PHYSICAL FITNESS ATTRIBUTES, VITAMIN D, DEPRESSION, AND BMD IN OMANI'S CHILDREN

Hashem Kilani, PhD
Physical Education Department
Saif Alyaarubi, MD
Child health department
Kashef Zayed, PhD
Physical Education Department
Ibrahim Alzakwani, PhD
Pharmacy Department
Hadia Bererhi
Radiology and Molecular Department
Raghda Shukri, PhD
Mental & Social Nursing
Khalid Alrasadi, MD
Sultan Qaboos University, Oman

Abstract

Physical fitness attributes, vitamin D, depression, and BMD in Omani's Children 9-12 years old were investigated in 54 girls and 42 boys (average age of 12.9 ± 1.6) to assess health related fitness, body composition. Eighty two percent of the females and forty two percent of the males were deficient in vitamin D (<50 nmol/L). Those females deficit in vitamin D were associated with higher fat percentage compared to those with normal vitamin D status. There were no significant differences in all physical exercise attribute scores ($p > 0.05$) in females between those with normal and those with low vitamin D levels. These results were also replicated in males except for grip and cardio-respiratory components. Initial analysis also indicates that the prevalence of symptoms of depression among Omani children was 32% ranging from mild to severe depression with negative correlation with vitamin D deficiency is significant at the 0.01 level (-0.353 2-tailed). The females are deficient in vitamin D, might be susceptible to the early diagnosis of osteoporosis and depression due to their deficiency. Children should be involved in physical activity program and meet the required sunlight exposure during all season to gain a healthy lifestyle.

Keywords: Physical fitness, vitamin D, depression, Omani children

Introduction:

Most people reach their "peak bone mass" in their 20s. This is when bones have achieved their maximum density and strength. After peak bone mass is reached, bone density remains stable during adulthood, and then begins to decline. Physicians once thought that reaching this peak depended primarily on diet, including sufficient calcium intake, and exposure to sunlight, which is necessary for the production of Vitamin D in the skin. In fact, Vitamin D is necessary for the absorption of calcium from food, for the healthy functioning of bone tissues, and thus for maintaining bone strength.

A recent study has shown that in laying down the bone foundation that will serve for a lifetime, exercise is just as important as diet. This is true throughout childhood and adolescence, but especially more important around the growth spurt at puberty (Bass, Pearce, Bradney, Hendrich, *et.al.*, 1998, Kilani, & Abu Eisheh, 2010).

In this respect, number of studies showed that those boys who did the most vigorous daily activity had nine percent more bone area and 12 percent more bone strength than the less active ones (Janz, Burns, Levy, Torner, Willing, *et.al.*, 2004). Most physically active young girls gain about 40% more bone mass than the least active girls of the same age (Lehtonen-Veromaa Mottonen, Heinonen, *et.al.*, 2004). In girls, the bone tissue accumulated during the ages 11 to 13 approximately equals the amount lost during the 30 years following menopause. (Bass Pearce, Bradney, Hendrich, Delmas *et.al.*, 1998). When astronauts first traveled beyond the Earth's atmosphere, the first and most obvious impact was that their muscles atrophied soon after it was realized that their bones weakened (Vico, Collet, Guignandon, Lafage-Proust, Thomas, *et.al* (2000). Grimston, Willows, Hanely, (1993) studied gymnasts' vs. swimmers' bone mineral density and found that the gymnasts have more BMD than the swimmers due to high impact and gravity effect during tumbling and acrobatic skills. Egan, Reilly, Giacomoni, Redmond, Turner, (2006) searched BMD in female athletes: rugby, netball, running, and non–active as control and also found that the running group have the greatest BMD the other groups. Kemmler, Engelke,Baumann,Beeskow, Von, (2006) confirmed Egan results when they also found greater BMD in the pelvis, legs and total body bone strength for runners when compared with sedentary group. Saxon, Robling, Alam,Turner (2005) pointed out that the Mechano-sensitivity of bone is saturated over time and that pause during loading increases BMD. In a retrospective study which contained 4 impact groups, Dook, Jams, Henderson, Pice (1997) found unexpected results. The impact of activities led to an increase of bone

mass even if calcium supplement was low (Grimston & Zernicke, 1993). Impact stimuli increase the bone quality. According to O'Connor, Lanyon, & MacFie (1982), an increase of bone mass can be explained by 61- 81% through the loading rate. This in itself explains that active young children with high agility may build and maintain their bone health faster than inactive ones especially when they play under sun lighting condition.

This is of important due to the fact that athletes usually expose their skin to the sunlight more than others (Waly, Kilani, AL-Busafi, 2013). Ideally, the best place to get vitamin D is from your skin being exposed to the UV-B that is in normal sunlight. However, UV-B does not penetrate deeply into your skin especially if you have darker pigmentation. On another word the more tanned skin is, the less UV-B penetrates. Window glasses allow only 5 percent of the UV-B light range that produces D to get into your home or car. These circumstances prevail in Oman so one should consider it. Even the timing of the sun exposure is also a major factor. Sun exposure must take place when UV-B is present. The actual degree of your sun exposure is quite complex since it involves knowing the amount of UV-B and one's skin color. This doesn't sound very complex, but the amount of UV-B is not constant. It is a major variable and is influenced by a number of factors: latitude, time of year, clouds or pollution, smog and ozone smog or dust as sometimes happen in Oman, and altitude(Holick,1994).

It is important to know the level of UV-B exposure. Longer exposure will not increase vitamin D production, but will increase the danger of skin damage and possible skin cancer.

Severe Vitamin D deficiency softens bones. In children, the result is rickets, characterized by malformed legs. Adults may develop a rare condition called osteomalacia, distinguished by weakened muscles as well as bones.

The best way to evaluate a person's vitamin D status would be to measure concentrations of an inactive form known as 25-hydroxy-vitamin D (25-D) that circulates in the blood. There are rarely obvious symptoms of D-marginal deficiency. Vitamin D also moves calcium around our bodies, into and out of bone, muscle, hair, arteries, and cells. Both low and high levels of vitamin D appear to contribute to misbehaving calcium (Sullivan *et.al.* 2003). The amount of calcium (Ca) that is required to support optimal growth in children and in turn, maximize peak bone mass remains a topic of considerable debate and disagreement among scientists and clinicians alike, both within and between nations (Heaney, 2000; Specker, 2000; Holick, 2006).

In addition, Ca supplementation studies in growing children have shown that an increase in Ca intake is associated with higher bone mineral status in the order of 1% to 5%, with the effect appearing to be stronger in

the pre-pubertal years, and the greatest impact being seen in the early months of the supplementation period (Johnston, Millar, & Slemenda, 1992; Nowson Green, & Hopper, 1997). Ca supplementation in teenage girls with low dietary Ca intake (mean intake ~600 mg/day) was studied and results showed significantly greater bone mineral content/bone mineral density (BMC/BMD) following supplementation of 300 mg/day of Ca in fortified fruit juice (Lambert, Eastell, & Barker, 2000) .

Stear and Coworkers (UK) showed that Ca supplementation (1000 mg/day) in a total of 131 female adolescents aged 17 years resulted in an increase in bone-size adjusted bone mass; the effect was still persistent at the femoral neck after 14 months of follow-up. Dodiuk-Gad, Rozen, Rennert, Rennert, & Ish-Shalom,(2005) examined the effectiveness of Ca supplementation on BMD 5 years after discontinuation of treatment and found that the beneficial effect of short-term (12 months) Ca supplementation on BMD in 14-year-old girls was sustained. Supplementation with milk/dairy products/milk-derived products has been shown to improve the nutritional quality of the diet to a much greater extent than that of Ca alone. In addition, increased insulin-like growth factor I (IGF1) levels have been reported in children (Bonjour, Carrié, Ferrari, Clavien, Slosman *et.al.*, 1997).

Statement of the problem and significance

It is well-documented that vitamin D (in combination with PTH) plays a crucial role in the regulation of Ca and phosphorus (P) metabolism, and promotes Ca absorption from the gut and kidney tubules (Lambert, Eastell, & Barker, 2000). Supplementation trials have shown vitamin D to improve Ca absorption, lower PTH levels, and reduce wintertime bone loss in postmenopausal women (Dawson-Hughes, Harris, Palermo, Castaneda-Sceppa, Rasmussen, & Dallal, 2009, Dawson-Hughes, Harris, Krall, & Dallal, 2000). The child population is especially at risk for vitamin D insufficiency/deficiency. It is therefore crucial to increase bone density and bone development in children. Thus, active lifestyle and physical activity outside halls and complex buildings are necessary for children and adults.

Some people in Oman live sufficiently high in the mountains for more Ultraviolet (UV) -B to reach their skins. However, many people in Oman do not expose their skin to sunlight due to the modern society they are living in, avoiding heat through shade and by means of air conditioning whether at home, work or in automobiles with shielded windows up to 50%. For both sexes, if they have to be outside for any reason, they cover both the head and body by the traditional clothing that they wear. For those reasons, the proper amount of sun is presumably not possible; and an oral form of vitamin D should be considered as supplement. High quality cod liver oil is

probably the best choice, as it also supplies vitamin A that helps limit vitamin D toxicity and also beneficial omega-3 fats. Milk does provide vitamin D, but only about 250 units per 8 ounces. So, one would need to drink a half gallon of milk per day to receive enough vitamin D. In addition, one would need to consume 25 eggs to get the daily amount of Vitamin D which is impossible. The assumption that children in Oman are receiving the proper amount of an essential source to obtain Vitamin D from fish, milk, and eggs, must be investigated. It will be important to take calcium while receiving vitamin D, or it will tend to take calcium out of the bones. Finally, children raised in such a society who are kept safe from sun exposure spend a great deal of time indoors with video hi-tech games, computers, play stations and TV. Besides, they tend to imitate what they see from media to get the junk food and increase the sedentary life time (Kilani, Al-Hazzaa, Waly, & Musaiger, 2013, Kilani, Waly, & Yousef, 2012). A tendency to become depressed is a probability.

Purpose

It is imperative to assess children in Oman where sun exposure is limited and inactive lifestyles are prevalent with respect to BMD and vitamin D status. Physical assessment would also be of interest to compare and classify children according to whether they have high or low fitness levels. Muscle and bone strength in health-related physical fitness profile for an age range of between 5 and 20 years will be determined. The objectives of this research proposal are to:

1- Assess health-related physical fitness components for the sample in the study;
2- Test their vitamin D level using blood sample;
3- Determine their range body composition (BMD, FAT, LEAN MASS) status;
4- Assess their psychological status using Beck Depression Inventory (BDI, BDI-II);
5- Profile their data based on active/inactive, depress/ none depress according to Vitamin D and BMD status;

Methods:

The study sample (N = 97) were males and females randomly chosen immediately after their involvement in the Summer Club at Sultan Qaboos University consisting of 500 average age of 12.9 ± 1.6. Health-related fitness components were modified and measured to suit the age group such as cardiovascular endurance (Modified Bruce protocol). In the present study, children were required to perform the maximal exercise test on a motor-driven treadmill. The test starts at a low work level, allowing time for warm-

up. Children were encouraged to perform to voluntary exhaustion. The test was terminated if the subject develops signs of breathlessness, fatigue, loss of walking-coordination or when the target heart rate is achieved. Muscle strength (Dynamometer of Grip Strength), muscular endurance (Modified sit-up), and flexibility (Modified Flexibility) (Kilani, & Lala, 2001). Body composition was tested including Lumbar spine and whole body BMD, as well as body fat and lean masses were measured using DEXA Hollogic Delphi. Before the scanning, the height and weight of the children were measured. Body composition measurements were performed using a Dual X-ray Absorptiometry (DXA), Hologic Delphi, W fan beam X-ray bone densitometer. The whole body was scanned and scan results were analyzed as follows:

The total body scan image was divided into 10 regions including the left and right arm, ribs, thoracic spine, lumbar spine, pelvis, left and right leg, and head. The data from the 10 body regions were summed-up to provide values for the whole body mass composition; the bone mineral content (BMC) expressed in grams, bone mineral density (BMD) expressed in g/cm2, the fat content (FC) expressed in grams, the body muscle mass and body lean mass (BLM) (sum of the body muscle mass and the BMC), and Fat mass (FM). Lean mass and fat mass were also expressed as percentage of total body mass.

The DiaSorin 25-Hydroxy Vitamin D assay consists of two-step procedure. The first step involves a rapid extraction of 25-OH Vitamin D and other hydroxylated metabolites in serum or plasma with acetonotrile. Following extraction, the treated sample is then assayed using equilibrium RIA procedure. The RIA method is based on an antibody with specificity to 25-OH-D. The sample, antibody and tracer are incubated for 90 minutes at 20-25°C. Phase separation is accomplished after a 20-minute incubation at 20-25°C with a second antibody precipitating complex. A NSB/Addition buffer is added after this incubation period to centrifugation to aid in reducing non-specific binding. Bound radioactivity is inversely proportional to the concentration of 25-OH-Vitamin D.

A valid questionnaire was distributed to 186 randomly selected samples to identify the prevalence of depressive symptoms among them before participating in the Summer Club events. A 27 items instrument called Arabian Child Depression Inventory (ACDI) was used. ACDI is a symptom-oriented instrument for assessing depression in children between the ages 7 and 17 years (Alnufaiei & Abdullah, 2001). All participants were asked to fill in the ACDI and during June 2011, after they indicated their consent to participate in the study. It took around 10 minutes from each participant to fill the questionnaire.

The study protocol and procedures were approved from the office of the Advisor for Academic Affairs at Sultan Qaboos University.

Statistical Analysis

Descriptive statistics were used to describe the data. For categorical variables, frequencies and percentages were reported. Differences between groups were analyzed using Pearson's chi-square test (or *Fisher's* exact test for cells <5). For continuous variables, means and standard deviation and median and interquartile range (25^{th} and 75^{th} percentiles) were used to present the data while analysis was performed using Pearson Correlation, Student's t-test and Wilcoxon-Mann-Whitney, respectively. Frequencies and percentages were tabulated for depression analysis. An *a priori* two-tailed level of significance was set at the 0.05 level. Statistical analyses were conducted using STATA version 12.1 (STATA Corporation, College Station, TX) and SPSS version 19.

Results

The demographic and bone densitometry characteristics of the study sample (N = 97) are summarized in Table 1. Fifty-three percent of the cohort (51/97) has low vitamin D levels (<50 nmol/L). The overall mean age of the cohort was 13 ± 2 years with no significant differences in age among the two groups (12.8 *versus* 12.9 years; $p = 0.856$). Fifty-six percent (54/96) of the patients were females, with the females more likely to be vitamin D deficient than males (82% *versus* 18%; $p < 0.001$). The overall mean weight, height and BMI of the study cohort were 42±15 kg, 147±12 cm and 18.9±4.8 kg/m^2, respectively, with no significant differences amongst the groups ($p > 0.05$).

The Bone Mineral Content (BMC), bone mineral density, fat mass, lean BMC, and lean mass are 1,263±344g, 0.84±0.1g/cm^3, 9,775 (5,852-15,234g), 29.4±8.7 kg, and 28.1±8.4 kg respectively, with no significant differences amongst the groups ($p > 0.05$). However, the vitamin D deficient group was associated with higher fat percent compared to those with normal vitamin D status (29% *versus* 24%; $p = 0.011$).

Table 1: Association between Vitamin D and various demographic and bone densitometry characteristics (N=97)

Characteristic	**All** (N=97)	**Vitamin D status**		***p***
		Normal (≥50 nmol/l) (n=46; 47%)	**Low** (<50 nmol/l) (n=51; 53%)	
Demographic				
Age, mean±SD, years (N=73)	12.9±1.6	12.8±1.8	12.9±1.4	0.856
Gender, n (%), (N=96)				
Female	54 (56%)	12 (27%)	42 (82%)	<0.001
Male	42 (44%)	33 (73%)	9 (18%)	

Weight, mean±SD, kg (N=95)	42±15	41±15	43±15	0.546
Height, mean±SD, cm (N=95)	147±12	146±14	147±11	0.560
BMI, mean±SD, kg/m^2 (N=95)	18.9±4.8	18.6±4.8	19.2±4.8	0.575
Bone densitometry data				
BMC, mean±SD, g, (N=86)	1,263±344	1,253±323	1,270±363	0.813
BMD, mean±SD, g/cm^3, (N=86)	0.84±0.10	0.85±0.09	0.83±0.11	0.590
Fat mass, median (IQR), g, (N=86)	9,775 (5,852, 15,234)	7,906 (4,943, 13,641)	11,734 (7,011, 15,503)	0.044
Lean BMC, mean±SD, kg, (N=86)	29.4±8.7	30.2±9.4	28.7±8.1	0.426
Lean mass, mean±SD, kg, (N=86)	28.1±8.4	29.0±9.1	27.4±7.8	0.403
Fat percent, mean±SD, (N=85)	27±9	24±10	29±8	0.011
Depression, mean±SD, (N=61)	40.3±8		38.1±12	0.005

BMI = Body mass index;
SD = Standard deviation;
IQR = Interquartile range;
BMC = Bone mineral content;
BMD = Bone mineral density;
DEP = Depression;
Analyses were evaluated using Pearson's chi-squared test, Fisher's Exact test, Student's t-test and Wilcoxon-Mann-Whitney test, and person correlation coefficient wherever appropriate.

The association between vitamin D and various physical exercise attributes are stratified gender-wise (females and males), and presented in Tables 2, 3 and 4 respectively. Grip scores were significantly higher in males than females (21 *versus* 15; $p < 0.001$). They were also significantly lower in vitamin D deficient participants in males (16 *versus* 23; $p = 0.039$) but not females (16 *versus* 13; $p = 0.057$). Females were also associated with higher flex scores (5.0 *versus* -0.7; $p < 0.001$), lower sit-up scores (13 *versus* 16; $p = 0.001$), lower end-2 scores (131 *versus* 160; $p < 0.001$), higher end-3 scores (176 *versus* 155; $p < 0.001$), and higher end-4 scores (187 *versus* 180; $p = 0.008$). There were no significant differences in all physical exercise attribute scores ($p > 0.05$) in females between those with normal and those with low vitamin D levels. These results were also replicated in males except for grip and end-2 scores for which those with low vitamin levels were associated with low (16 *versus* 23; $p = 0.039$) and high scores (150 *versus* 137; $p = 0.034$), respectively.

Table 2: Association between vitamin D and various physical exercise attributes (N=97)

Characteristic	**All** (N=97)	**Vitamin D status**		***P***
		Normal (≥50 nmol/l) (n=46; 47%)	**Low** (<50 nmol/l) (n=51; 53%)	
GRIP score (N=96)				
Mean ±SD	17.8±7.2	19.9±8.7	16.1±5.2	0.009
Median (IQR)	16 (13, 22)	17 (13, 25)	16 (12, 18)	0.070
Low GRIP (<17)	53 (55%)	21 (47%)	32 (63%)	0.001 3
Normal GRIP (17/19)	14 (15%)	4 (9%)	10 (20%)	
High GRIP (>19)	29 (30%)	20 (44%)	9 (18%)	
FLEX score (N=96)				
Mean ±SD	2.5±7.4	1.6±8.7	3.3±6.1	0.265
Median (IQR)	2.6 (-2.2, 7.1)	0.7 (-2.3, 6.6)	3.5 (-0.7, 7.6)	0.216
Low FLEX (<2)	43 (45%)	25 (56%)	18 (35%)	
Normal FLEX (2/3)	7 (7%)	1 (2%)	6 (12%)	0.058
High FLEX (>3)				
SIT-UP score (N=96)				
Mean ±SD	14.6±5.4	15.2±7.2	13.6±3.1	0.149
Median (IQR)	14 (11, 17)	15 (11, 20)	14 (11, 15)	0.042
Low SIT-UP (<14)	41 (44%)	16 (37%)	25 (49%)	
Normal SIT-UP (14/15)	23 (24%)	7 (16%)	16 (32%)	0.016
High SIT-UP (>15)	30 (32%)	20 (47%)	10 (20%)	
END 1 score (N=96)				
Mean ±SD	145±0.65	156±0.62	135±0.66	0.126
Median (IQR)	129 (121, 136)	127 (122, 134)	130 (120, 140)	0.219
Low END1 (>130)	37 (39%)	14 (31%)	23 (45%)	
Normal END1 (130)	8 (8%)	3 (7%)	5 (10%)	0.235
High END1 (<130)	51 (53%)	28 (62%)	23 (45%)	
END 2 score (N=96)				
Mean ±SD	152±19	144±19	158±18	<0.00 1
Median (IQR)	149 (139, 163)	141 (133, 155)	157 (143, 174)	<0.00 1
Low END2 (>150)	43 (45%)	14 (31%)	29 (57%)	
Normal END2 (150/152)	4 (4%)	2 (4%)	2 (4%)	0.024
High END2 (<152)	49 (51%)	29 (64%)	20 (39%)	
END 3 score (N=94)				
Mean ±SD	167±18	161±18	173±16	0.001
Median (IQR)	169 (153, 184)	161 (147, 173)	174 (165, 186)	<0.00 1
Low END3 (>150)	48 (51%)	14 (31%)	34 (69%)	<0.00 1
Normal END3 (150/152)	5 (5%)	4 (9%)	1 (2%)	
High END3 (<152)	41 (44%)	27 (60%)	14 (29%)	
END 4 score (N=94)				
Mean ±SD	184±13	182±13	184±14	0.099
Median (IQR)	187 (178, 194)	184 (176, 190)	189 (181, 196)	0.038
Low END4 (>182)	56 (61%)	23 (52%)	33 (69%)	
Normal END4 (182)	2 (2%)	0 (0%)	2 (4%)	0.048
High END4 (<182)	34 (37%)	21 (48%)	13 (27%)	

SD=Standard deviation;
IQR=Interquartile range;
Analyses were evaluated using Pearson's chi-squared test, Fisher's exact test, Student's t-test and Wilcoxon-Mann-Whitney test, wherever appropriate.

Table 3: Association between Vit D and various physical exercise attributes in females (N=54)

Characteristic	All (N=54)	Vit D status		P
		Normal (≥50 nmol/l) (n=12; 22%)	Low (<50 nmol/l) (n=42; 78%)	
GRIP score (N=54)				
Mean±SD	15.4±4.7	13.1±3.5	16.1±4.9	0.057
Median (IQR)	15.0 (12, 17)	13.4 (10, 15)	15.6 (12, 18)	0.062
Low GRIP (<17)	36 (67%)	10 (83%)	26 (62%)	
Normal GRIP (17/19)	9 (17%)	1 (8%)	8 (19%)	0.427
High GRIP (>19)	9 (17%)	1 (8%)	8 (19%)	
FLEX score (N=54)				
Mean±SD	5.0±6.2	7.1±7.4	4.4±5.8	0.191
Median (IQR)	4.1 (1.8, 9.8)	4.8 (1.4, 10.6)	3.6 (1.8, 9.5)	0.505
Low FLEX (<2)	15 (28%)	3 (25%)	12 (29%)	
Normal FLEX (2/3)	6 (11%)	1 (8%)	5 (12%)	1.000
High FLEX (>3)	33 (61%)	8 (67%)	25 (60%)	
SIT-UP score (N=53)				
Mean±SD	13.1±3.6	11.5±4.3	13.6±3.2	0.079
Median (IQR)	13 (11, 15)	12 (10, 15)	13 (11, 15)	0.251
Low SIT-UP (<14)	30 (57%)	8 (73%)	22 (52%)	
Normal SIT-UP (14/15)	14 (26%)	2 (18%)	12 (29%)	0.472
High SIT-UP (>15)	9 (17%)	1 (9%)	8 (19%)	
END 1 score (N=54)				
Mean±SD	131±17	127±7	132±18	0.402
Median (IQR)	129 (120, 138)	127 (123, 130)	130 (120, 140)	0.632
Low END1 (>130)	22 (41%)	3 (25%)	19 (45%)	
Normal END1 (130)	4 (7%)	1 (8%)	3 (7%)	0.459
High END1 (<130)	28 (52%)	8 (67%)	20 (48%)	
END 2 score (N=54)				
Mean±SD	160±17	161±15	160±17	0.824
Median (IQR)	157 (148, 172)	157 (151, 171)	157 (148, 174)	0.892
Low END2 (>150)	34 (63%)	9 (75%)	25 (60%)	
Normal END2 (150/152)	3 (6%)	1 (8%)	2 (5%)	0.380
High END2 (<152)	17 (31%)	2 (17%)	15 (36%)	
END 3 score (N=53)				
Mean±SD	176±15	178±13	176±15	0.629
Median (IQR)	177 (168, 188)	174 (168, 188)	179 (167, 187)	0.949
Low END3 (>150)	37 (70%)	7 (58%)	30 (73%)	
Normal END3 (150/152)	5 (9%)	4 (33%)	1 (2%)	0.008
High END3 (<152)	11 (21%)	1 (8%)	10 (24%)	
END 4 score (N=51)				
Mean±SD	187±13	187±8	187±14	0.968
Median (IQR)	189 (180, 196)	188 (179, 193)	189 (180, 196)	0.630
Low END4 (>182)	35 (69%)	8 (73%)	27 (67%)	
Normal END4 (182)	2 (4%)	0 (0%)	2 (5%)	0.235
High END4 (<182)	14 (27%)	3 (27%)	11 (27%)	

SD=Standard deviation;
IQR=Interquartile range;

Analyses were evaluated using Pearson's chi-squared test, Fisher's Exact test, Student's t-test and Wilcoxon-Mann-Whitney test, wherever appropriate.

Table 4: Association between Vit D and various physical exercise attributes in males (N=42)

Characteristic	All (N=42)	Vit D status		P
		Normal (≥50 nmol/l) (n=33; 73%)	Low (<50 nmol/l) (n=9; 18%)	
GRIP score (N=41)				
Mean±SD	21.2±8.6	22.6±8.6	16±6.7	0.039
Median (IQR)	18.2 (15, 28)	22.0 (16, 31)	15.0 (11, 17)	0.040
Low GRIP (<17)	16 (39%)	10 (31%)	6 (67%)	
Normal GRIP (17/19)	5 (12%)	3 (9%)	2 (22%)	0.023
High GRIP (>19)	20 (49%)	19 (59%)	1 (11%)	
FLEX score (N=41)				
Mean±SD	-0.7±7.8	-0.4±8.4	-1.9±5.0	0.619
Median (IQR)	-1.4 (-6.1, 4.9)	-0.7 (-6.3, 6.4)	-3.2 (-3.9, 3.0)	0.468
Low FLEX (<2)	27 (66%)	21 (66%)	6 (67%)	
Normal FLEX (2/3)	1 (2%)	1 (11%)	0 (0%)	0.314
High FLEX (>3)	13 (32%)	11 (34%)	2 (22%)	
SIT-UP score (N=40)				
Mean±SD	16.0±6.9	16.6±7.6	13.9±2.3	0.296
Median (IQR)	16 (13, 21)	18 (15, 23)	14 (12, 15)	0.047
Low SIT-UP (<14)	10 (25%)	7 (23%)	3 (33%)	
Normal SIT-UP (14/15)	9 (22%)	5 (16%)	4 (44%)	0.089
High SIT-UP (>15)	21 (52%)	19 (61%)	2 (22%)	
END 1 score (N=41)				
Mean±SD	128±11	127±10	134±13	0.082
Median (IQR)	129 (122, 135)	127 (122, 135)	130 (128, 145)	0.196
Low END1 (>130)	15 (37%)	11 (34%)	4 (44%)	
Normal END1 (130)	4 (10%)	2 (6%)	2 (22%)	0.189
High END1 (<130)	22 (54%)	19 (59%)	3 (33%)	
END 2 score (N=41)				
Mean±SD	139±16	137±14	150±20	0.034
Median (IQR)	139 (132, 149)	136 (126, 147)	143 (137, 159)	0.074
Low END2 (>150)	8 (20%)	4 (13%)	4 (44%)	
Normal END2 (150/152)	1 (2%)	1 (3%)	0 (1%)	0.117
High END2 (<152)	32 (78%)	27 (84%)	5 (56%)	
END 3 score (N=40)				
Mean±SD	155±15	154±15	159±16	0.463
Median (IQR)	152 (144, 167)	152 (144, 163)	160 (146, 169)	0.446
Low END3 (>150)	10 (25%)	6 (19%)	4 (50%)	
Normal END3 (150/152)	0 (0%)	0 (0%)	0 (0%)	0.089
High END3 (<152)	30 (75%)	26 (81%)	4 (50%)	
END 4 score (N=40)				
Mean±SD	180±13	179±13	183±14	0.471
Median (IQR)	181 (171, 189)	179 (170, 189)	188 (178, 189)	0.369
Low END4 (>182)	20 (50%)	14 (44%)	6 (75%)	
Normal END4 (182)	0 (0%)	0 (0%)	0 (0%)	0.235
High END4 (<182)	20 (50%)	18 (46%)	2 (25%)	

SD=Standard deviation;
IQR=Interquartile range;

Analyses were evaluated using Pearson's chi-squared test, Fisher's Exact test, Student's t-test and Wilcoxon-Mann-Whitney test, wherever appropriate.

Figure 1 illustrates classification of depression prevalence among females and males (1= no depression symptoms, 2= mild, 3= moderate, and 4= severe depression symptoms) with no significant differences between males and females. A negative correlation was achieved between those who have vitamin D deficiency and depression (significant at the 0.01 level -0.353 2-tailed).

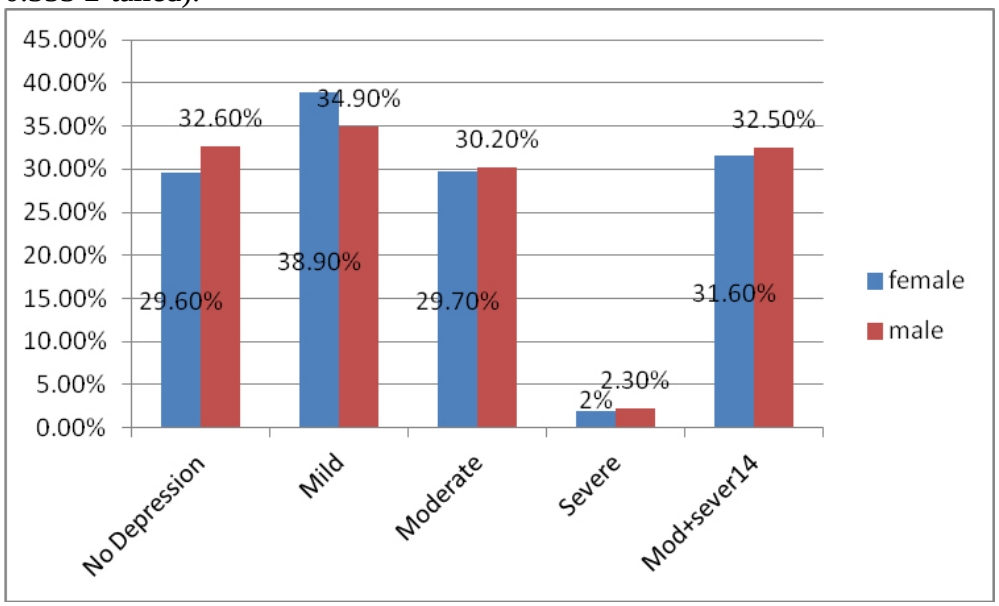

Figure 1: Classification of depression prevalence among females & males (n=97)

Discussion:

When looking at the tables and see the results of BMD we could not make any inferences or interpretation due to two factors; firstly is the limiting of the sample size and secondly is the unknown BMD standards for children in Oman. Vitamin D is unique among hormones because it can be made in the skin from exposure to sunlight (Holick, *et.al.*, 2007, 2008). Vitamin D comes in two forms. Vitamin D2 is obtained from the UV irradiation of the yeast sterol ergo-sterol and is found naturally in sun-exposed mushrooms. Vitamin D3 is synthesized in the skin and is present in oil-rich fish such as salmon, mackerel, and herring; which are not available in Oman. Commercially available, vitamin D3 is synthesized from the cholesterol precursor 7-dehydrocholesterol naturally present in the skin or obtained from lanolin. Both vitamin D2 and D3 are used for food fortification and in vitamin D supplements. Vitamin D that comes from the skin or diet is biologically inert and requires its first hydroxylation in the liver by the vitamin D-25-hydroxylase (25-OHase) to 25(OH)D (Holick, 2007). However, 25(OH)D requires a further hydroxylation in the kidneys by the 25(OH)D-1_-OHase (CYP27B1) to form the biologically active form of

vitamin D 1,25(OH)2D. 1,25(OH) 2D interacts with its vitamin D nuclear receptor, which is present in the small intestine, kidneys, and other tissues (DeLuca, 2004). 1,25(OH)2D stimulates intestinal calcium absorption (Christakos, Dhawan, Liu, Peng, & Porta, 2003). Without vitamin D, only 10 to 15% of dietary calcium and about 60% of phosphorus are absorbed. Vitamin D sufficiency enhances calcium and phosphorus absorption by 30–40% and 80%, respectively (Heaney, 2004).

Since children aged 9–18 years has a rapid growth spurt characterized by a marked increase in their requirement of calcium and phosphorus to maximize skeletal mineralization, the metabolism of 25(OH) D to 1,25(OH)2D increases. In our study, vitamin D was deficit in high percentages for females and in moderate percentages in males which indicate non-sufficient exposure to the sunlight as it was assumed. In the past, children of all races obtained most of their vitamin D from exposure to sunlight and drinking vitamin D-fortified milk, and therefore, they did not need to take vitamin D supplements. However, children are spending more time indoors now, and when they go outside, they often wear sun protection that limits their ability to make vitamin D in their skin. Children and adolescents are also drinking less vitamin D fortified milk (Sullivan *et.al.*, 2005).

Moreover, the females & males who were more having depression than those who did not have vitamin D deficiency, Figure 1. A systematic review and meta-analysis of 14 studies with a total of 31,424 participants revealed an association between vitamin D levels and depression which concluded that low vitamin D concentration is associated with depression (Anglin *et.al.*, 2013). Given the high prevalence of both vitamin D deficiency and depression, an association between these two conditions would have significant public health implications, particularly as supplementation with vitamin D and regular exercise under sunlight for the skin exposure. However, vitamin D and depression may be linked is still unclear. Vitamin D deficiency may result in depression, or depression may increase the risk for low vitamin D levels. For example, depressed people may spend more time indoors, and are less likely to eat a healthy diet and take care of themselves, all of which could affect vitamin D levels. On the other hand, there are vitamin D receptors everywhere in the body including the brain. These receptors need vitamin D to do their job. More research is urgently needed to determine whether vitamin D can prevent and treat depression.

In young children who have little mineral in their skeleton, this defect results in a variety of skeletal deformities classically known as rickets. In addition, reduction in serum calcium level may affect ventricular contraction, thus cardiomyopathy may develop in rickets. (Uysal, *et.al*.,1999) However,

BMDs were not marked at this age group nor cardiovascular endurance (Modified Bruce protocol). The reason for these asymmetrical results may be due to small number of subject running for four stages on the treadmill. In turn, the increased blood levels of 1,25 (OH)2D enhance the efficiency of the intestine to absorb dietary calcium and phosphorus to satisfy the growing skeleton's requirement for these minerals during its rapid growth phase.

We can't assume that there were malnutrition since the optimal nutrition from various sources will not be sufficient for the sufficient production of vitamin D for the body. Therefore, the best sources to have vitamin D are from the sunlight exposure to the skin. As we mentioned earlier and despite the fact that sunlight is available almost all year round in Oman, heat is so high that prevent kids from playing outside in the schools and most of the physical education classes for girls were substituted with other subject (Mehana, & Kilani, 2010). Vitamin D deficiency also causes muscle weakness; affected children have difficulty standing and walking (Holick, 2006). Our males who have vitamin D deficiency scored low in grip strength. Muscle weakness is a prominent feature of the clinical syndrome of severe vitamin D deficiency. Clinical findings in vitamin D deficiency myopathy include proximal muscle weakness, diffuse muscle pain, and gait impairments such as a waddling way of walking (Schott & Wills, 1976).

Wortsman and his colleagues, (2000) found that there was an inverse association of serum 25(OH) D and body mass index (BMI) greater than 30 kg/m2, and thus, obesity is associated with vitamin D deficiency. Children in our study who have higher fat percentages (29±8) were vitamin D deficient. This is because the body fat sequesters the fat-soluble vitamin. When obese and non-obese adults were exposed to simulated sunlight or received an oral dose of 50,000 IU of vitamin D2, they were able to raise their blood levels of vitamin D by not more than 50% compared with non-obese adults (Wortsman *et.al.,* 2000).

Although, the cardiovascular endurance in our study was not in all stages associated to vitamin D deficiency, Many studies have suggested that ultraviolet light and vitamin D also might have a role in cardiovascular disease (Zittermann, Schleithoff, Koerfer,2005, Scragg 1981). In a recent cohort study, it was found that low levels of vitamin D were an independent risk factor for myocardial infarction in men(Giovannucci, Liu, Hollis, Rimm, 2008).

Conclusion:

Our results showed that a high prevalence of the females are deficient in vitamin D, and are susceptible to early diagnosis of osteoporosis and depression due to this deficiency. Male children were also at moderate risk of vitamin D deficiency. This indicates that children at this stage should be

involved in physical activity program and meet the required sunlight exposure during the entire season to gain healthy lifestyle. Therefore, we recommend screening for vitamin D deficiency in children and adolescents at risk for deficiency especially in Oman where a prevalence of inactivity, malnutrition, short sleep duration and unhealthy habits were reported (Kilani, *et.al.,* 2013). In addition, we suggest that obese children should reduce their fat percentages by diet and exercise and increase time exposure of their skin to sunlight or are given at least two to three times more vitamin D for their age group to satisfy their body's vitamin D requirement. We also recommend prescribing vitamin D supplementation for muscle weaknesses prevention and to improve muscle strength with regular exercise. Finally, we suggest repeating this study on a large number of sampling to represent most regions in Oman.

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References:

Anglin RE, Samaan Z, Walter SD, McDonald SD. (2013) Vitamin D deficiency and depression in adults: systematic review and meta-analysis. Br J Psychiatry. 2013 Feb; 202:100-7. doi: 10.1192/bjp.bp.111.106666. PMID: 23377209 [PubMed - in process]

Bass S, Pearce G, Bradney M, Hendrich E, Delmas PD, Harding A, Seeman E. (1998): Exercise before puberty may confer residual benefits in bone density in adulthood: studies inactive pre-pubertal and retired female gymnasts. J Bone Miner Res.; 13:500.507.

Bonjour JP, Carrié AL, Ferrari S, Clavien H, Slosman D, Theintz G & Rizzoli R (1997) Calcium enriched foods and bone mass growth in prepubertal girls: a randomized, double-blind, placebo-controlled trial. Journal of Clinical Investigation 99 1287–1294.

Christakos S, Dhawan P, Liu Y, Peng X, PortaA (2003) New insights into the mechanisms of vitamin D action. J Cell Biochem 88:695– 705

Dawson-Hughes B, Harris SS, Krall EA, Dallal GE.(2000) Effect of withdrawal of calcium and vitamin D supplements on bone mass in elderly men and women. Am J Clin Nutr. Sep;72(3):745-50. PubMed PMID: 10966893

Dawson-Hughes B, Harris SS, Palermo NJ, Castaneda-Sceppa C, Rasmussen HM, Dallal GE (2009), "Treatment With Potassium Bicarbonate Lowers Calcium Excretion And Bone Resorption In Older Men And Women," Journal of Clinical Endocrinology and Metabolism, 94, 96-102.

DeLuca H 2004 Overview of general physiologic features and functions of vitamin D. Am J Clin Nutr 80(6 Suppl):1689S–1696S

Dodiuk-Gad RP, Rozen GS, Rennert G, Rennert HS, Ish-Shalom S. (2005) Sustained effect of short-term calcium supplementation on bone mass in adolescent girls with low calcium intake. American Journal of Clinical Nutrition 81: 168–74.

Dook, J E.; Jams S, C.; Henderson, N. K.; Pice, R. I (1997): Exercise and bone mineral density in mature female athletes. Clinical Sciences Medicine & Science in Sports & Exercise. 29(3):291-296, March

Egan, E, Reilly, T, Giacomoni, M, Redmond, L, Turner, C (2006) Bone mineral density among female sports participants, 38,2, 227- 233. http://www.sciencedirect.com/science/article/pii/S8756328205003443

Frey, J. Rebecca. "Child Depression Inventory." Gale Encyclopedia of Mental Disorders. The Gale Group Inc. (2003) Encyclopedia.com. 6 Oct. 2009 <http://www.encyclopedia.com>.

Giovannucci E., Liu Y., Hollis B.W., Rimm E.B.(2008): 25-Hydroxyvitamin D and risk of myocardial infarction in men. Arch Intern Med 168. 1174-1180.

Grimston, ND Willows, DA Hanely (1993): Mechanical loading regime and its relationship to bone mineral density in children. Clinical Sciences, Medicine & Science in Sports & Exercise. 25(11):1203-1210, November

Heaney RP (2004) Functional indices of vitamin D status and ramifications of vitamin D deficiency. Am J Clin Nutr 80 (6 Suppl): 1706S–1709S

Heaney RP, eds. (2000) Nutritional Aspects of Osteoporosis. A Serono Symposia S.A. Publication. New York, NY: Springer Verlag New York, Inc.

Heaney RP. (2000) there should be a dietary guideline for calcium. Am J Clin Nutr.;71:658-670

Holick MF (2006) Resurrection of vitamin D deficiency and rickets. J Clin Invest 116:2062–2072

Holick MF (2007) Vitamin D deficiency.NEngl JMed 357:266–281

Holick MF (2008) Vitamin D: a D-lightful health perspective. Nutr Rev 66(10 Suppl 2):S182–S194

Holick MF, Chen TC, Sauter ER 2007 Vitamin D and skin physiology**:** a Delightful story. J Bone Miner Res 22(Suppl 2):V28–V33

Holick MF. McCollum Award Lecture, (1994): Vitamin D—new horizons for the 21st century. Am J Clin Nutr;60:619–30.

Holmes RP, Kummerow FA.(1983) The vitamin D status of elderly Americans. Am J Clin Nutr Aug; 38(2):335-9.

Janz, K. F., T. L. Burns, S. M. Levy, J. C. Torner, M. C. Willing, T. J. Beck, J. M. Gilmore, and T. A. Marshall. (2004). Everyday activity predicts bone geometry in children: The Iowa bone development study. Med Sci Sports Exerc.; 36:1124-1131.

Johnston CC, Millar JZ, Slemenda CW, (1992). Calcium supplementation and increases in bone mineral density in children. N Engl J Med.; 327:82-87.

Kemmler,W., Engelke,K.,Baumann,H.,Beeskow,C., von,S. (2006): Bone status in elite male runners - European Journal of Applied Physiology, – Springer

Kilani, H, Al-Hazzaa, H, Waly, M, & Musaiger, A. (2013) Lifestyle Habits: Diet, Physical Activity and Sleep Duration among Omani Adolescents. SQU Med J, accepted for publication.

Kilani, H. & Lala, O., (2001): Physical activities, its relation to Health related fitness for pupils. Proceedings of the 1st Educational Activity Conference,. Dubai, UAE Feb.25-27,

Kilani, H., Abu Eisheh, A. (2010) Optimum Anthropometric Criterion for Ideal Body Composition. SQU Med J, Vol. 10, Iss. 1, pp. 74-79.

Kilani, H., Waly, M., & Yousef, R. 2012. Trends of Obesity and Overweight among College Students in Oman: A cross sectional study. SQU Med J, Feb.l 2012, accepted for publication 16 Nov.2011.

Lambert HL, Eastell R, Barker ME.(2000) Calcium supplementation in teenage girls with low dietary calcium intakes. Proceedings of the 4th International Symposium on Nutritional Aspects of Osteoporosis. May 17-20, Lausanne, Switzerland. In: Burckhardt P, Dawson-Hughes B,

Lehtonen-Veromaa M, Mottonen T, Heinonen OJ, et al. (2004) Influence of physical activity and vitamin D on bone mineral gain among peripubertal Finnish girls: a 3-year prospective study. Osteoporos Int 15(Suppl.1):S13-S18.

Mehana, M., & Kilani, H. (2010). Enhancing Physical Education in Omani Basic Education Curriculum: Rationale and Implications, International Journal for Cross-Disciplinary Subjects in Education (IJCDSE), Volume 1, Issue 2.

Moan J, Porojnicu AC, Dahlback A, Setlow RB (2008). Addressing the health benefits and risks, involving vitamin D or skin cancer, of increased sun exposure. Proc Natl Acad Sci USA 105:668–673

Nowson CA, Green RM, Hopper JL, (1997). A co-twin study of the effect of calcium supplementation on bone density during adolescence. Osteoporosis Int.; 7:219-225.

O'Connor JA, Lanyon LE, MacFie H.: (1982) The influence of strain rate on adaptive bone remodeling. J Biomech. 1982; 15(10):767-81.

Saxon,L, Robling,A, .Alam,I,Turner,C:(2005) Mechano-sensitivity of the rat skeleton decreases after a long period of loading, but is improved with time off. Bone, Volume 36, Issue 3, Pages 454-464

Scragg R.(1981): Seasonality of cardiovascular disease mortality and the possible protective effect of ultraviolet radiation. Int J Epidemiol 10. 337-341.

Specker BL. (2000) Should there be a dietary guideline for calcium intake? No. Am J Clin Nutr.; 71:661-664.

Stear SJ, Prentice A, Jones SC, Cole TJ.(2000) Bone mineral status of female adolescents 14 months after the cessation of a calcium and exercise intervention. Osteoporosis Int.; 11 (suppl 2):S84.

Sullivan SS, Rosen CJ, Halteman WA, Chen TC, Holick MF (2005) Adolescent girls in Maine at risk for vitamin D insufficiency. J Am Diet Assoc 105:971–974

Sullivan, P.G., Dube, C., Dorenbos, K.D., Steward, O., Baram, T.Z., (2003). Mitochondrial uncoupling protein-2 protects the immature brain from excitotoxic neuronal death. Annals of Neurology, 53, 711-717.

Uysal S, Kalayci AG, Baysal K. (1999) Cardiac functions in children with vitamin D deficiency rickets. Pediatr Cardiol. Jul-Aug;20(4):283-6. PubMed PMID:10368454.

Vico L, Collet P, Guignandon A, Lafage-Proust MH, Thomas T, Rehalia M, Alexandre C, (2000) Effects of long-term microgravity exposure on cancellous and cortical weight-bearing bones of cosmonauts. The Lancet, Volume 355, Issue 9215, Pages 1607-1611

Zittermann A., Schleithoff S.S., Koerfer R.: Putting cardiovascular disease and vitamin D insufficiency into perspective. Br J Nutr 94. 483-492.2005.

Waly, M, Kilani, H, AL-Busafi, M. 2013. Nutritional Practices of Athletes in Oman: A Descriptive Study, accepted in Jun.18, Oman Medical Journal.

Wortsman J, Matsuoka LY, Chen TC, Lu Z, Holick MF (2000) Decreased bioavailability of vitamin D in obesity. Am J Clin Nutr 72:690–693