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13. ABSTRACT (Maximum 200 Words) Available data indicate that the genetic susceptibility for low bone mass is present very early in life. The aim of this project is to establish whether bone acquisition in teenagers who have sustained a fracture and have low bone mass can be enhanced by changing environmental factors, such as mechanical loading. The effects of two twelve-month interventions on musculoskeletal development will be studied and the results will be compared to matched teenagers undergoing no intervention. This study also examines the possible relations between the cross-sectional properties of bone and circulating levels of IGF-I, IGF-binding protein-3, and IGF-I genotypes, and between bone acquisition induced by interventions and insulin-like growth factors, in teenagers ages 15 to 20 years old. The cross-sectional arm of this project was successfully completed in 144 females and 144 males in August, 2004. Twenty-four females have completed the vibration intervention and calcium intake for one year, 24 female controls have completed the calcium intake for one year, and 24 females are currently being enrolled in the physical exercise intervention. Of the 144 males, 72 are currently being enrolled in the vibration intervention, as controls, or in the exercise intervention for one year.				
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INTRODUCTION

Available data indicate that the genetic susceptibility for low bone mass is present very early in life. The aim of this project is to establish whether bone acquisition in teenagers who have sustained a fracture and have low bone mass can be enhanced by changing environmental factors, such as mechanical loading. The effects of two twelve-month interventions on musculoskeletal development in teenagers will be longitudinally studied and the results will be compared to matched groups of teenagers undergoing no intervention. The mechanical intervention consists of brief exposure to low level (0.3g; 1g = earth gravitational field) high frequency (30-Hz) mechanical loading for 10 minutes every day. The resistance exercise intervention consists of 30 minutes of weight-bearing and trunk stabilization exercises three times per week. The cross-sectional properties of the bone make a substantial contribution to its strength. Data indicate that the cross-sectional dimensions of bone are important determinants of low-energy impact fractures in children, stress fractures in military recruits, and osteoporotic fractures in elderly women. Insulin-like growth factor-I (IGF-I), a major regulator of longitudinal bone growth, has also recently been shown to be an important determinant of cross-sectional bone growth. This study will examine the possible relations between the cross-sectional properties of bone and circulating levels of IGF-I, IGF-binding protein-3, and IGF-I genotypes in teenagers with fractures. The possible relations between bone acquisition induced by mechanical stimulus and circulating levels of IGF-I and the IGF-I genotype will also be assessed.

BODY

Cross-sectional Study. One hundred females completed the cross-sectional phase of this project by July 2003 and 44 more were completed by August 2004. Thus, a total of 144 females have completed the cross-sectional phase of the project. During the past 12 months, 144 males have also been enrolled and completed the cross-sectional phase. All participants underwent physical examinations to confirm completion of sexual development, anthropometric measurements, x-rays of the left hand/wrist for skeletal age, blood draws for IGF-I, IGF-BP-3, IGF-I genotyping, measurements of bone and body composition obtained via computed tomography (CT) and dual energy x-ray absorptiometry (DXA), and questionnaires pertaining to dietary intake and physical activity. Baseline characteristics for all subjects are shown in Table 1.

Longitudinal Study - Females. Forty-eight female subjects have completed one year of participation in the longitudinal study: 24 using the mechanical (vibration) intervention and 24 as controls. Of these, 41 have had a post-intervention appointment and bone measurements; 7 are scheduled in September and October. In addition, another 24 females have been recruited to participate in the passive-resistance intervention. Hence, as stated above, we plan to longitudinally study 72 females.

On the day of enrollment and following the informed consent process, subjects were provided with a daily dosage supply of TUMS 500 mg and a daily calendar for documenting compliance with study procedures. Height, weight and trunk height were obtained.

Vibration Intervention. Subjects in the intervention group were asked to stand on the vibration system platform once a day for 10 minutes, to take 500 mg TUMS daily, and to document both in a daily calendar. Weekly telephone calls were made to encourage compliance, and after six months dietary intake and physical activity questionnaires were completed over the telephone. In addition, the vibration system is equipped with a

monitoring device to check usage, and monthly site inspections by a technician were performed to calibrate the equipment and download usage data. Figure 1 shows the degree of compliance in the 24 subjects. Technical problems with the equipment were limited to minor issues regarding electrical outlets and battery replacements. No complaints were received from the users.

Controls. Subjects in the control group were asked to take a daily dosage of TUMS 500 mg and document usage in a daily calendar. Weekly telephone calls were made to encourage compliance and after six months dietary intake and physical activity questionnaires were completed over the telephone. Three subjects complained of the taste of TUMS and changed their calcium intake to a brand of their choice in 500 mg dosage.

Resistance Exercise Intervention. The commencement of this arm of the project was delayed due to difficulty recruiting females. However, recruitment has been completed and of the additional 44 female subjects recruited, 24 are now being enrolled in this intervention. Additionally, rather than risk loss of compliance by asking the participants to visit CHLA three times per week, the exercise program will take place in the homes of the subjects. In this manner, participant's tasks are eased, travel time and expense for the participant (and, for some, their parent) are omitted, and willingness to comply is enhanced for the considerable long-term demands of this study.

Longitudinal Study – Males. The 72 male subjects with the lowest measures of bone mass were randomized to the mechanical intervention group, the physical exercise group, or the control group. As of September 9, 2004, 26 subjects have been contacted, 20 are enrolled and 6 are scheduled for enrollment appointments. We anticipate that by the end of October enrollment in all three groups (mechanical intervention, resistance exercise and control) will be completed. On the day of enrollment and following the informed consent process, subjects are provided with a daily dosage supply of TUMS 500 mg and a daily calendar for documenting compliance with study procedures. Height, weight and trunk height are obtained.

Preliminary analysis of the associations between age, skeletal age, anthropometric measures, dietary intake, and physical exercise and serum levels of IGF-I and IGFBP-3 with baseline bone measurements obtained by CT and DXA for males and females independently are shown in Tables 2 – 9.

Positive Findings: There are moderate correlations between DXA and CT bone measurements and the weight and body mass of young men and women (Table 1). Moderate relations were observed between CT and DXA determinations for bone (Tables 3-6).

Negative Findings: No significant correlations were seen between CT and DXA measurements and: 1) activity levels by questionnaire and these bone measures; 2) dietary levels by questionnaire; or, 3) biochemical determinations of IGF-I and IGFBP-3.

KEY RESEARCH ACCOMPLISHMENTS

- Baseline studies for 144 females completed
- Mechanical intervention arm of the longitudinal study in 24 females completed and post-intervention determinations completed

- Control arm of the longitudinal study in 24 females completed and post-intervention determinations completed
- Enrollment for the resistance exercise intervention in 24 females completed
- Baseline studies for 144 males completed
- Enrollment for the mechanical intervention, resistance exercise intervention and control arm, consisting of 24 males in each group, commenced

REPORTABLE OUTCOMES

- The relationship between IGF-I genotype and bone measurements for boys and girls are shown in Table 10. Subjects with the 192/192 genotype had lower values for all DXA BMD measurements and lower CT values for bone density in the spine. These data were presented at the 26th Annual Meeting of the American Society for Bone and Mineral Research in October, 2004 (1). The results of the longitudinal arm will help clarify the very important issue of whether differences in genotype are related to differences in response to mechanical interventions.
- Like females, males 15 to 20 years of age who have sustained a low-impact fracture tend to be overweight when compared with males of the same age who have never fractured. Whether this association is due to the increasing prevalence of obesity among young adults or is indeed related to individuals who sustain a fracture, is yet to be determined.

CONCLUSIONS

The results of the cross-sectional phase of the current study indicate that there is a relation between the IGF-I genotype and bone mass at sexual and skeletal maturity. Young adults with a simple sequence repeat in the IGF-I gene had low DXA and CT bone measures. This information may contribute to the identification of a subset of the population of normal young adults who may be at risk for developing vertebral fractures later in life, and may ultimately be of value in the planning of early preventive strategies for osteoporosis.

Table 1. Baseline Characteristics in Female and Male Subjects

Characteristics	Baseline Values*	
	Females (n=144)	Males (n=144)
Age (yr)	17.39 ± 1.46	17.34 ± 1.46
Weight (kg)	63.75 ± 16.12	72.23 ± 15.66
Height (cm)	161.33 ± 6.07	173.75 ± 7.65
Body Mass Index (kg/m ²)	24.47 ± 5.87	23.84 ± 4.54
Skeletal Age (yr)	17.28 ± 0.92	17.39 ± 1.14
CT - Vertebrae		
Cancellous Bone Density (mg/cm ³)	177.39 ± 28.28	166.28 ± 26.98
Cross-sectional Area (cm ²)	8.57 ± 1.14	10.89 ± 1.45
Vertebral Height (cm)	2.33 ± 0.24	2.45 ± 0.18
Vertebral Volume (cm ³)	20.08 ± 3.81	26.88 ± 5.41
CT - Femur		
Cortical Bone Density (mg/cm ³)	1237.67 ± 110.91	1193.43 ± 46.37
Cross-sectional Area (cm ²)	4.98 ± 0.81	6.21 ± 1.07
Cortical Bone Area (cm ²)	4.05 ± 0.64	5.02 ± 0.72
DXA - Lumbar Spine		
Bone Mineral Content (g)	54.17 ± 4.55	60.61 ± 13.53
Bone Mineral Density (g/cm ²)	1.00 ± 0.11	0.98 ± 0.13
DXA - Hip		
Bone Mineral Content (g)	38.16 ± 6.95	50.57 ± 8.85
Bone Mineral Density (g/cm ²)	1.04 ± 0.14	1.11 ± 0.14
DXA - Total Body		
Bone Mineral Content (g)	1998.33 ± 347.65	2422 ± 442.41
Bone Mineral Density (g/cm ²)	1.10 ± 0.09	1.14 ± 0.16
Calcium Intake (mg/day)	1227.12 ± 857.56	pending
Sodium Intake (mg/day)	2870.17 ± 1823.07	pending
IGF-I (ng/mL)	331.8 ± 82.5	336.8 ± 80.1
IGFBP-3 (ng/mL)	4803 ± 851	pending
Physical Activity (hrs/wk; inc. walking)	18.9 ± 12.13	23.10 ± 14.75

*Values are mean ± SD

Table 2. Correlations between age, anthropometric measurements, bone measurements and levels of activity in 288 healthy subjects

	Females (n = 144)				Males (n = 144)			
	Age	Weight	Height	BMI	Age	Weight	Height	BMI
Age	1.000	.240	.059	.237	1.000	.128	.113	.086
Wt	.240	1.000	.312	.937	.128	1.000	.482	.887
Ht	.059	.312	1.000	-.031	.113	.482	1.000	.031
BMI	.237	.937	-.031	1.000	.086	.887	.031	1.000
CT Vertebral BD (cancellous)	.012	.282	-.071	.318	.176	-.072	-.093	-.031
CT Vertebral BD (integral)	.038	.236	.131	.179	.185	-.074	-.076	-.044
CT Vertebral CSA	.158	.561	.433	.438	.096	.553	.516	.350
CT Vertebral Height	.144	.311	.623	.109	.289	.259	.551	.006
CT Vertebral Volume	.171	.536	.556	.368	.184	.545	.626	.283
CT Femur BD	.163	-.092	-.099	-.065	.159	.046	.009	.043
CT Femur CBA	.137	.747	.414	.632	.255	.556	.582	.336
CT Femur CSA	.137	.688	.480	.550	.242	.522	.399	.394
DXA BMD Spine	.233	.587	.297	.502	.287	.352	.374	.212
DXA BMC Spine	.162	.496	.495	.343	.315	.322	.579	.061
DXA BMD Hip	.178	.563	.132	.532	.256	.343	.127	.331
DXA BMC Hip	.161	.595	.314	.499	.287	.416	.415	.264
DXA BMD Total Body	.246	.525	.251	.452	.170	.173	.125	.129
DXA BMC Total Body	.199	.702	.461	.569	.289	.557	.622	.308
Physical Activity	-.205	.017	-.038	.022	.080	-.058	-.036	-.049
Non-Activity	-.040	.026	.058	.004	-.004	-.107	.020	-.129

BMI = Body Mass Index; BD = Bone Density; CSA = Cross-sectional Area; CBA = Cortical Bone Area; BMD = Bone Mineral Density; BMC = Bone mineral Content

Table 3. Correlations between levels of activity and age, anthropometric measurements, and bone measurements in 288 healthy subjects

	Females (<i>n</i> = 144)		Males (<i>n</i> = 144)	
	Physical Activity	Non-Activity	Physical Activity	Non-Activity
Age	-.205	-.040	.080	-.004
Wt	.017	.026	-.058	-.107
Ht	-.038	.058	-.036	.020
BMI	.022	.004	-.049	-.129
CT Vertebral BD (cancellous)	.019	-.010	.002	-.138
CT Vertebral BD (integral)	.086	.029	-.030	-.099
CT Vertebral CSA	.107	.088	.016	-.046
CT Vertebral Height	-.058	.104	-.097	.032
CT Vertebral Volume	.057	.104	-.023	-.025
CT Femur BD	-.026	-.072	.009	-.036
CT Femur CBA	.062	.029	-.018	.039
CT Femur CSA	.050	-.019	-.028	-.038
DXA BMD Spine	.095	-.009	-.057	-.020
DXA BMC Spine	.076	.028	-.041	-.004
DXA BMD Hip	.071	-.047	-.011	-.039
DXA BMC Hip	.083	-.060	.018	-.002
DXA BMD Total Body	.115	.027	.009	-.030
DXA BMC Total Body	.082	.046	-.013	-.042
Physical Activity	1.000	.103	1.000	-.030
Non-Activity	.103	1.000	-.030	1.000

BMI = Body Mass Index; BD = Bone Density; CSA = Cross-sectional Area; CBA = Cortical Bone Area; BMD = Bone Mineral Density; BMC = Bone mineral Content

Table 4. Correlations between CT bone determinations and age, anthropometric measurements, DXA bone measurements and levels of activity in 144 females

	CT							
	Vertebral					Femur		
	BD (cancellous)	BD (integral)	CSA	Height	Volume	BD	CBA	CSA
Age	.012	.038	.158	.144	.171	.163	.137	.137
Wt	.282	.236	.561	.311	.536	-.092	.747	.688
Ht	-.071	.131	.433	.623	.556	-.099	.414	.480
BMI	.318	.179	.438	.109	.368	-.065	.632	.550
CT Vertebral BD (cancellous)	1.000	.789	.084	.029	.071	-.124	.410	.372
CT Vertebral BD (integral)	.789	1.000	.029	.017	.025	-.052	.418	.351
CT Vertebral CSA	.084	.029	1.000	.542	.953	-.162	.549	.601
CT Vertebral Height	.029	.017	.542	1.000	.768	-.170	.326	.363
CT Vertebral Volume	.071	.025	.953	.768	1.000	-.167	.535	.593
CT Femur BD	-.124	-.052	-.162	-.170	-.167	1.000	-.167	-.077
CT Femur CBA	.410	.418	.549	.326	.535	-.167	1.000	.900
CT Femur CSA	.372	.351	.601	.363	.593	-.077	.900	1.000
DXA BMD Spine	.694	.673	.363	.322	.393	-.026	.647	.618
DXA BMC Spine	.565	.549	.541	.587	.622	-.140	.675	.699
DXA BMD Hip	.641	.628	.320	.192	.312	-.003	.756	.651
DXA BMC Hip	.540	.552	.459	.270	.447	-.056	.829	.755
DXA BMD Total Body	.658	.659	.299	.257	.324	.092	.715	.641
DXA BMC Total Body	.560	.549	.532	.416	.559	-.012	.866	.840
Physical Activity	.019	.086	.107	-.058	.057	-.026	.062	.050
Non-Activity	-.010	-.029	.088	.104	.104	-.072	.029	-.019

*BMI = Body Mass Index; BD = Bone Density; CSA = Cross-sectional Area; CBA = Cortical Bone Area;
BMD = Bone Mineral Density; BMC = Bone mineral Content*

Table 5. Correlations between CT bone determinations and age, anthropometric measurements, DXA bone measurements and levels of activity in 144 males

	CT							
	Vertebral					Femur		
	BD (cancellous)	BD (integral)	CSA	Height	Volume	BD	CBA	CSA
Age	.176	.185	.096	.289	.184	.159	.255	.242
Wt	-.072	-.074	.553	.259	.545	.046	.556	.522
Ht	-.093	-.076	.516	.551	.626	.009	.582	.399
BMI	-.031	-.044	.350	.006	.283	.043	.336	.394
CT Vertebral BD (cancellous)	1.000	.962	-.069	.064	-.037	.100	.284	.130
CT Vertebral BD (integral)	.962	1.000	-.107	.066	-.067	.093	.321	.137
CT Vertebral CSA	-.069	-.107	1.000	.342	.928	.121	.602	.520
CT Vertebral Height	.064	.066	.342	1.000	.665	.075	.329	.316
CT Vertebral Volume	-.037	-.067	.928	.665	1.000	.125	.607	.540
CT Femur BD	.100	.093	.121	.075	.125	1.000	.034	-.006
CT Femur CBA	.284	.321	.602	.329	.607	.034	1.000	.704
CT Femur CSA	.130	.137	.520	.316	.540	-.006	.704	1.000
DXA BMD Spine	.673	.705	.357	.456	.458	.106	.664	.450
DXA BMC Spine	.482	.506	.549	.622	.678	.119	.726	.495
DXA BMD Hip	.666	.714	.278	.159	.273	.098	.655	.434
DXA BMC Hip	.472	.523	.428	.277	.442	.058	.788	.544
DXA BMD Total Body	.599	.616	.155	.175	.192	.147	.451	.268
DXA BMC Total Body	.468	.484	.588	.454	.643	.109	.863	.587
Physical Activity	.002	-.030	.016	-.097	-.023	.009	-.018	-.028
Non-Activity	-.138	-.099	-.046	.032	-.025	-.036	.039	-.038

*BMI = Body Mass Index; BD = Bone Density; CSA = Cross-sectional Area; CBA = Cortical Bone Area;
BMD = Bone Mineral Density; BMC = Bone mineral Content*

Table 6. Correlations between DXA bone determinations and age, anthropometric measurements, CT bone measurements and levels of activity in 144 females

	DXA					
	Spine BMD	Spine BMC	Hip BMD	Hip BMC	Total Body BMD	Total Body BMC
Age	.233	.162	.178	.161	.246	.199
Wt	.587	.496	.563	.595	.525	.702
Ht	.297	.495	.132	.314	.251	.461
BMI	.502	.343	.532	.499	.452	.569
CT Vertebral BD (cancellous)	.694	.565	.641	.540	.658	.560
CT Vertebral BD (integral)	.673	.549	.628	.552	.659	.549
CT Vertebral CSA	.363	.541	.320	.459	.299	.532
CT Vertebral Height	.322	.587	.192	.270	.257	.416
CT Vertebral Volume	.393	.622	.312	.447	.324	.559
CT Femur BD	-.026	-.140	-.003	-.056	.092	-.012
CT Femur CBA	.647	.675	.756	.829	.715	.866
CT Femur CSA	.618	.699	.651	.755	.641	.840
DXA BMD Spine	1.000	.862	.719	.726	.804	.811
DXA BMC Spine	.862	1.000	.646	.724	.726	.820
DXA BMD Hip	.719	.646	1.000	.912	.841	.819
DXA BMC Hip	.726	.724	.912	1.000	.796	.864
DXA BMD Total Body	.804	.726	.841	.796	1.000	.893
DXA BMC Total Body	.811	.820	.819	.864	.893	1.000
Physical Activity	.095	.076	.071	.083	.115	.082
Non-Activity	-.009	.028	-.047	-.060	.027	.046

BMI = Body Mass Index; BD = Bone Density; CSA = Cross-sectional Area; CBA = Cortical Bone Area; BMD = Bone Mineral Density; BMC = Bone mineral Content

Table 7. Correlations between DXA bone determinations and age, anthropometric measurements, CT bone measurements and levels of activity in 144 males

	DXA					
	Spine BMD	Spine BMC	Hip BMD	Hip BMC	Total Body BMD	Total Body BMC
Age	.287	.315	.256	.287	.170	.289
Wt	.352	.322	.343	.416	.173	.557
Ht	.374	.579	.127	.415	.125	.622
BMI	.212	.061	.331	.264	.129	.308
CT Vertebral BD (cancellous)	.673	.482	.666	.472	.599	.468
CT Vertebral BD (integral)	.705	.506	.714	.523	.616	.484
CT Vertebral CSA	.357	.549	.278	.428	.155	.588
CT Vertebral Height	.456	.622	.159	.277	.175	.454
CT Vertebral Volume	.458	.678	.273	.442	.192	.643
CT Femur BD	.106	.119	.098	.058	.147	.109
CT Femur CBA	.664	.726	.655	.788	.451	.863
CT Femur CSA	.450	.495	.434	.544	.268	.587
DXA BMD Spine	1.000	.878	.766	.723	.652	.813
DXA BMC Spine	.878	1.000	.608	.702	.512	.848
DXA BMD Hip	.766	.608	1.000	.828	.646	.746
DXA BMC Hip	.723	.702	.828	1.000	.571	.836
DXA BMD Total Body	.652	.512	.646	.571	1.000	.609
DXA BMC Total Body	.813	.848	.746	.836	.609	1.000
Physical Activity	-.057	-.041	-.011	.018	.009	-.013
Non-Activity	-.020	-.004	-.039	-.002	-.030	-.042

BMI = Body Mass Index; BD = Bone Density; CSA = Cross-sectional Area; CBA = Cortical Bone Area; BMD = Bone Mineral Density; BMC = Bone mineral Content

Table 8. Correlations between values for calcium, sodium, IGF-I and IGFBP-3 and age, anthropometric measurements, and bone measurements in 144 females

	Calcium	Sodium	IGF-1 (ng/ml)	IGFBP-3 (ng/ml)
Age	-.117	.070	-.419	-.030
Wt	.003	-.001	-.097	-.073
Ht	-.078	.083	.068	.143
BMI	.026	-.044	-.136	-.129
CT Vertebral BD (cancellous)	-.131	.087	.144	-.064
CT Vertebral BD (integral)	-.096	.153	.192	-.0.00
CT Vertebral CSA	-.008	.154	-.138	-.018
CT Vertebral Height	-.057	.055	.051	.153
CT Vertebral Volume	-.031	.138	-.090	.036
CT Femur BD	.095	.019	-.018	-.091
CT Femur CBA	.010	.127	.116	.054
CT Femur CSA	-.071	.079	.116	.026
DXA BMD Spine	-.099	.125	.034	-.108
DXA BMC Spine	-.032	.199	.096	.035
DXA BMD Hip	.083	.202	.182	-.084
DXA BMC Hip	.099	.228	.176	-.029
DXA BMD Total Body	-.002	.208	.098	-.057
DXA BMC Total Body	-.040	.188	.081	-.025

BMI = Body Mass Index; BD = Bone Density; CSA = Cross-sectional Area; CBA = Cortical Bone Area; BMD = Bone Mineral Density; BMC = Bone mineral Content

Table 9. Correlations between values for IGF-I and age, anthropometric measurements, and bone measurements in 144 males (calcium, sodium and IGFBP-3 pending)

	IGF-1 ng/ml
Age	-.496
Wt	.078
Ht	.147
BMI	.013
CT Vertebral BD (cancellous)	-.243
CT Vertebral BD (integral)	-.225
CT Vertebral CSA	.046
CT Vertebral Height	-.047
CT Vertebral Volume	-.023
CT Femur BD	-.145
CT Femur CBA	-.089
CT Femur CSA	-.102
DXA BMD Spine	-.209
DXA BMC Spine	-.144
DXA BMD Hip	-.228
DXA BMC Hip	-.189
DXA BMD Total Body	-.213
DXA BMC Total Body	-.119

BMI = Body Mass Index; BD = Bone Density;

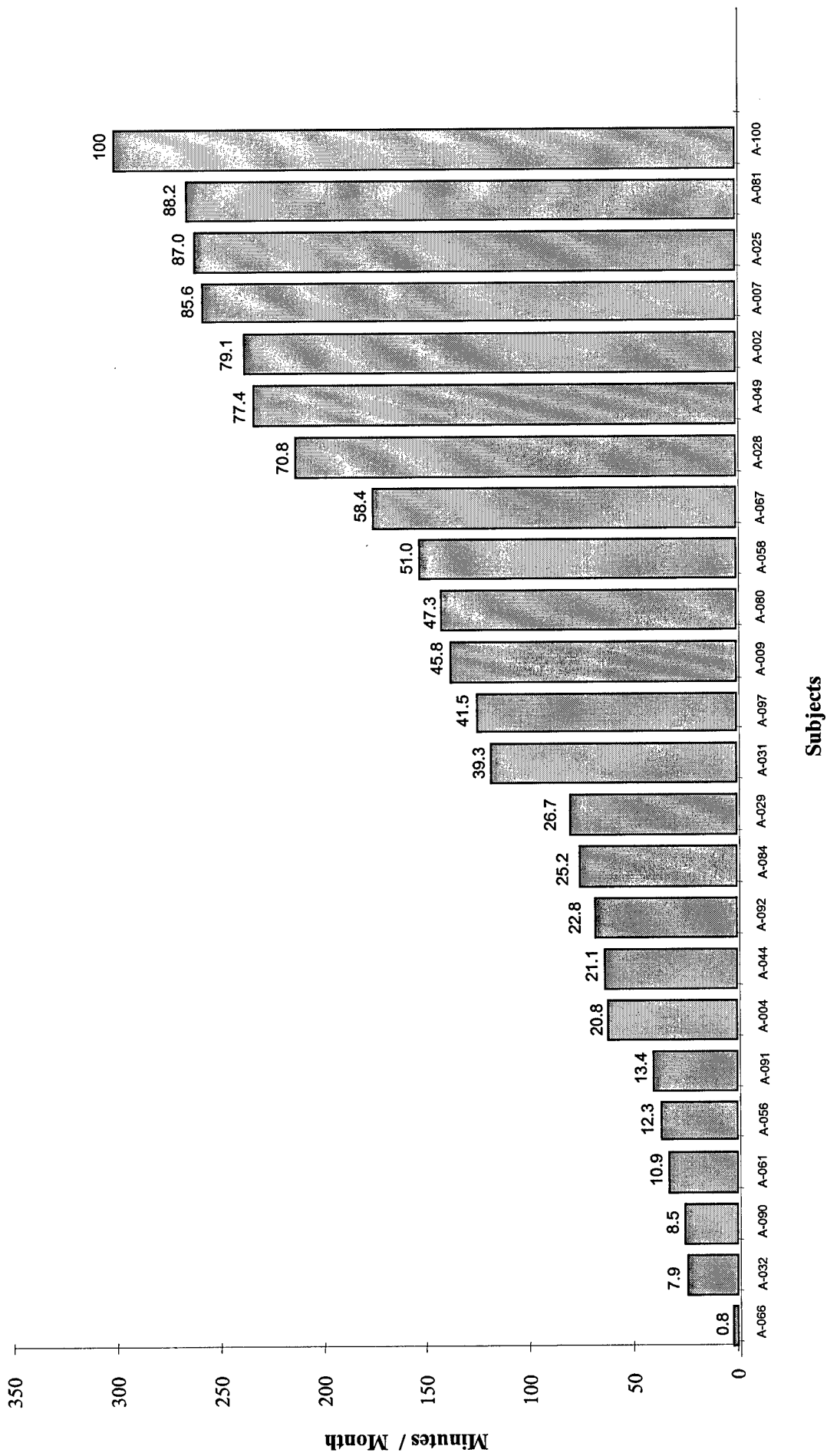
CSA = Cross-sectional Area; CBA = Cortical Bone Area;

BMD = Bone Mineral Density; BMC = Bone mineral Content

Table 10. Differences in DXA and CT Bone Measures in Young Adults with and without a Simple Sequence Repeat in IGF-1 Gene

Genotype	%	Age yrs	BMI kg/m ²	DXA			CT	
				Spine mg/cm ²	Hip mg/cm ²	Total Body mg/cm ²	Spine BD mg/cm ²	Femur CBA cm ²
192/192	67	17.4±2.3	24.3±5.2	1.00±0.12	1.11±0.14	1.14±0.14	298±47	4.72±0.76
Heterozygous	43	17.3±2.2	24.8±5.4	0.97±0.12	1.06±0.13	1.10±0.09	284±40	4.52±0.73
T test		p=0.43	p=0.51	p=0.056	p=0.021	p=0.019	p=0.046	p=0.040

Figure 1. Mechanical Intervention Use Both in Minutes/Month and Percent Compliance



REFERENCES

1. Liu X, Rosen C, Mora S, Dong D, Pitukcheewanont P, Gilsanz V 2004 Low DXA and CT bone measures in young adults with a simple sequence repeat in IGF-I gene. J Bone Min Res **19**:S248.

APPENDICES

None