and bone mineral composition. Future studies should continue to expand on the foundation laid by the present study and increase sample size. This study remains as a pilot sized study, so next steps should include more participants to analyze the physical dynamics of freestyle skiing that could help solidify the scientific hypothesis of why freestyle skiing athletes may have unique body and bone composition a result of their training.

Figure 2: aBMD (g/cm²) across both hips and lower back grouped by category and stratified by sex. Bars denote standard deviation.



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